SCANDINAVIAN FISHES

SECOND EDITION

A HISTORY OF

SCANDINAVIAN FISHES

BY

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WITH COLOURED PLATES

BY

W. VON WRIGHT

AND TEXT ILLUSTRATIONS

SECOND EDITION

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TEXT

PART II

P. A. NORSTEDT & SÖNER
STOCKHOLM

BERLIN
R. FRIEDLÄNDER & SOHN
CARLSTRASSE 11

LONDON
SAMPSON LOW, MARSTON & COMPANY, LIMITED
ST DUNSTAN'S HOUSE, FETTER LANE

PARIS
LIBRAIRIE C. REINWALD & C[IE]
15, RUE DES SAINTS-PÈRES

STOCKHOLM 1895
P. A. NORSTEDT & SÖNER
ROYAL PRINTING OFFICE

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Fam. AMMODYTIDÆ.

Body elongated, fusiform, terete or compressed, covered with thin cycloid scales or partly naked. Caudal fin separated from the other vertical fins. Jaws without teeth[a]. *Gill-openings large; branchiostegal membranes more or less completely free from each other and from the isthmus. Pseudobranchiæ well-developed and distinct. Air-bladder wanting. Pyloric appendages rudimentary.*

The place of this family in the system has long been a debated question. The original opinion of modern systematists, that of ARTEDI, was that the Sand-Eels — with their long dorsal fin occupying the greater part of the back — should be ranged beside the genus *Coryphæna*. This opinion, borne out by the Mackerel-like coloration of the Sand-Eels, still survived in 1839 in SWAINSON[b], who pointed out the external resemblances between these fishes and *Lepidopus*. LINNÆUS had imagined that he had made an improvement by uniting all fishes without ventral fins into an order (*Apodes*), and thus in 1817—1829 the Sand-Eels assumed in CUVIER'S works[c] the rank of a genus within the family of the Eels, and in 1832—1841, in BONAPARTE[d], that of a subfamily (*Ammodytini*) of the *Ophidiidæ* among *Malacopterygii apodes*. When MÜLLER[e] formed the order *Anacanthini*, he did not hesitate to include in this order the family *Ophidiidæ*, but he declared himself unable to give a decided opinion as to the place of *Ammodytes*, though he positively denied the relationship between this genus and the Eels. In his later work[f], however, BONAPARTE ranged the Sand-Eels, as a distinct family (*Ammodytidæ*), among the *Gadi*, and GÜNTHER[g] did not hesitate to include these fishes among the *Anacanthini* as a subfamily (*Ammodytina*) of the *Ophidiidæ*.

This diversity of opinion has been caused by the absence in the Sand-Eels both of the ventral fins and the air-bladder. The reduction and eventual disappearance of the ventral fins is a characteristic which, as we have seen above, may occur within several piscine orders. The absence of the air-bladder may be explained in the same way. We must, therefore, look to other characters in order to discover the nearest relations of the family, and as often happens in such cases, we may have recourse to characters apparently of minor importance. The Sand-Eels are approximated by their form and coloration not only to the Mackerels but, still more closely, to the Garpikes. To the latter fishes, which are Pharyngognate Anacanthini, it is impossible to unite the Sand-Eels, in which the lower pharyngeals are free from each other. Still, where the lateral line lies in the Garpikes and Flying-fishes, along the ventral margin, at the boundary between the sides and the belly, and also along the base of the anal fin, here we find in the Sand-Eels a dermal ridge, somewhat raised in the same way. The physiological signification of this ridge is indeed unknown, but in a morphological respect it shows at least a trace of resemblance to the Garpikes and Flying-fishes, such a resemblance as we have seen above in other *Anacanthini*, in the *Couchia*-stage of *Onos*. The Garpike-like coloration of these last fishes, in its sharp contrast to that of adult Rocklings, may also be a trace of their original relationship to the Sand-Eels. Among the osteological peculiarities which we have above remarked in the Gadoid family,

[a] DAY (*Fishes of India*, p. 420) observed, however, "a few, fine teeth opposite the symphysis in either jaw" in *Ammodytes (Bleekeria) kallolepus*.

[b] *Nat. Hist. Fish., Amph., Rept.*, vol. II, p. 254.

[c] *Regne Animal*, tome II, ed. 1, p. 240; ed. 2, p. 360.

[d] *Iconogr. Fn. Ital.*, tom. III, *Pesci*, Introd., p. 15.

[e] Abh. Akad. Wiss. Berl. 1844, p. 177.

[f] *Catalogo Metodico dei Pesci Europei*, Napoli 1846, pp. 6 and 40.

[g] *Cat. Brit. Mus., Fish.*, vol. IV, p. 384.

there recurs in the Sand-Eels the characteristic, lobate process on the intermaxillary bones, though it is removed farther forward, to about the end of the first third (*Ammodytes tobianus*) or fourth (*Am. lanceolatus*) of the length of the bones. This resemblance may be not without importance in a morphological respect. With this exception, however, the intermaxillary bones of the Sand-Eels are very unlike those of the Codfishes, not only in their narrow and terete, almost needle-like shape, but also in the more or less complete freedom of the nasal processes, which vary considerably in length and mobility, and are united to the anterior end of the bones only by cartilage and ligaments. The skeleton of the Sand-Eels is also distinguished from that of the Codfishes in two other essential respects. Ribs are attached to the abdominal vertebræ from the very first of these bones; and in the caudal fin, which is far more differentiated than in the Codfishes, and the base of which is composed exclusively of the last two vertebræ and the urostyle, the development of the hypural bones is quite as typical as in the rest of the Teleosts.

Still, though we may find in the above-mentioned points of resemblance to the Codfishes and the Garpikes fully valid reasons of morphological significance for the opinion advanced by GÜNTHER and other modern writers, that the Sand-Eels are Anacanthine fishes, we are not destitute of grounds for a close comparison of these fishes with the Eels, though the latter are assigned to a far distant place in the system by the arrangement of the jaws and shoulder-girdle, as well as by their character of Physostomous fishes. This comparison is suggested by the scales. Their structure most strongly reminds us partly of the Eels and partly of *Enchelyopus*. In the Scandinavian Sand-Eels, as in most fishes, and in a manner that especially calls to mind the simple scales of our common Flatfishes, the anterior part of the scale is quite different from the posterior; but here the difference is so marked that the former resembles in structure an entire scale of *Enchelyopus*, with dense, concentric striæ, interrupted by grooves radiating from the nucleus, while the latter resembles the scales of the Eels, with continuous concentric striæ, but with the grooves broken up into more or less irregular, round or oblong, small patches. On the anterior part of the scale too, the concentric striæ are about twice as dense (numerous) as on the posterior part. The scales of the Sand-Eels also vary considerably in form and development, not only in different species but even in the same fish. All of them are comparatively small and thin. The most developed are set on the back of the fish, the largest of them, as usual, on the hind part of the body. These scales are imbricated, with the posterior part free; and they vary in shape from rounded to oblong or linguiform. On the sides of the body the scales lie in dermal folds that run in an oblique transverse direction downward and backward from the lateral line proper, which is situated high on the back, to the raised dermal ridge that coasts each side of the belly, forming a boundary between the latter and the sides of the body. On the belly itself, between these dermal ridges, the folds are less sharply marked, but the scattered (not imbricated) scales lie hidden in the skin, in rows that run from each dermal ridge obliquely forward and inward, towards a similar but lower dermal ridge at the middle of the belly. The scales which lie in the skin are of a broad oval (linguiform) shape, with the hind extremity pointed[a].

In their manner of life the Sand-Eels remind us both of the Garpikes and of the Eels: in the open sea they are active and eager in their pursuit of small fishes and fry, but now and then they hide themselves in the sand to escape their numerous enemies, just as the Eels burrow in the sand and mud or creep into crevices between the stones.

The family contains remarkably few forms: among the 4 or 5 known species[b] only two genera can with reason be distinguished. Most of the species belong to the Northern Hemisphere, both to the Atlantic and the Pacific; but one species occurs in the Indian Ocean.

[a] In the Indian species, which GÜNTHER has adopted as the type of a distinct genus (*Bleekeria*), the scales are said to be larger (of moderate size), and the said dermal ridges are wanting.

[b] Five distinct species have been described from America. But the Greenland species is undoubtedly identical with our Sand-Launce, and JORDAN and GILBERT (Bull. U. S. Nat. Mus., No. 16, pp. 414 and 909), who have rejected one species as based merely on a description of a damaged specimen, advance the opinion that all the others are hardly more than varieties of the Sand-Launce. BROWN-GOODE, however (*Fisher., Fisher. Industr. U. S.*, sect. 1, p. 244), insists upon maintaining a rigid distinction between the European and American Sand-Eels.

GENUS AMMODYTES.

Body more or less terete (only slightly compressed). A longitudinal dermal ridge on each side of the belly. Branchiostegal rays 7 or 8.

The extremely similar species that form this genus, have long been known. At the middle of the fifteenth century SALVIANUS described and figured the '*sandilz*' (Sand-Eel) of English waters, and gave an account of its habits and the manner in which it was taken. The figure and description recur in GESNER[a], who gave the genus its Greek name[b]. RAY[c] and JAGO[d] mention two species; but although we can see, from the statement of the latter as to the length of the fish described and figured by him (15 1/2 in.), that he referred to a species regarded as distinct in modern times (*Ammodytes lanceolatus*), still the supposed specific distinction was based merely on defects in the figure of SALVIANUS. ARTEDI described[e] the smaller of our forms both fully and accurately, but did not distinguish between it and the larger one. In his *Systema Naturæ*[f] LINNÆUS adopted only one species (*Am. Tobianus*), the name of the species being clearly derived from ARTEDI'S quotation of SCHONEVELDE[g]; but in his *Fauna Suecica*[h] he draws attention to the fact that in his travels through Öland[i] he had found more fin-rays in the Sand-Eel than ARTEDI, to which fact he probably refers when he remarks, in the twelfth edition of his *Systema* (1766): "In Sweden there seem to be two distinct species, as RAY once conjectured was the case in England." There is no doubt, however, that in 1741 KLEIN had already distinguished between ARTEDI'S *Tobianus* and JAGO'S "*Ammodytes Anglorum verus, The Launce, sive True Sand-Eel*" though without giving them binomial names. Afterwards, in 1810[k], when RAFINESQUE described his *Ammodytes cicerelus*, the three European species now accepted became known; but the largest of them was without any binomial specific name, which it first received in 1824 of LESAUVAGE[l]. The natural relations between these three species, as they are distinguished at present, may be expressed as follows:

A: Pectoral fins shorter than the lower jaw:
- *a*: The whole body behind the head scaly, with the scales on the sides of the body hidden in transverse dermal folds even on the forepart ... *Ammodytes lanceolatus.*
- *b*: Forepart of the body naked, without transverse dermal folds ... *Ammodytes cicerelus.*

B: Pectoral fins longer than the lower jaw ... *Ammodytes tobianus.*

[a] *Paralipomena*, p. 3.
[b] From ἄμμος, *sand* and δύτης, *diver*.
[c] *Syn. Meth. Pisc.*, p. 38.
[d] Ibid., p. 165, fig. 12.
[e] *Spec. Pisc.*, p. 55.
[f] Ed. X, tom. I, p. 247; ed. XII, tom. I, p. 430.
[g] To which form SCHONEVELDE himself referred, is a question difficult to decide. *Ichth. Slesv. Hols.*, p. 76.
[h] Ed. I, p. 114; ed. II, p. 109.
[i] *It. Œl.*, p. 87.
Hist. Pisc. Nat. Prom. Miss. IV, pp. 55 and 56, tab. XII, figs. 8—10.
[k] *Caratteri d. alc. n. gen.*, p. 21, Tab. IX, fig. 4.
[l] Bull. Sc., Soc. Philom. 1824, p. 140.

THE SAND-EEL (SW. HVITTOBISEN OR TOBISKUNGEN).

AMMODYTES LANCEOLATUS.

Plate XXIII, fig. 4 and Fig. 135.

Upper jaw not at all (or only slightly) protrusile; nasal processes of the intermaxillary bones short — measuring about 11—13 % of the length of the intermaxillary bones — and more or less firmly united by ligaments to the ethmoid bone. Pectoral fins short, their tip extending scarcely to the perpendicular from the beginning of the dorsal fin, and their length being less than that of the lower jaw, less than 46 % of that of the head, and at most 33 % of the distance between the dorsal fin and the tip of the snout. Head of the vomer furnished with two pointed, crooked teeth, diverging at the tip. Dorsal and anal fins with straight margin. A black spot generally visible on the middle of the sides of the snout.

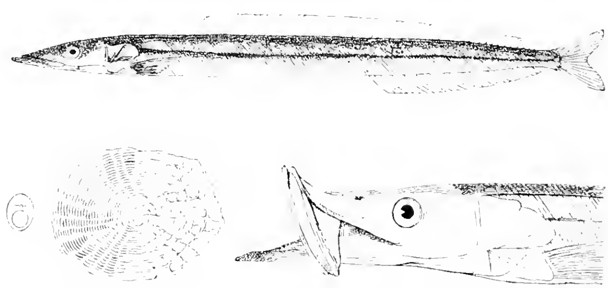

Fig. 135. *Ammodytes lanceolatus*, with the body in transverse section, a scale, and a head with open mouth. After BENECKE.

R. br. 7; *D.* 53—59[a]; *A.* 28[b]—33; *P.* 12—14; *V.* 0; *C.* $x+1+13+1+x$; *Lin. lat.* 172—183[c]; *Vert.* 66—67.

Syn. *Enchelyopus* No. 7; KLEIN, l. c., p. 56, tab. XII, fig. 10; *Ammodytes tobianus*, p. p., SWARTZ, *Svensk Zoologi*, II. 11, No. 64.

Ammodytes lanceolatus, LESAUV. l. c.; SUNDEV., *Skand. Fisk.*, ed. 1, p. 209, tab. 54; GTHR, *Cat. Brit. Mus., Fish.*, vol. IV, p. 384; MALMGR., *Finl. Fisk.* (disp. Hels.) p. 32; COLL., Forh. Vid. Selsk. Christ. 1874, Tillaegsh., p. 126; ibid. 1879, No. 1, p. 69 (corr. N. Mag. Naturv. Christ., Bd. 29 (1884), p. 94); MALM, *Gbgs. Boh. Fn.*, p. 500; WINTH., Naturh. Tid-kr. Kbhvn, ser. 3, vol. XII, p. 35; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 99; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 217; DAY, *Fish. Gt. Brit., Irel.*, vol. I, p. 329, tab. XCII, fig. 1; MOB., HCKE, *Fisch. Osts.*, p. 85; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 211.

Ammodytes tobianus, CUV., *Règne Anim.*, ed. 2, tom. II, p. 360; NILSS., *Prodr. Ichthyol. Scand.*, p. 63; EKSTR., Vet.-Akad. Handl. 1834, p. 67; KR., *Danm. Fiske*, vol. III, p. 575; NILSS., *Skand. Fn., Fisk.*, p. 653.

The Sand-Eel is the largest Scandinavian species of this genus, and attains a comparatively considerable size: SUNDEVALL met with a specimen 32 cm. long; DAY gives 33 cm., and JAGO (in RAY) 394 mm., as the maximum length of the species. The ordinary length on our coasts, however, is only 12—20 cm.

The body is elongated, the greatest depth, across the belly, measuring in ordinary cases only about 6 or 7 % of the length of the body to the end of the outermost caudal rays, though in gravid females the belly is of course deeper. The body is also of nearly uniform depth, with gradually tapering tail and conical, pointed head, and almost terete, the greatest breadth being usually at least more than $^3/_4$ (81—84 %) of the greatest depth. The compression of the tail is confined to the base of the caudal fin.

The conical head is also only slightly compressed, but above and on the sides somewhat flattened and smooth, without scales. The depth across the occiput is somewhat less than the greatest depth of the body.

[a] Sometimes 61, according to GÜNTHER and MOREAU.
[b] " 26, " " LILLJEBORG.
[c] " 169, " " MALM.
" 203, " " DAY.

The length from the tip of the upper jaw to the occiput is twice the depth at the occiput, and in a small specimen (about 15 cm. long) nearly $\frac{1}{8}$ of the total length (including the whole of the caudal fin). The length of the head — according to the method of measuring it usually employed in this work, from the tip of the snout to the hindmost point of the opercular (here the subopercular) flap — measures in specimens between 11 and 14 cm. long about 21 % (20·8—20·7 %, according to our measurements) of the length of the body (from the tip of the snout to the end of the middle caudal rays), and in specimens between 26 and 28 cm. long about 19 % (18·5—19·6 %) of the same length. The eye is fairly round, but closely surrounded by a sharp, soft orbital margin, the opening of which is usually transversely oblong (the height greater than the length). Both in large and small specimens the hind margin of the eye lies half-way between the tip of the lower jaw and that of the gill-cover; but in large specimens the size of the eye is less in proportion to that of the body than in smaller ones, the diameter of the eye in a specimen 30 cm. long being only twice as great as in a specimen $7\frac{1}{2}$ cm. in length. During the growth of the body from 11 to 28 cm. the longitudinal diameter of the eye decreases from about $3\frac{1}{2}$ to $1\frac{3}{4}$ % of the length of the body or from 16 to 9 % of the length of the head from the tip of the snout. The length of the snout measures about 60 % ($61\frac{1}{2}$—$59\frac{1}{2}$ %) of the postorbital length of the head, or about $\frac{1}{3}$ ($32\frac{1}{2}$—35 %) of the total length of the head from the tip of the snout, in specimens between 11 and 28 cm. long. The breadth of the interorbital space, on the other hand, shows even relative increase during growth, in the said specimens from about $2\frac{1}{2}$ % to about $3\frac{3}{4}$ % of the length of the body, or from $12\frac{1}{2}$ to $18\frac{1}{3}$ % of the length of the head.

The nostrils are small, oblong, not raised, and only slightly more than twice as large as the small muciferous pores which retain their normal position in the supraorbital, suborbital, and preoperculo-mandibular branches of the cephalic system of the lateral line. The anterior nostrils are set on each side somewhat behind the middle point between the eye and the tip of the snout, the posterior somewhat higher but much nearer to the anterior nostrils than to the eye. The tip of the snout, seen from above, is parabolic, flattened, and flexible; it projects considerably, almost concealing the upper jaw (the intermaxillaries) when the mouth is closed.

The mouth is rather large, but capable of hardly any protrusion. When the jaws are opened, the upper jaw thus assumes a vertical position and bends the tip of the snout upwards. In young specimens, however, the mouth is somewhat protrusile. The intermaxillary bone is rather narrow, and extends somewhat behind the nostrils when the mouth is closed. The maxillary bone is much more robust; it articulates below the sides of the tip of the snout and, when the mouth is closed, lies hidden under a dermal fold of the cheek (the lower preorbital margin). The total length of the upper jaw, from the tip of the snout to the hind extremity of the maxillary bones, increases with age, in the specimens mentioned above — between 11 and 28 cm. long — from 6 to $6\frac{2}{3}$ % of the length of the body or from 29 to 34 % of that of the head. The lower jaw is fairly strong and much longer than the upper. In the specimens just mentioned its length measures about $\frac{1}{10}$ (10·2—9·1 %) of that of the body or about $\frac{1}{2}$ (46·8—50 %) of that of the head, and is greater than the length of the pectoral fins (113—155 % thereof). Its articulation lies vertically below the eye, and its tomial margin is deeply sinuated. The conical tip of the lower jaw, which projects beyond the upper jaw, and thus forms the tip of the head, measures as much as $\frac{1}{5}$—$\frac{1}{4}$ of the snout proper, or even a little more. The lips are well-developed. Transverse palatal folds are present both in the upper jaw and in the lower. Teeth are entirely wanting in the jaws, on the palatine bones, and on the tongue. On the head of the vomer alone we find two teeth, which are strong, set close together, and curved. The pharyngeals, which are small (3 above and 1, elongated in form, below on each side), are furnished with close-set, fine, cardiform teeth. The gill-rakers are setiform, numbering about 25 on the front surface of the first branchial arch. The tongue is of a shape not so common among fishes: it is free, broad but thin, and concave at the top, with depressed, rounded tip.

The gill-openings are large, nearly the whole of the gill-cover being free at the top, while below the opening is continued down to the articulation of the lower jaw. The branchiostegal membrane is thus completely divided, without being united to the narrow front part of the belly (the isthmus) between the gills. It is furnished with 7 rays, which are, however, difficult to count, as the outermost ray is rather short and fine, and is hidden by the extraordinarily strong muscles. The rays are covered by the margin of the fold and extend nearly to its extremity. The opercular apparatus as a whole is fairly large, but the operculum proper is the smallest part (about 1/3) thereof. The operculum is smooth, convex, triangular, and almost equilateral. The greatest part of the opercular apparatus consists of the suboperculum, which forms the whole of the inferior and posterior parts, and with its broadly rounded point projects somewhat behind and above the base of the pectoral fin. It is united to the operculum by an oblique, straight line; the lower margin forms a large, rounded sinus, to receive the base of the pectoral fin; and the surface is smooth, with 9 distinct, radiating lines on the lower part. The four branchial arches are complete, and a well-developed pseudobranchia, composed of from 12 to 14 threads, occupies the inner surface of each gill-cover.

On the body itself we observe several longitudinal lines, first the lateral line proper, which lies high on the back, the distance between it and the dorsal fin being about 1/2 of that between it and the median line. The lateral line is parallel to the dorsal fin, straight, and depressed in the rather large scales, each of which contains a branch of the muciferous canal with its opening. The line begins above the gill-cover, without its usual external continuation on the head, and ends at the termination of the dorsal fin. — Along the middle of the sides there runs a somewhat depressed median line along the middle angles formed by the aponeurotic septa of the large lateral muscles. This line is quite straight and consists of rather small dots, pricked, as it were, with a needle, and invisible without the help of an ordinary magnifying-glass. They form an irregular double (or multiplex) row, equal in width to half a scale. The line resembles a lateral line, but is less marked and destitute of muciferous ducts. — On the sides of the belly we find a still more remarkable carina or dermal fold, which begins below the base of the pectoral fin, follows a perfectly straight course, and gradually disappears half-way between the vent and the caudal fin. Its height is about equal to the greatest breadth of a scale; it is thin and soft, and does not seem to contain any muciferous canal; but, in specimens preserved in spirits at least, it lies with the free margin bent outwards, covered by the mucus of the skin, and thus appears itself to surround a canal. — On the belly, between the two lateral carinae, three fine longitudinal lines run from below the pectoral fin to the vent, the two lateral ones slightly depressed, but the middle one very fine, somewhat raised, of clear colour, and scaleless. In middle-sized specimens the anal aperture lies at the end of the third fifth of the length of the body, in the largest specimens a little farther back, its position thus growing more posterior with age. It is only slightly, if at all, prominent, hardly more so than the smaller opening for the genital organs that lies behind it.

The dorsal fin is of almost uniform height, its height in large specimens being scarcely half the depth of the body. It begins at the end of the first fourth of the body, or usually a little farther back, about as far (in young specimens somewhat less, in old somewhat more) behind the occiput as the latter from the tip of the snout. It ends some way from the caudal fin, the distance between them being about equal to the least depth of the tail, or a little greater. The rays are about 56 in number, the variations being apparently confined to 2 or 3 more or less; all the rays are fine and articulated, but perfectly simple and pointed though not pungent. The membrane is thin and fragile.

The anal fin begins just behind the genital opening and ends opposite to the termination of the dorsal fin. It is equal in height to the latter, and contains about 30 rays of the same structure as those of the dorsal fin.

The caudal fin is deeply forked; its greatest length is about equal to the depth of the body. It contains 15 true (articulated) rays. Thirteen of these are branched, though not very deeply, the outermost ray above and below being simple and only slightly shorter than the corners of the fin. Outside these rays there lie several small, unarticulated or supporting rays: in a specimen 3 dm. long SUNDEVALL counted 11 above and 9 below.

In middle-sized specimens the pectoral fins do not extend further back than to the perpendicular from the first ray of the dorsal fin. In the very largest specimens they are relatively much shorter. In the specimens mentioned above, between 11 and 28 cm. long, the length of the pectoral fins varies with increasing age between 9 and 6 1/3 % of that of the body, from 33 to 22 % of the distance between the dorsal fin and the tip of the snout, or between 81 and 56 % of the postorbital length of the head. They are also invariably shorter than the lower jaw, their length varying with increasing age in the said specimens between 88 and 64 % of that of the latter. They contain 14 rays, all articulated; the first is simple and measures only slightly more than half the length of the fin, the second is indistinctly branched at the extreme tip, the others are doubly branched, and the fifth (4—6) is the longest. — The ventral fins are wanting.

The small scales cover the entire body, but not the head. On the back and belly they are set more closely and irregularly, on the sides of the body they lie arranged in the regular, oblique, simple rows described above. These rows run from the lateral line on the back, obliquely backwards, down to the lateral ventral carinae. Their number varies considerably: in a large male SUNDEVALL found only 172; in another large specimen we found 176, in a middle-sized one 183; KROYER has found as many as 195. The usual number is probably about 180. The first ones, about 5, above the gill-cover, and the last 6 or 7, at the caudal fin, are short and incomplete. Furthermore, on the front and middle parts of the body these rows are a little way apart from each other, while on the tail they are set close together. In each row the scales are set so densely that they overlap each other to a small extent of their surface. At the middle of the body each row contains about 46 scales, 18 or 19 of which lie between the lateral line and the median line, the other 27 or 28 between the median line and the lateral carina on the belly. In the largest specimens (about 3 dm. long) 7 scales in one of these rows occupy a space 5 mm. long.

The coloration is greenish on the back and white on the rest of the body, shifting into all the colours of the rainbow; but in the living fish the whole body is somewhat transparent. All the fins are pale. A large blackish spot occurs on the sides of the snout, half-way between the tip of the snout and the eye.

No distinct external difference between the sexes has been discovered.

With regard to the internal organs we merely remark that the peritoneum is white with a silvery lustre, the stomach rather small, firm, and wide, with a long, narrow continuation in a backward direction, which when empty resembles a narrow, cylindrical appendage, but when full of food becomes rather large and extends back to the anal region. The liver is small and white, and lies in front of the stomach, round the œsophagus. The intestine is narrow, with a sharp bend. Only one short, conical appendage occurs at the pylorus. The ovaries are separate in front, but towards the vent completely united into one mass. The eggs are flame-yellow, fairly numerous, and fine: their diameter is only slightly more than $^1/_2$ mm., 7 ripe eggs occupying a space 4 mm. long.

As all the Sand-Eels, so far as is known, live in the same manner, and as the two species that occur in any abundance in Sweden, are found in company with each other, we shall shortly return to the habits and development of the Sand-Eel.

THE SMOOTH SAND-LAUNCE (SW. SLATTOBISLN[a]).

AMMODYTES CICERELUS.

Fig. 136.

Upper jaw protrusile. Pectoral fins short, as in the preceding species. Head of the vomer toothless. Dorsal and anal fins with undulating margin. No regular transverse folds across the sides of the body.

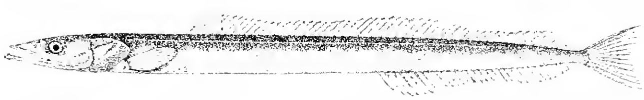

Fig. 136. *Ammodytes cicerelus*, natural size. Taken at a depth of 30 fathoms off Grip (Norway), by LILLJEBORG. Specimen in the possession of the Zoological Museum of Upsala University.

R. br. 7; *D.* 53—59; *A.* 28—30; *P.* 13—14[b]; *V.* 0; *C.* $x+1+13+1+x$; *Vert.* 68[c].

Syn. *Cicerelus Messanensis*, BOCCONE, *Rech., Observ. Nat.*, Amsterdam 1674, p. 294, fig. in tab. ad p. 287.

Ammodytes cicerelus, RAFIN., *Caratt. d. alc. n. gen.*, p. 21, tab. IX, fig. 4; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 219; DAY, *Fish. Gt. Brit., Irel.*, vol. I, p. 333, tab. XCII, fig. 3; LILLJ., *Sv., Norg. Fisk.*, vol. 2, p. 228.

[a] LILLJEBORG, l. c.

[b] According to DAY, MOREAU, and LILLJEBORG.
15 according to COSTA.
16 „ „ SWAINSON.

[c] According to COSTA.

Ammodytes tobianus, Risso, *Ichth. Nice*, p. 95; Costa, *Fn. Nap.*, *Pesci*, Gen. Ammod., pp. 1—10, tab. LI.

Ammodytes Siculus, Swainson, *Zool. Illustr.*, vol. I, tab. 63; Bonap., *Cat. Met. Pesci Eur.*, p. 40; Gthr, *Cat. Brit. Mus.*, *Fish.*, vol. IV, p. 386; Ann. Mag. Nat. Hist., ser. III, vol. XX, p. 290; Steind., Stzber. Akad. Wiss. Wien. Math. Naturw. Cl., vol. LVII, 1 (1868) p. 712, tab. II, fig. 3; Gigl., Espos. Intern. Pesca. Berl. 1880, Catal. Sez. Ital., p. 97.

The chief characteristic of this species is the weak development of the scales. Distinct scales occur only on the hind part of the tail, and the sides of the body are without the oblique, transverse, dermal folds in which the rest of the scales are hidden in the other two species. To this we may add the apparently characteristic shape of the dorsal and anal fins[a]. The former is furnished with two sinuses, one in the front part of the upper margin and one in the hind part thereof; while the anal fin contains one sinus, corresponding to the posterior one in the dorsal fin. In other respects the Smooth Sand-Launce is an intermediate form between our other two species: the pectoral fins are short as in the Sand-Eel, but the structure of the mouth and of the head of the vomer is the same as in the Sand-Launce. The back is greenish (olive) or bluish. A broad band with a strong, silvery lustre extends along the whole length of the sides. A blue spot often occurs, according to Moreau, on the top of the head. The snout is flesh-coloured, according to Costa. The iris is silvery white.

According to Günther, Moreau, and Giglioli the Smooth Sand-Launce is the only Mediterranean species of the genus. Günther states that in 1867 Gwyn-Jeffreys took a specimen 15 cm. long in a dredge, off the Shetland Islands, in 80 or 90 fathoms of water. In 1858 and with the same tackle Lilljeborg took a specimen $12^1/_2$ cm. long, on a bottom of shell sand, at a depth of about 30 fathoms, off Christiansund in Norway. The former specimen had attained the maximum size assigned to the species by Moreau.

THE SAND-LAUNCE (SW. BLÅTOBISEN).

AMMODYTES TOBIANUS.

Fig. 137.

Upper jaw protrusile: nasal processes of the intermaxillary bones long — measuring about $^2/_3$ (64—67 %) of the length of the intermaxillary bones — and mobile, with a gliding motion, in the groove in the upper surface of the ethmoid bone. Pectoral fins comparatively long, their tip extending distinctly behind the perpendicular from the beginning of the dorsal fin, and their length being greater than that of the lower jaw, more than 46 % (47—60 %) of that of the head, and at least 37 % (37—43 %) of the distance between the dorsal fin and the tip of the snout. Head of the vomer toothless. Dorsal and anal fins of uniform height.

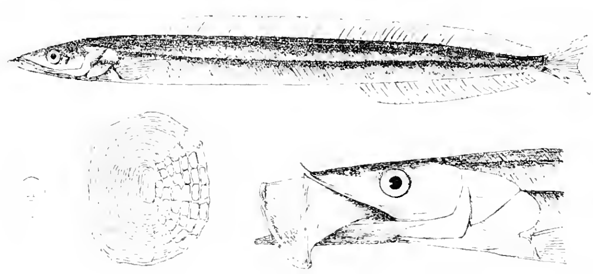

Fig. 137. *Ammodytes tobianus*, with the body in transverse section, a scale, and a head with opened mouth. After Benecke.

R. br. 7; *D.* (51) 55—62 (64); *A.* (26) 29—33; *P.* 12—15; *V.* 0; *C.* $x+1+13+1+x$; *L. lat.* 120—145; *Vert.* 62—63.

Syn. *Enchelyopus No. 6*, Klein, l. c., p. 55, tab. XII, fig. 8 et 9; *Ammodytes*, Art., l. c.; *The Launce*, Penn., *Brit. Zool.* (London, Warrington, 1776) vol. III, p. 137.

Ammodytes tobianus, Lesauv., l. c.; Gthr, l. c., p. 385; Steind., l. c.; Coll., Forh. Vid. Selsk. Christ. 1874, Tillægsh., p. 126; Malm, *Gbgs. Boh. Fn.*, p. 500; Winther, l. c.; Bncke, l. c., p. 100; Mor., l. c., p. 218; Day, l. c., p. 331, tab. XCII, fig. 2. Mob., Hcke, l. c., p. 86.

[a] This character is not noticed by Costa, either in his description or figure.

Ammodytes lancea, Cuv., *Regne Anim.*, ed. 2, tom. II, p. 360; Nilss., *Prodr. Ichthyol. Scand.*, p. 63; Kr., l. c., p. 593; Nilss., *Skand. Fn., Fisk.*, p. 656; Malmgr., l. c.; Lindstr., Gotl. L. Hush. Sällsk. Arsber. 1866, p. 24 (sep.); Mela, *Vert. Fenn.*, p. 296, tab. IX; Lillj., l. c., p. 221.

The Sand-Launce never attains so great a size as the maximum size of the Sand-Eel. Kroyer's largest specimen was 187 mm. long; a specimen from Greenland, brought home by O. Torell, measures 204 mm. from the tip of the lower jaw to the end of the longest rays of the caudal fin, or 197 mm. from the tip of the snout to the end of the middle rays of the same fin.

The body is generally somewhat deeper and more compressed than that of the Sand-Eel, though no constant character can be drawn from this relation. The greatest depth of the body, across the belly, varies in ordinary cases between about 9 and $10\frac{1}{2}$ % of the length from the tip of the lower jaw to the end of the outer rays of the caudal fin, and the greatest breadth between about 66 and 75 % of the greatest depth. We have found the depth at the beginning of the anal fin to vary between $6\frac{1}{5}$ and $9\frac{1}{5}$ %[a] of the length of the body from the tip of the snout to the end of the middle caudal rays; and, in the same specimens, the greatest breadth varied between 4 and $7\frac{1}{3}$ %[b] of the same length.

In specimens of equal size the head is of essentially the same shape as in the Sand-Eel; but as a rule it is shorter. In specimens between 95 and 197 mm. long we have found its length to vary between 19 and $17\frac{3}{4}$ % of that of the body. The longitudinal diameter of the eye varied in these specimens between 20 and 13 % of the length of the head. The length of the snout varied between 64 and 56 % of the postorbital length of the head or between 33 and 30 % of the total length thereof. The least breadth of the interorbital space varied between $2\frac{1}{3}$ and $3\frac{2}{5}$ % of the length of the body or between $12\frac{1}{2}$ and $19\frac{1}{2}$ % of the length of the head.

In the nostrils we find scarcely any difference from those of the Sand-Eel; but the structure of the mouth, as we have remarked above, affords one of the most important characters for the Sand-Launce and the forms akin to it in this respect. The mobility of the intermaxillary bones is produced in the same manner as in the case of most other fishes, and in striking contrast to the Sand-Eel. The difference lies partly in the long nasal processes, which glide forward and backward in a groove in the upper surface of the ethmoid bone, partly in the greater length of the muscular band that extends under each of these processes, starting from the inner (posterior) surface of the front of the intermaxillary bone and from its articular process (cf. the explanation of fig. 118, p. 463, above), and attached to the inward vomeral process of the maxillary bone, which process is closely united by ligaments to the anterior end of the vomer. These two muscular bands serve to draw back the intermaxillary bones. The protrusion of the intermaxillary bones is effected by their union to the lower jaw by skin, muscles, and ligaments, and they thus follow the lower jaw when it is depressed. The anterior end of the maxillary bones is rendered independent of this downward motion by the union of the vomeral processes to the vomer; and on casual examination these processes, with their sharp, transverse, osseous points, present a confusing resemblance to the teeth on the head of the vomer in the Sand-Eel—they have several times been confounded with those teeth. The length of the upper jaw shows even relative increase with age from the earliest stages until the fish is of middle size, but it subsequently seems to be retrogressive, unless our observations are based on individual variations. In a specimen 30 mm. long we find this length to be $22\frac{2}{3}$ % of that of the head, and in larger specimens, up to a length of about 13 cm., this percentage increases to about 33; but in our largest specimen the proportion is no more than $28\frac{1}{2}$ %. The lower jaw is usually shorter than in the Sand-Eel, its length being about 8 % (between 8·6 — exceptionally 9·3 — and 7·6 %) of that of the body, or about 45 % (between 47·8 — in our smallest specimen 49 — and 42·8 %) of the length of the head, and never so much as 15 % (14·2—12·2 %)[c] of the length of the base of the dorsal fin. The conical tip in which the lower jaw projects beyond the tip of the snout, is also generally less than in the Sand-Eel, and seems at most not to exceed $\frac{1}{4}$ of the length of the snout proper. The gill-rakers are setiform in this species too, and number 22 or 23 on the first branchial arch. The lips, tongue, palatal folds, pharyngeal bones, and gill-covers resemble those of the Sand-Eel, but the operculum is more scalene, with the lower side (along the suboperculum) perceptibly greater than the upper. The

[a] In the Sand-Eel between $6\frac{2}{3}$ and 8 %.
[b] „ „ „ „ $5\frac{2}{3}$ „ $6\frac{2}{3}$ %.
[c] „ „ „ from 16·3 % to 15·3 %.

lateral line contains about 125 scales; and the oblique dermal folds on the sides of the body number about 130, being thus fewer than in the Sand-Eel. It is also easy to see, on comparing specimens of equal size, that the scales of the Sand-Launce are larger. The anal aperture lies nearer the middle of the body, the distance between it and the tip of the lower jaw measuring, according to KRÖYER, about 53—56 % of the length of the body to the end of the outermost caudal rays. We have found the distance between it and the tip of the snout, in specimens from 97 to 130 mm. long, to rise from $56^{3}/_{4}$ to $58^{1}/_{2}$ % of the length of the body to the end of the middle caudal rays[a].

The dorsal fin generally begins somewhat further forward than in the Sand-Eel, usually in front of the end of the first fourth of the length of the body, but sometimes behind it. On the other hand, its extent is apparently always somewhat greater, sometimes as much as $^{2}/_{3}$ of the length of the body. Consequently, the distance between it and the tip of the snout, according to our measurements, never exceeds 40 % of the length of its base[b]. As a rule too, its length increases even relatively with age, the length of the head in specimens about 9 cm. long measuring 28·7 % of the length of the base of the dorsal fin, in specimens between 13 and 20 cm. long only 26·7 % thereof[c]. The anal fin generally begins somewhat further forward and in most cases is of somewhat greater extent than in the Sand-Eel; but in both species the length of its base varies between 48 and 43 % (in the Sand-Launce exceptionally 41·3 %). In the caudal fin we find no characteristic peculiarity worthy of mention, the least depth of the tail in this species, too, being generally somewhat more[d] than half the length of the middle rays of the caudal fin.

In the Sand-Launce the pectoral fins always extend distinctly (for $^{1}/_{4}$—$^{1}/_{3}$ of their own length) behind the perpendicular from the beginning of the dorsal fin. Their length is at least somewhat more than 9 % (according to our measurements 9·1—10·3 %) of that of the body, than 37 % (43—37·2 %) of the distance between the dorsal fin and the tip of the snout, or than 90 % (113·6—90·1 %) of the postorbital length of the head. They are also always longer than the lower jaw, the length of which we have found to vary between 80 and 95 % of that of these fins.

The coloration is the same as that of the Sand-Eel, but is often more bluish, olive-green with steel-blue lustre, on the back. The young specimens in particular are finely punctated with round, dark brown spots, one row above the lateral line, one row below it, and a third row along the base of the dorsal fin composed of somewhat larger pigmental spots. This marking is, however, by no means peculiar to the Sand-Launce. The upper part of the silvery white iris is in most cases more shaded with black than is usually the case in the Sand-Eel, where the whole iris is generally silvery. In this species too, the lower part of the sides has a silvery lustre, but the belly is of a duller white. The youngest specimens have a row of dark brown, pigmental spots along each side of the base of the anal fin. The snout is without the black spot on the sides, or possesses merely a trace of this spot in the form of scattered pigmental spots, larger and denser than on the rest of the snout. The tip of the lower jaw is also destitute of the black colour which we find there in most Sand-Eels, at least in old specimens. The caudal fin is darkened at the base above and below by brown pigment between the rays. The peritoneum is silvery white as in the Sand-Eel, but more densely punctated with small, round dots of black pigment, sometimes so dense that the preponderating colour of the membrane becomes coal-black.

In order to ascertain the natural relations between these three species of European Sand-Eels, we shall now notice some points in the manner in which the most significant characteristics appear in these species. In general *Ammodytes lanceolatus* has a longer head, measuring more than $^{1}/_{5}$ of the length of the body; but

[a] In specimens of the Sand-Eel between 135 and 289 mm. long, this proportion rises from 59·2 to 60·2 %, the increase thus seeming to advance with fair regularity.

[b] From 40 to 36 % in the Sand-Launce; from 45 to 44 % in the Sand-Eel.

[c] In Sand-Eels between 11 and 29 cm. long this proportion sinks from 33 to 30·6 %. In a Sand-Launce 56 mm. long, however, the percentage was 32·1.

[d] Sometimes perceptibly less, however, according to KRÖYER.

this relative length decreases with increasing age, and in this respect *Am. lanceolatus* thus retains a juvenile character. Nor can the character be employed as a specific distinction, for in a young specimen of the Sand-Launce 56 mm. long, taken by Fries in Bohuslän, the length of the head is nearly 24 % of that of the body. In the same specimen the length of the lower jaw is 9·3 % of that of the body, while in other cases the boundary between the species in this respect lies at 9 %. The length of the pectoral fins, where the line of distinction is the same, but the direction of distinction reversed — the percentage less in *Am. lanceolatus* than in *Am. tobianus* — in a specimen of *Am. tobianus* 20 cm. long is only 9·1 % of the length of the body, and in a specimen of *Am. lanceolatus* 14 cm. long 9 % of the same length. In this respect, too, the percentages decrease with increasing age, and in this respect *Am. tobianus* thus retains a juvenile character. In his description of *Ammodytes americanus*[a] Storer says the dorsal fin begins just at the end of the pectoral fin, and that the length of the latter fin is only 1/3 of that of the head. It was by this statement that I was induced to refer the Sand-Eels brought home by the Vega Expedition from Pitlekaj, north-west of Behring Strait, to *Am. lancea, var. americana*[b], for in a specimen 77 mm. long the beginning of the dorsal fin lay at a distance from the tip of the snout measuring 29·3 % of the length of the body, and extremely little in front of the tip of the pectoral fin, though this fin measured 14 % of the length of the body. Later investigations, however, especially those of Jordan and Gilbert, show that Storer's description and figure must have been based on some exceptional specimen, for, unless this were so, such a character could not have escaped observation. Still, this shows that even the characters most important in a systematic respect are subject to variation. According to Storer *Am. americanus* may also attain a size of 3 dm., though from a specimen which the Royal Museum has received through the Smithsonian Institution from Woods Hole (Mass.), it appears to be quite identical with *Am. tobianus*. The other two American species that have been ranged beside Dekay's *Ammodytes americanus*[c], but which are regarded by Jordan and Gilbert merely as varieties of this species, show among their characters a variation of the transverse dermal folds on the sides of the body between 130 and 182, thus filling the gap between the normal numbers in *Am. tobianus* and *Am. lanceolatus*, and showing how the form-differentiation may bring about a resemblance to *Am. lanceolatus*, without alteration in the structure of the mouth and without the development of teeth on the head of the vomer. The development of the said dermal folds, the absence of which is one of the most important characters of *Am. cicerelus*, in *Am. tobianus* is a character of growth extremely irregular in its appearance. Even in specimens 7 cm. long it is sometimes impossible to discover them. Of the other character which should serve to distinguish *Am. cicerelus*, the undulating margins of the dorsal and anal fins, I have found at least a trace in a slight concavity of the margin of the anal fin in a young Sand-Launce. All this goes to show, not only that all the species are extremely closely related — so closely that we may well be tempted to regard them merely as varieties of the same species, or as species at the beginning of their differentiation from each other — but also that this relationship has its origin in a form essentially resembling *Am. tobianus*, or perhaps in this very species.

At least one of the species described above, the Sand-Launce, must be regarded as circumpolar. The Royal Museum possesses examples of this species from Norwegian Finmark, the Murman Coast, the White Sea, North-East Siberia, Greenland, and Iceland. In Spitzbergen, however, it is unknown. According to Machado (quoted by Steindachner) the range of this species extends southward to Cadiz. Day assumes that it may occasionally wander into the Mediterranean; but he gives no observation of its occurrence there. In the Baltic the Sand-Launce penetrates at least to the island-belt of Stockholm and, according to Mela, to the islands round Åland and Åbo and into the Gulf of Finland up to the island of Hogland. In the first locality Sundevall could not find it; but during the investigations which I caused to be made this summer (August, 1890)

[a] Mem. Amer. Acad. Arts, Sc., n. ser., vol. VIII, p. 411, pl. XXXIII, fig. 2.

[b] Gt. Intern. Fisher. Exhib. London 1883. Swed. Spec. Catal., p. 176.

[c] Girard's *Ammodytes personatus* and Cope's *Am. alascanus*.

by Mr. A. SVENSSON, with a Sand-Eel net from Halland, a quantity (several hundreds, if not thousands) of Sand-Launces about 7 cm. long were taken and observed at Rönnklippa off Runmarö. LINDSTRÖM found the species off Gothland. In the north and east of the Baltic, however, it is considered at least rarer than the Sand-Eel, the range of which extends, according to MELA, in the Gulf of Bothnia to the neighbourhood of Björneborg and in the Gulf of Finland to Cronstadt. In the Atlantic, on the other hand, the Sand-Eel does not go so far north, for it is unknown, according to COLLETT, north of Trondhjem Fjord. On the English coast it is common at certain spots, though here and still more in the Channel on the coast of France the Sand-Launce is the commoner species. BONAPARTE includes the Sand-Eel among the fishes of Italy, and according to DAY it occurs, though extremely rarely, in the Mediterranean; but neither STEINDACHNER, MOREAU, nor GIGLIOLI assigns it to this locality.

These two species, the most common Scandinavian forms of the genus, seem to have exactly the same habits, and in most places are found together. In general the smaller species, the Sand-Launce, seems to be the more plentiful. This is evidently the case in Scania, where SUNDEVALL found the Sand-Eel to form hardly a tenth of the catch. Off the Danish islands KROYER considered the two species to be more evenly distributed, but on the coast of Jutland the Sand-Launce was said to be the more common. In the Great Belt and Samsœ Belt WINTHER found the catch to consist almost entirely of Sand-Eels. Among some hundred Sand-Launces forwarded to the Royal Museum from Halmstad in the month of August, there was only one specimen of the Sand-Eel. On the coast of Bohuslän, too, according to MALM, the Sand-Eel is rarer than the Sand-Launce, which at suitable spots is common.

The Sand-Eel[a] generally haunts a sandy bottom, in which it can bury itself. It works itself with wonderful skill and rapidity into the sand, where it seems to lie hid, at a depth of $1^1/_2$ dm. or more, the greater part of the day, coming up only at intervals. In winter it lives in deeper water; but in spring, when the water begins to grow somewhat warmer, both species ascend together to sandy, shelving spots along the shore and stay there all the summer. In Scania this takes place at the end of May, and the fishery begins immediately afterwards. During the course of October they again return to deep water.

The most productive Sand-Eel fishery in the whole of Sweden is carried on in the little inlet just north of Simrishamn. So much fish is taken here, according to NILSSON, that the Rector of Gladsax receives as his tithe of the fishery 6 barrels (989 litres) of dried Sand-Eels. The town probably owes its origin to this fishery. During the whole summer and until October the fishery is pursued there daily, when not interrupted by storms, with fine-meshed seines, which are shot at a depth of 3 fathoms and hauled up on shore. The fishing begins soon after noon and continues until nearly sunset. Sand-Eels are also especially plentiful at the following places: south of Åhus, at the fishing-villages of Vik and Baskemölla (north of Simrishamn) — where in 1880, according to Mr. LUNDBERG, Inspector of Fisheries, the catch was about 50 hectolitres, of a value of 302 crowns (£16 10s.) — at Käseberga (between Simrishamn and Ystad), off Ystad, just east of the town and down to the mouth of Köpinge River, and at the fishing-village of Abekas (west of Ystad). At these spots some quantity sometimes comes into the market, but in the rest of Scania, as well as in Halland, Sand-Eels seem to be used almost exclusively as bait for Cod. At the south-west corner of Scania (Trelleborg, Skanör) these fishes are quite unknown to the fishermen, according to SUNDEVALL; and in the Sound according to SCHAGERSTRÖM, both species are rare, though large quantities were taken at the fishing-village of Råå in September, 1837. Further up the Baltic, as even LINNÆUS tells us, some Sand-Eels are caught off Ottenby, on the south point of Öland, and used as bait for Cod. This fishery is carried on with seines the cod-end (sac) of which is composed of a sheet which is turned towards the sun and thus attracts the Sand-Eels by its brightness. A similar seine is used in Halland. — At Simrishamn, it is said, the fishery is carried on in the afternoon. At Åhus and Ystad the fishermen are out both in the morning and in the evening, and in dull weather in the middle of the day as well. It is only at these times that the Sand-Eels move about in the water. In the island-belt of Stockholm, in summer, SUNDEVALL pretty often met with small Sand-Eels, between $^3/_4$ and 1 dm. long, swimming about freely here and there among the islands where there was no sand at the bottom, and also

[a] From this point to the end of the description Sand-Eel is used as a general term for both species, except where otherwise stated. TR.

out in deep water, but not far (5—14 metres) from the surface, at the spots where Herring-fry were abundant. As he did not see any large specimens at the same time, he concluded that the young Sand-Eels lead a roving life, while the older ones seem to be more tied to one spot.

On the shores of Norway the Sand-Eels are not rare and are known by the name of *Sil*. When the bottom is left dry by the ebb-tide, they bury themselves there, and move about at high water. But they also occur far out at sea in water of considerable depth, where during summer they are caught in large numbers by several seabirds (*Mormon arcticus*, *Uria troile*). This can, of course, happen only when the fish is swimming about. — During winter, when the Sand-Eel keeps to deep water, we may in all probability assume that like most other fishes at this season, it leads a still more quiet life than in summer. At this season, too, it probably haunts a sandy bottom and lies buried in the sand. Professor F. W. ARESCHOUG informed SUNDEVALL that one winter a fisherman who was dragging to find some Cod-lines that had been lost, took up a Sand-Eel King (a large *Ammodytes lanceolatus*) on a sandy bottom at a great depth. It appears, however, that even at this season the Sand-Eel occasionally moves about, from the fact that during winter it is often found in Cod caught in deep water.

The food of the Sand-Eel is composed of all kinds of small marine animals, especially worms, which it is believed by some to search for in the sand. It is not for this purpose, however, that it burrows in the ground. It is impossible for a fish buried in this manner to seek or seize any prey. The Sand-Eel lies in the sand to rest and to avoid its many different enemies: Porpoises — which have been observed even to root up the bottom to find their victims — Mackerel, Cod-fishes — especially the Pollack, which has been seen in shoals chasing the Sand-Eels up towards the surface to seize them from below and devour them — Garpike, and other fishes-of-prey, as well as seafowl. The principal food of the Sand-Eel consists, however, of small fishes, belonging even to its own genus. We have already mentioned that the fry swim about where young Herrings are plentiful. The middle-sized Sand-Eels devour their smaller congeners and other fry; while the largest Sand-Eels seem to live almost exclusively on the middle-sized ones.

The spawning-season of the smaller species, the Sand-Launce, occurs in August. SUNDEVALL was informed, however, by Mr. HALCK of Simrishamn, that in 1856 the spawning of the Sand-Launce lasted at least until the 15th of September. Still the spent fish remain in the shallows together with the others. At many spots in England and Ireland[a] the Sand-Launce is caught between the tide-marks even in winter, though then, after the spawning-season, it is "so thin as not to be sought after generally for food". It is a remarkable circumstance that the spawning does not begin until the fish has been three months at the spawning-place. — Less is known of the spawning-season of the larger species, the Sand-Eel. NILSSON received information from Ystad to the effect that the Sand-Eel spawns there in April; but it is hardly probable that the species ascends to the shallows so early. On the 12th of October, 1892, our Museum received through Mr. C. A. LINDROTH a newly caught Sand-Eel 25 cm. long, with the testes just beginning to swell, from Stenvik (Ljusterön) in the island-belt of Stockholm. MALM gives an observation of a female 28 cm. long, that had fully developed roe on the 5th of June; but he does not state whether the roe was quite ready to be deposited. At St. Ives DAY found the generative organs of the Sand-Eel and the Sand-Launce to be equally developed in August. In Scandinavia both species ascend into shallow water at the same time, in the month of May, and it seems most probable that they also spawn at about the same time, the larger perhaps, as is common among fishes (in the Herring, for example), before the smaller.

Of the growth of the fry SUNDEVALL remarks that the young specimens, 75 or at most 100 mm. long, which in summer (from July to September, or perhaps still longer) rove far and wide in search of prey, probably belong to the fry of the previous year, and that the ordinary specimens 125 mm. or more in length seem to be a year older. At the end of July, 1880, off Grötö among the Lofoden Islands, COLLETT also distinguished between three different generations of the Sand-Launce, 75, 125, and 170 mm. long and, in his opinion, respectively 2, 3, and 4 years old[b]. Whether

[a] See for example THOMPSON, *Nat. Hist. Irel.*, vol. IV, p. 238.

[b] We arrived at quite different results in a consignment of Sand-Launces from Söndrum, off Halmstad, taken at the beginning of August. Among these specimens a few measured between 50 and 55 mm. in length, while the others, we may almost say, were of all possible sizes between 95 and 125 mm.

the Sand-Eel (*Am. lanceolatus*) has reached maturity at the size last mentioned, is as yet an open question. It grows, as we have mentioned above, to a length of 30 cm. or more; and both males and females attain this size. These largest specimens of the Sand-Eel are known in Scania by the name of *Kungar* (Kings). At Ahus they are also called *Gröningar* (Greenfish), a name which is sometimes applied to all specimens of this species. Some fishermen know that there are two kinds of Sand-Eels, and that the Kings belong only to one of them. NILSSON has adopted the names of *hvit-tobis* (White Sand-Eel) and *blatobis* (Blue Sand-Eel) from Blekinge.

The Kings are rare, probably from a cause easy of comprehension. It is no doubt difficult for many specimens to escape for some years the tackle constantly set for them, especially the seine. They are, therefore, most numerous in proportion to the entire catch at spots where the two species are not plentiful enough to make the use of the seine remunerative. That some few of them do escape, in spite of all, seems probably to depend on the fact that the older specimens bury themselves in the sand and lead a much more sluggish life than the young ones, being thus much less exposed to the risk of being caught. They are said to be taken only towards evening. The fishery for Sand-Eels is indeed remarkable, for it shows the extraordinary hardiness of these species. Off Simrishamn Sand-Eels are still taken in quantities only slightly, if at all, less than in former times, although a war of extermination has been pursued against them yearly for several centuries. This war has been carried on with fine-meshed seines long before, during, and after the spawning-season; and would thus seem to have been enough entirely to extirpate the species in a few years. But it is just this hardiness that renders the history of the species so much more deserving of careful study. The fine and extremely numerous eggs, and perhaps the roving life of the young specimens, may perhaps compensate to some extent the numbers destroyed, if only a few large females be yearly permitted to deposit their roe. Still it is not unusual to hear the fisherman complain of the decline of this fishery. Thus we learn now (1890) from Söndrum (off Halmstad) that "the Sand-Eel has become rarer in this neighbourhood than it used to be. Formerly it was sold and eaten in quantities. Now the supply is scarcely enough for bait."

The Sand-Eel is eaten fresh, boiled, or fried, and is regarded by many as a delicacy. Others assert that it is too lean, and others again find the smell of the flesh repulsive. At Simrishamn a great portion of the catch is dried and preserved for winter use. There is no distinguishable difference in flavour between the two species. These fishes are, however, very important to man in another respect as well. The large shoals in which they live, entice larger and more valuable fishes to the fishing-grounds. Mr. LUNDBERG[a], Inspector of Fisheries, remarks that the Sand-Eel is important as food for the Salmon, which at shelving spots along the Scanian coast comes close in shore chiefly to hunt Sand-Eels, and which during certain years thus becomes the object of a highly lucrative seine-fishery. The Sand-Eel is also considered excellent bait for Cod and other large fishes-of-prey, and is used for this purpose wherever it can be procured.

We have already described the seines used for Sand-Eels. In tidal waters, as for instance on the coasts of the North Sea, in England, Ireland, and France, persons may be seen, when the tide is out, scratching up Sand-Eels with spades and other implements adapted to this purpose. Similar implements are used in Sweden to secure the Sand-Eels that have buried themselves in the sand after they have been drawn ashore.

(SUNDEVALL, SMITT.)

[a] LUNDBERG, Meddelanden rörande Sveriges fiskerier, häft. 2, p. 151.

Fam. MACRURIDÆ.

Body clavate (more or less tadpole-like), with more or less straight back and concave (arcuate) caudo-ventral margin, compressed, with elongated, more or less whip-like tail; covered with thin but spiny, carinated or striated scales. No distinct caudal fin (the vertical fins confluent behind), but a distinct anterior dorsal fin or at least a trace thereof in the elongation of the first dorsal rays. Teeth on the intermaxillary bones and in the lower jaw, but the vomer, palatine bones, and tongue toothless; mouth highly protrusile. Gill-openings large; branchiostegal membranes more or less united to each other, but free from the isthmus. Branchiostegal rays 6 or 7. Pseudobranchiæ wanting. Air-bladder present. Pyloric appendages well-developed.

Here we have a family consisting almost exclusively of deep-sea fishes[a]; and besides the characters given above we observe in the first place those peculiarities which generally belong to such fishes, especially in the loose structure of the head, with its ample space for muciferous canals. Two in particular of the cephalic bones, the nasal bones, are greatly enlarged, and form the framework of the highly variable form of the snout in the *Grenadiers*, as these fishes are called in Italy[b]. The suborbital bones, which form the lower margin of the orbit, also afford an instance of a systematic peculiarity rare among the *Anacanthini*. They sometimes develop a connexion with the opercular apparatus similar to that we have seen above in the *Cottomorphi* and *Cyclopteridæ*. Another systematic exception might also be used as an argument in favour of the inclusion of these fishes among the Acanthopterygians. The first large ray in the anterior dorsal fin (really the second ray in the fin, the first ray being extremely short and rudimentary) is a true spinous ray, without joints. These two points of resemblance to the Acanthopterygians might well induce us to range the family *Macruridæ* beside the Gurnards and the *Agonidæ*, according to SWAINSON'S[c] proposal. However, if we trace the form-series back to the least differentiated Grenadier types[d], we find in the form of the head the most distinct approximation to the *Phycis* group, within which the relationship to the Grenadier-fishes is also expressed in the form of the snout in the American *Haloporphyrus* (*Antimora*) *viola*[e]. In the cranium, too, we find an evident sign of the relationship to the Codfishes in the advanced development of the styloid bone (*os opisthoticum*), and the lobate process erected in an upward and backward direction on the hind part of the intermaxillary bones is also as well-developed as in most of the Codfishes. Thus, the most natural place of the Grenadier-fishes in the system is beside the Codfishes, as a remarkable variation of the Anacanthine type, with a characteristic common among deep-sea fishes in the reversion to or retention of the original form of the tail without separate caudal fin[f]. The primitive (palæichthyic) appearance of the Grenadier-fishes also depends on the covering of scales. In one species we find the scales replaced by projecting spines scattered in the skin. Only in few species and in the fry of other species do we meet with thin, fully typical cycloid scales. In the rest of the family the scales are generally furnished throughout their free surface with spines or raised carinæ, which give the fish a Ganoid appearance. BONAPARTE, therefore, referred the Grenadier-fishes to the order *Ganoidei*, when in 1837 he established a special family[g], *Macrouridæ*, for these forms.

A juvenile form, *Krohnius*, is described by COCCO[h] and EMERY[i] as reminding us, by the long rays of the ventral fins and the position of the first dorsal fin far forward on the head, of the larvae of the *Trachypteroids*, but as most closely resembling, in the form of the

[a] One species (*Macruronus novæ-zelandiæ*) is said to live in shallower water.

[b] See RISSO, *Ichthyologie de Nice*, p. 201, where the name is supposed to have originated from the resemblance between a soldier's helmet and the snout of *Macrurus cœlorhynchus*. The same name occurs in CUVIER (*Règne Animal*, tome II, ed. 1, p. 217; ed. 2, p. 336) and in BROWN-GOODE (*Fisher., Fish. Industr. U. S.*, Sect. I, p. 244).

[c] *Nat. Hist. Fish., Amph., Rept.*, vol. II, pp. 179 and 261.

[d] See for example *Macrurus* (*Nematonurus*) *longifilis*, GÜNTHER, *Deep Sea Fishes*, Chall. Exped., p. 151, pl. XXXV.

[e] BROWN-GOODE, *The Fisheries and Fishery Industries of the United States*, Sect. I, pl. 64; GÜNTHER, l. c., p. 94, pl. XV.

[f] A separate caudal fin may, however, appear to be present. This is due to cicatrization following upon the breaking off of the tail in an adult Grenadier-fish. Cf. NILSSON, *Skand. Fauna, Fiskarne*, p. 606.

[g] Trans. Linn. Soc. London, vol. XVIII (1838—1841), p. 295.

[h] Giorn. Gabin. Letter. Messina, anno III, tomo V, fasc. XXV (1844), p. 21 reprinted in Il Naturalista Siciliano, anno VII, No. 4, 1:o Gennajo 1888, p. 101.

[i] Mem. d. R. Acad. d. Lincei, ser. 3, vol. III, p. 395, figs. 7 and 8.

body, GÜNTHER'S *Macrurus crassiceps*[a] from the deep-sea fauna of Australia.

In 1884 Professor LECHE took a specimen of a *Krohnius*-form at the surface off Messina. This specimen (fig. 138) has advanced so far in development that we need not hesitate in referring it at least to the genus *Macrurus*. Including the very fine tip of the tail the specimen measures 92 mm., the forepart of the body being 12 mm. long, 9 mm. deep, 6 mm. broad, clumsy, and almost spherical, while behind this point the strongly compressed tail begins with a depth of $4\frac{1}{2}$ mm. and very gradually tapers to a filamentous, narrow but compressed, and membranous appendage. This appendage, which is $18\frac{1}{2}$ mm. long, forms a slight break at its insertion in the tip of the tail and advances straight back, marked with dark reddish brown spots of pigment, small, but dense, and set in two rows at the base of the appendage, in one row, more scattered, and larger (finally occupying the entire breadth of the appendage) towards its tip, which is, however, colourless. The head does not measure even half of the bulky forepart, though its length, measured as usual from the tip of the snout to the hind margin of the gill-cover (obliquely against the longitudinal axis of the body), is $6\frac{2}{3}$ mm. From the same cause the length of the snout becomes fairly great, measuring $1\frac{1}{5}$ mm., although the round eyes, with a longitudinal diameter of 2 mm., and set at a distance of about 2 mm. from each other, evidently lie far forward. The postorbital part occupies about half the length of the head, or $3\frac{1}{5}$

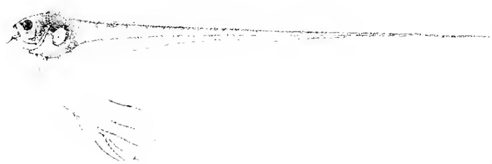

Fig. 138. *Krohnius filamentosus*, natural size. From Messina, Feb., 1884, V. LECHE. Original in the possession of the High School of Stockholm.

mm. The mouth is both terminal and lateral, with sharply ascending cleft. The maxillary bones end almost below the middle of the eyes. Below the chin there hangs a barbel about equal in length to the diameter of the eye. The nostrils are set on each side at the upper anterior corner of the eye, in a common opening, divided into two parts by a thin partition-wall. The first dorsal fin begins at a distance of 7 mm. from the tip of the snout, or a little behind the head. It is high — the longest ray measuring about $7\frac{1}{2}$ mm. — and pointed, almost falciform; but the anterior rays (except the first, which is rudimentary) are elongated into filaments. The fin contains one rudimentary ray and nine perfect, but simple rays. The length of its base is $2\frac{1}{2}$ mm., or somewhat more than the longitudinal diameter of the eyes. Behind this fin the dorsal edge still retains a low dermal flap, a remnant of the embryonic vertical fin, and distinguishable not quite to the end of the bulky forepart. At this point the flap disappears, but soon returns again, though at first scarcely distinguishable, at about the end of the swollen forepart of the body, now with true rays and in the form of a second dorsal fin, which is remarkably low and follows the dorsal edge back to the base of the caudal filament. The anal fin begins at a distance of $11\frac{1}{5}$ mm. from the tip of the snout, on the posterior part of that which we have termed the swollen forepart of the body. Its base thus follows the ventral margin backwards and upwards, then passing in a rounded obtuse angle to the ventral margin of the caudal part, and following the latter to its termination. The rays of the anal fin, which, like those of the dorsal fins, are all simple, first increase in length uniformly but sharply, the length of the rays at the beginning of the tail being about equal to the depth of the latter. Thus the margin of the anal fin is fairly straight, in spite of the sinus in the margin of the body at this spot. From this point the rays gradually decrease in length, until at the beginning of the posterior half of the tail their length increases somewhat, the height of the anal fin being here greater than the depth of the tail; but towards the tip of the tail the length of the rays again decreases. At the base of each ray of the anal fin we find a dark-brown, pigmental spot. The pectoral fins are perhaps the most characteristic peculiarities of this larva. They are almost semicircular disks, for the greater part free, attached to the shoulder-girdle only at the top by a narrow shaft, which is inserted on about a level with the middle of the eye. The outer part of these disks is extremely thin and membranous, but with rudiments of the future pectoral rays; the inner part is somewhat thicker, in the specimen preserved in spirits opaque, and is of an almost regular, but flattened kidney-shape, the upper corner of which, situated about one-third of the way up the pectoral fins, forms the point of origin for the said shaft. If we compare this form of the pectoral fins with their arrangement in certain Codfishes, where the internal structure is known[b], it appears extremely probable that the shaft corresponds to the rudiments of the proximal parts of the shoulder-blade and the coracoid bone, while the distal parts of these bones and the basal bones of the pectoral rays are developed in the kidney-shaped part of the base of the pectoral disk. Shafted (lobate) pectoral fins are indeed by no means rare in the fry of other species[c]; but a shaft so long and so narrow as in this larva — reminding us of the elongation of the basal bones in *Lophius* — is unparalleled within our experience. The ventral fins are set vertically below the insertion of the pectoral fins, somewhat in front of the middle point between the tip of the snout and the anal fin — the foremost point of their insertion lies at a distance of 6 mm. from the beginning of the anal fin — and are remarkable for the great elongation of the six middle rays. The first ray is not short, its length being very nearly as great as that of the head; but the next 6 rays attain a length of as much as 30 mm., are pigmented in the outer part in the same way as the caudal filament, and are also flattened throughout their length like this filament. The innermost two rays are short, the innermost ray the shortest of all. The anal aperture lies about half-way between the insertions of the ventral fins and the beginning of the anal fin; it has a pointed anal papilla behind it. Half-way between the ventral fins and the isthmus we find a round depression in the ventral wall, coasted in front by a semicircular, membranous, dermal swelling, the two ends of which are continued each by a dermal ridge which disappears behind. This structure evidently bears the appearance of having served as an adhesive apparatus by means of which the larva has been enabled to attach itself to floating objects, and is probably of importance as an explanation of the bare (scaleless) spot which in adult examples of some species of the genus occurs on this part of the body. On the upper portion of the abdominal sides the scales have apparently begun to develop; but the rest of the body is naked.

It is difficult as yet with certainty to determine the species of this larva. Among the four Mediterranean species of the genus given by GIGLIOLI[d], it can hardly be referred to any other than *Macrurus lævis*. This opinion is borne out both by the number of rays in the

[a] *Deep Sea Fish., Chall. Exp.*, p. 143, pl. XXXVII.

[b] See for example EMERY, *Fierasfer* in Fauna und Flora des Golfes von Neapel, II Monogr., p. 29, taf. IV, fig. 40.

[c] Cf. above, fig. 77, p. 311.

[d] Espos. Intern. di Pesca. Berlino 1880, Sez. Ital. Cat., p. 98.

first dorsal (10) and the ventral fins (9) and by the form of the adhesive ventral disk. The specimen would thus seem to belong to a species that also occurs within the limits of the Scandinavian fauna. But GÜNTHER[a] has described a Mediterranean fish that in another publication by GIGLIOLI[b] had been named *Macrurus (Hymenocephalus, Mystaconurus) italicus*, and to this species, which is distinguished from *Macrurus lævis* by small, villiform teeth in the lower as well as in the upper jaw and by larger (fewer) scales, our larva may be more properly referred. The most interesting points in this larva, however, are the tadpole-like form of the body, a form which is persistent in *Macrurus crassiceps*, the short snout with the mouth set in the position normal among the *Anacanthini*, the shafted pectoral fins, a trace of the oldest period of the piscine type — though considerably altered by the broad form of the pectoral disks —, the evanescent adhesive disk on the belly, and the long appendages to the rays of the ventral fins and to the tip of the tail. These appendages certainly play their part in assisting the larva to support itself in the water; but probably serve also to give it a protective resemblance to the stinging *Medusæ*.

Some of the members of this family have long been known, at least since the times of STRÖM[d] and FABRICIUS[e]; but the great wealth of forms that represent it in the abysses of the ocean, have first been discovered and described in recent times by GÜNTHER[f] and VAILLANT[g], BROWN-GOODE and BEAN[h]. According to the first-mentioned writer the family contains at least 46 species, which he distributes among 4 genera. Only one of these genera is represented in the Scandinavian fauna.

GENUS MACRURUS.

First branchial arch united above and below on the outside by a membrane to the inside of the opercular apparatus, leaving a foramen at the middle which is much smaller than the other gill-slits, of which even the last is complete. Gill-rakers on the first branchial arch tubercular. Branchiostegal membranes united to each other. Chin furnished with a barbel. Dorsal fins well-separated from each other.

Within this genus, which received the name it now bears of BLOCH[i], GÜNTHER, the most eminent among those writers who have revised the arrangement of the genus, in his last treatment of the question has united several genera which he formerly regarded as distinct, but which he has now reduced to the rank of sub-genera. "The dredge of the Challenger," he writes[j], "secured more than one hundred and forty examples, referable to thirty species, and proved that this type of fishes is not only one of the most widely spread in the depths of all oceans, but also extremely abundant with regard to species and individuals. These materials afforded the further evidence that the characters on which I had relied for the generic groups of *Macrurus*, *Coryphænoides*, and *Malacocephalus*, did not possess the taxonomic value assigned to them, with the exception of the modifications of the dentition, which, however, were capable of more precise definition.

"With regard to the form of the snout and position of the mouth, there exists every gradation, from the most specialized types, such as *Macrurus japonicus* and *Macrurus parallelus*, to *Macrurus longifilis*, which may be regarded as representing the original type whence the others were derived. Its head is compressed, well proportioned, formed by firm bones, the superficial of which enclose a muciferous system not more enlarged than we find it in many surface fishes: its snout is not more tumid or projecting than in the majority of surface Gadoids, and the wide mouth terminal and lateral. As the muciferous cavities increase in width, the bones are expanded into thin lamellæ and lose in firmness, those of the infraorbital ring cover more or less the side of the head, extend backwards to the angle of the præoperculum, and push the latter backwards. The snout[k] becomes the receptacle of large or even enormously enlarged cavities, supported by

[a] *Deep Sea Fish*, Challeng. Exped., p. 140.

[b] GIGLIOLI e ISSEL, *Pelagos*, p. 228, c. fig. (without description) — cited from GÜNTHER, l. c. To this publication we have not had access.

[c] Cf. above, p. 312, note *h*.

[d] *Søndmørs Beskrivelse* (1762), vol. I, p. 267.

[e] *Fauna Groenlandica* (1780).

[f] *Deep Sea Fishes*, Chall. Exped.

[g] *Exp. l. Scient. du Travailleur et du Talisman, Poissons*.

[h] *Report on the Fishes*, Dredg. 1880 U. S. Survey Steamer "Blake". Bull. Mus. Comp. Zool., Harv. Coll., vol. X, No. 5.

[i] *Naturg. Ausl. Fische*, Th. 2, p. 150; from μακρός, long and οὐρά, tail. The oldest generic name is *Coryphænoides* (GUNNER, 1765), but was formed contrary to current rules and suggested for one of the Scandinavian species "until it please the great naturalist LINNÆUS to give the species its proper name."

[j] *Deep Sea Fish.*, Chall. Exped., p. 122.

[k] Chiefly by the extension of the nasal bones, as REINHARDT has already remarked.

thin osseous ridges, and projects more or less beyond the mouth, which is forced downwards to the lower surface of the head, like that of a shark. Thus, great as the dissimilarity is between the extreme forms of the snout in the species of *Macrurus*, there is no fundamental difference in structure; they merely represent different degrees of the same line of modification.

"With regard to the scales, there is also every gradation from the small-scaled *Malacocephali* to the large-scaled *Macrurus longibarbis*. In very young specimens of all species the scales formed at first are always thin, without any armature, in fact cycloid. Spines appear only after some time, generally in the median line of the scale, simply and not in series; scales with fully developed armature are generally not found in specimens under 8 inches in length. In some species which normally possess strongly spiniferous scales, individuals may occur (especially such whose skin is wanting in pigment), in which the spines are much more feeble and scarcely visible. And finally, there are species in which the cycloid structure of the scales remains normally persistent. Thus, neither the size nor the structure of the scales can be safely used as a generic character."

On the other hand, GÜNTHER fully recognises the validity of a character first suggested for this purpose by LÜTKEN[a], and derived from the presence or absence of the spines (set in an upward (backward) direction on the front surface of the ray) that arm the second (apparently the first) ray of the dorsal fin. Even this character is subject to changes of growth, for, where these spines are present, in old specimens they may become indistinct (tubercular); but they never disappear altogether.

The species hitherto discovered within the limits of the Scandinavian fauna may be distinguished, according to these opinions, in the following manner:

A: Jaw-teeth at least in front cardiform (or velvet-like); scales middle-sized or large.	
1: Snout pointed; cheeks carinated:	
a: Second ray of the first dorsal fin smooth (unarmed) ...	*Macrurus* (*Coelorhynchus*) *coelorhynchus*.
b: Second ray of the first dorsal fin spiny	*Macrurus* (*Macrurus*) *Fabricii*.
2: Snout blunt; cheeks almost even	*Macrurus* (*Coryphaenoides*) *rupestris*.
B: Jaws furnished with canine teeth set in two rows in the upper jaw, in one row in the lower	*Macrurus* (*Malacocephalus*) *laevis*.

It sometimes happens, however, that the character derived from the structure and arrangement of the jaw-teeth, employed in this manner, firstly brings together forms extremely dissimilar in other respects[b], and secondly is very difficult of employment, for in young specimens of the Coryphaenoid group, even when they are 12 cm. long, it is hardly possibly to discover more than two rows of teeth in the upper jaw and one row in the lower. Again, several species of GÜNTHER's subgenera *Chalinurus* and *Optonurus* have true canine teeth in the outermost row of the card in the upper jaw and only one row of teeth in the lower jaw. The following classification appears easier and, therefore, more trustworthy.

A: Least breadth of the interorbital space less than the length of the snout, than $^1/_4$ of the length of the head, or than $^3/_5$ of the greatest breadth of the head at the perpendicular from the centre of the eye:	
a: Least breadth of the interorbital space more than or equal to $^3/_5$ of the length of the lower jaw, which is less than 40 % of the length of the head......	*Macrurus coelorhynchus*.
b: Least breadth of the interorbital space less than $^1/_2$ the length of the lower jaw, which is more than 40 % (44 %?) of the length of the head	*Macrurus Fabricii*.
B: Least breadth of the interorbital space greater than the length of the snout, and greater than or equal to $^1/_3$ of the length of the head or $^7/_{10}$ of its greatest breadth at the perpendicular from the centre of the eye.	
a: Least breadth of the interorbital space more than $^4/_5$ of the length of the lower jaw	*Macrurus rupestris*.
b: Least breadth of the interorbital space less than or equal to $^3/_5$ of the length of the lower jaw	*Macrurus laevis*.

[a] Vid. Meddel. Naturh. For. Kbhvn 1872, p. 4.

[b] Cf., for example, *Macrurus laevis* and *Macrurus macrochir*.

MACRURUS COELORHYNCHUS

Fig. 139.

Snout pointed, flattened, of a broad triangular shape, with sharp sides, which are continued by the carina of the suborbital ring (the cheeks) until they join the angle of the preoperculum; length of the snout greater than the least breadth of the interorbital space, which is less than $^1/_4$ *(*= 22·1—23·6 % in the specimens examined by us, which are between 18 and 25 cm. long) *of the length of the head, than* $^1/_5$ *(*= 66·1—76·8 %) *of the longitudinal diameter of the orbits, than* $^2/_3$ *(*= 66·3—65 %) *of the postorbital length of the head, than* $^1/_4$ *(*= 19·4—20·4 %) *of the distance between the first dorsal fin and the tip of the snout, than* $^2/_5$ *(*= 56·9—54·1 %) *of the breadth across the cheeks at the centre of the eyes, or than* $^2/_3$ *(*= 61·1—64 %) *of the length of the lower jaw, which is less than or equal to* $^2/_5$ *(*= 35·7—39·1 %) *of the length of the head, or about* $^1/_3$ *(*= 31·9—33·6 %) *of the distance between the first dorsal fin and the tip of the snout, but greater than* (in young specimens equal to) *the postorbital length of the head. Mouth set on the under surface of the snout, its breadth at the corners less than* $^2/_3$ *(*= 52·9—60·4 %) *of the breadth across the cheeks at the centre of the eyes.* Length of the head about 23—22 % (or less) of that of the body, 90—85 % of the distance between the first dorsal fin and the tip of the snout, $58^1/_2$—57 % of the distance of the second dorsal fin from that same tip, and $71^1/_2$—67 % of the distance between the anal fin and the tip of the snout. Depth of the body at the beginning of the first dorsal fin about $14—12^1/_2$ % of the length of the body, at the beginning of the second dorsal fin about 10 % of the same. Pectoral fins lobate (with brachiate base). Length of the base of the first dorsal fin about $^1/_2$ (= 57—51 %) of the distance between the two dorsal fins, which is about equal to the breadth across the cheeks at the centre of the eyes. *4 or 5 scales in a row from the end of the first dorsal fin to the lateral line.* A narrow, oblong, bare spot in the median line of the belly between the ventral fins. *Scales densely set with spines throughout the free surface, but without carinae. Second ray of the first dorsal fin (spinous ray) smooth;* its height about equal to the depth of the body at its base or somewhat less. Length of the barbel under the chin about $^1/_4$ of that of the lower jaw. *Jaw-teeth cardiform.*

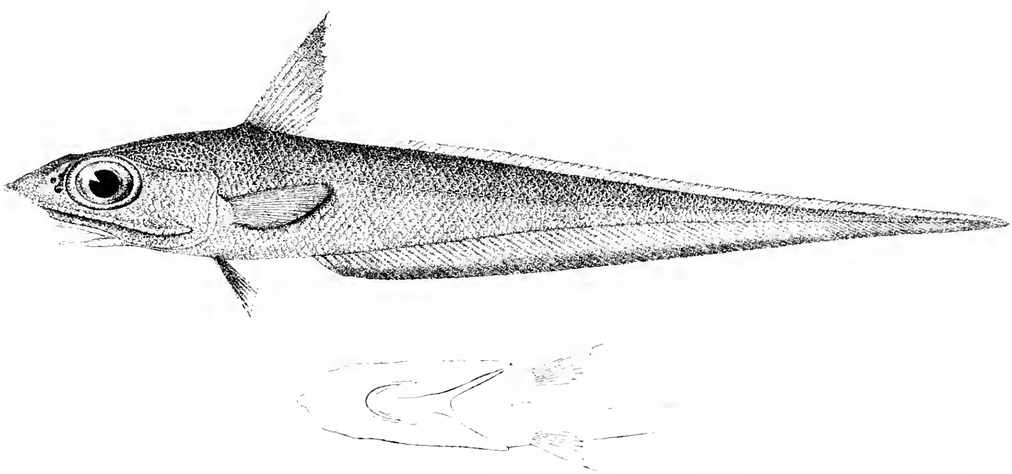

Fig. 139. *Macrurus coelorhynchus*, natural size. From Messina, through Professor V. L[illegible] Th[illegible] property of th[illegible] Mu[illegible] of the High School of Stockholm.

R. br. 6. D_1. (1)+$^1/_7$; D_2. 80—90; *A.* 83—98; *P.* (1)+$^1/_{16}$; *V.* $^1/_6$; *Lin. squ. transv.* 19—21.

Syn. *Lepidoleprus Coelorhynchus* Risso, *Ichth. Nice*, p. 200, tab. VII, fig. 22; *Eur. Mér.*, tom. III, p. 244; B[illegible] (*M*[illegible]).

Icon. Fn. Ital., tom. III (*Pesci*), tab. 123, fig. 1; GÜNTH. (*Macrurus*), *Cat. Brit. Mus., Fish.*, vol. IV, p. 392; COLL., Forh. Vid. Selsk. Christia 1874, Tillaegsh., p. 129, MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 278; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 253; GÜNTH., *Deep Sea Fish.*, Chall. Exped., p. 128.

Macrurus atlanticus, LOWE, Proc. Zool. Soc. Lond. 1839, p. 88; GÜNTH., *Cat.*, l. c., p. 392.

This species is one of those in which the Macruroid type appears in its most developed stage, a point which we observe principally in the structure and shape of the head. The species attains a length of $3^1/_2$ dm. The coloration, according to RISSO, is grayish with a reddish violet lustre on the back, silvery with mother-of-pearl and golden lustre on the sides, bluish black or black on the belly. The ventral fins, the branchiostegal membranes, the branchial cavities, the axil of the pectoral, and the margins of the vertical fins are also bluish black or black. The inside of the mouth and the tongue, on the other hand, are light (whitish yellow). The snout is transparent as if of cartilage.

To the above diagnosis we shall add merely that the anterior nostril — the nostrils are set on each side close to each other, as in most of the members of this genus — is round, the posterior kidney-shaped, on account of the semicircular dermal flap that overlaps it in front.

Macrurus coelorhynchus really belongs to the Mediterranean and the neighbouring part of the Atlantic[a], living in from 200 to 300 fathoms of water. In May, according to RISSO, the females repair to rocky shores to deposit their eggs, which number about 3,000. The adult specimens are said to feed on "worms and zoophytes." The dentition tells us distinctly that they cannot live on large or hard-shelled animals, but that their food probably consists chiefly of worms and thin-shelled crustaceans.

Only on one single occasion has this species been met with in Scandinavia. In February, 1842, the elder SARS found a specimen that had probably measured about 29 cm., in the stomach of a Cod that had been taken off Herlövaer, north of Bergen. This specimen was so well preserved — only the tip of the tail and a portion of the scales on one side of the body were wanting — that COLLETT justly concluded that the Cod must have devoured its victim only a short time before its own capture.

[a] Still, it comes extremely near — if it be not identical with — *Macrurus caribbaeus*, which BROWN-GOODE and BEAN have described (Proc. U. S. Nat. Mus., vol. VIII (1885), p. 594) from a depth of 210 fathoms in the north of the Gulf of Mexico, and which apparently differs from *M. coelorhynchus* chiefly in the somewhat smaller breadth of the interorbital space and the longer base of the first dorsal fin.

MACRURUS FABRICII.

Fig. 140.

Snout pointed and deep, pyramidal, with the sharp sides continued after a break by the carina of the cheeks until they join the angle of the preoperculum; length of the snout greater than the least breadth of the interorbital space, which is less than 1/4 (20·8—17·4 % in the specimens examined by us, which are between about 72 and 73 cm. long) *of the length of the head, than* [illegible] (59·6—49·4 %) *of the longitudinal diameter of the orbits, than* 3/5 (54—42 %) *of the postorbital length of the head, than* 1/[illegible] (17·2—15·2 %) *of the distance between the first dorsal fin and the tip of the snout, than* [illegible] (54 %) *of the breadth across the cheeks at the centre of the eyes, or than* 1/2 (47·2—37·6 %) *of the length of the lower jaw, which is more than* 2/5 (44·1—46·4 %) *of the length of the head, than* 1/3 (36·3—40·5 %) *of the distance between the first dorsal fin and the tip of the snout, and greater than the postorbital length of the head. Mouth set on the under surface of the snout, but its breadth at the corners more than* 2/3 (81—85 %) *of the breadth across the cheeks at the centre of the eyes.* Length of the head about 23—22 % (or less[a]) of that of the body, 90—86 % of the distance of the first dorsal fin from the tip of the snout, about 2/3 (61—64·3 %) of that distance of the second dorsal fin, and rather more than 1/2 (56—52 %) of the distance between the anal fin and the tip of the snout. Depth of the body at the beginning of the first dorsal fin about 1/5—1/6 of the length of the body, at the beginning of the anal fin about 1/7 of the same. Base of the pectoral fins only slightly brachiate. Length of the base of the first dorsal fin greater than the distance between the two dorsal fins, which is considerably less than the breadth across the cheeks at the centre of the eyes. *5 or 6 scales in a row from the end of the first dorsal fin to the lateral line.* No bare spot (except the anal aperture) in the median line of the belly. *Scales carinated and spiny. Second ray of the first dorsal fin spiny, or (in old specimens) at least granulated, on the front surface;* its length less than 2/[illegible] of the depth of the body at its base. Length of the barbel under the chin about 1/[illegible] of that of the lower jaw.

Jaw-teeth cardiform.

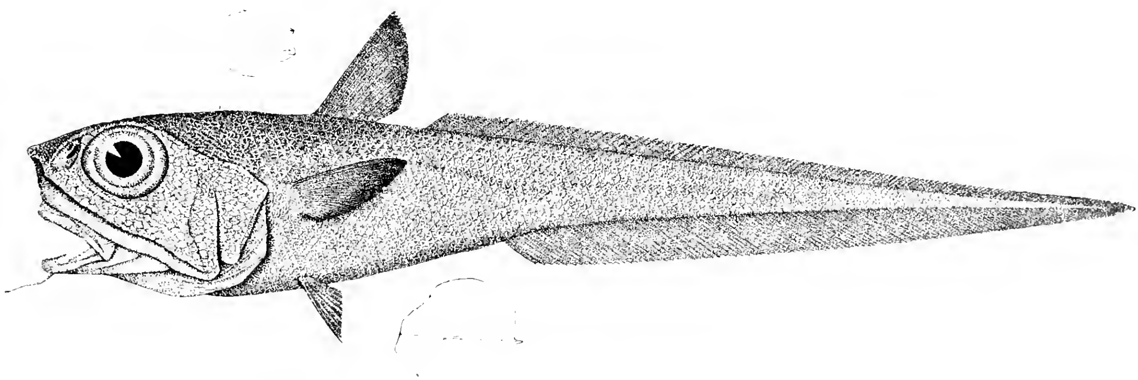

Fig. 140. *Macrurus Fabricii*, 3/10 of the natural size, and two scales, each of the natural size. From the coast of New England, through the Smithsonian Institution.

R. br. 6; D_1. (1) + $\frac{1}{11}$; D_2. 105—124; *A.* 113—148; *P.* 18—20; *V.* 1/7; *Lin. squ. tr.* 26—27 (ad pinn. ventr.).

Syn. *En egen sorts af fisk*, [illegible] *Brosmen*, [illegible] *Perlustration*, p. 51; [illegible] (ed. [illegible] suec.) pt. 1, p. 139.

[a] According to COLLETT 21·3—18·6 % in specimens between 538 and 935 mm. long. Perhaps the rule is that the head is smaller in the females than in the males.

Coryphaena rupestris, FABR., *Fn. Groenl.*, p. 154 (excl. synon.); BL. (*Macrourus*; p. p.), *Naturg. Ausl. Fisch.*, pt. II, p. 152, tab. CLXXVII; BL., SCHN. (*Macrurus*), *Ichthyol.*, p. 103, tab. 26; REINH., D. Vid. Selsk. Naturv., Math. Afh., vol. V (1832), p. XVIII; ibid., vol. VII, p. 129; NILSS., *Skand. Fn., Fisk.*, p. 604; GTHR. *Cat. Brit. Mus., Fish.*, vol. IV, p. 390, ESM., Forh. Naturf. M. Christ. 1868, p. 527; LTKN, Vid. Meddel. Naturhist. For. Kbhvn 1872, p. 1; BR. GOODE, *Fisher., Fisher. Industr. U. S.*, Sect. I, p. 244, tab. 66.

Macrourus Fabricii, SUNDEV., Vet.-Akad. Handl. 1840, p. 6; MGRN, Öfvers. Vet. Akad. Förh. 1867, p. 263; COLL. Forh. Vid. Selsk. Christ. 1874. Tillaegsh., p. 128; GOODE, BEAN, Bull. Essex Inst., vol. XI (1879), p. 7; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 811; COLL., N. Mag. Naturv., vol. 29 (1884), p. 95; LILLJ., *Sv., Norg. Fisk.*, vol. 2, p. 242; GTHR, *Deep Sea Fish., Chall. Exped.*, p. 130.

Macrurus Fabricii, which attains a length of at least nearly a metre ($9^1/_3$ dm.), is only slightly less typical of the Macruroids than the preceding species, though the snout is shorter and the mouth broader. In this species, too, the snout ends in a hard, wartlike protuberance, but the horizontal lateral carinæ are more concavely curved; and the front exterior corners of the nasal bones are more distinctly set off from the beginning of the suborbital carina on each side. Besides, the snout is not so depressed. The carinæ on the head are the same as in the preceding species: one in the middle line of the upper side of the snout, ending in a line with the anterior margin of the orbits; one on each side from the anterior outer corner of the nasal bones up to the orbital margin, and together with the latter and the anterior suborbital bone forming a triangular wall round the nasal cavity; one on each side of the forehead, which is only slightly concave, and along the side of the occiput, back to the beginning of the lateral line; one on each side along the temples, from the upper part of the hind margin of the orbit to the upper corner of the gill-opening; and lastly one at the middle of the occiput, very short and of a length no greater than that of 3 or 4 scales. The eyes are of a considerable size and oblong, the longitudinal diameter of the orbits occupying more than $^1/_3$ (about 35 %) of the length of the head, and the least breadth of the interorbital space measuring at most $^2/_3$ (60—49 %) of the former. The nostrils are set as in the preceding species. The intermaxillary bones form only about half of the margin of the upper jaw, their lobate process extending as far back as the bones themselves. The hind extremity of the maxillary bones lies nearly below the centre of the eye. The lower jaw is longer than in the preceding species — though the upper jaw projects beyond it in front — but on this head we must remark that in the preceding species we find a distinct alteration due to age, by which the length of the lower jaw is increased even relatively during growth, and young specimens of *Macrurus Fabricii* corresponding in size to the adult specimens of *M. coelorhynchus* are unknown. The pointed and fairly straight jaw-teeth are not large, but form broad cards (containing several rows) both in the lower jaw and on the intermaxillary bones. The pharyngeal teeth are thicker, strong, and of conical shape, with the blunt tip marked off as a distinct crown. The gill-rakers are verrucose. The operculum, as in most of the Macruroids, forms an almost right-angled triangle. The right (slightly obtuse) angle is turned backwards, the lower posterior side slightly concave, and the pointed end turned downwards, with the point fitted to the lower posterior corner of the preoperculum, which is elongated in a backward direction, so that the postorbital part of the side of the head almost forms a square. The branchiostegal membranes are united below into a free but not very broad fold across the isthmus.

The first dorsal fin, which is set in a deep groove in the dorsal edge, is high and trapeziform, the last ray — as in most of the Macruroids — being apparently destitute of membrane behind it, and the posterior rays, from the second branched ray, decreasing in length with fair uniformity, so that the hind part of the upper margin of the fin is straight or slightly convex. In a specimen 725 mm. long the second branched ray is 77 mm. long, the second simple (the spiny ray) 73 mm., and the last ray 18 mm. The first-mentioned ray is exactly as long as the lower jaw, the length of the last-mentioned ray only slightly more than half the distance between the two dorsal fins and somewhat less than half the base of the first dorsal fin. In the form of the second dorsal fin *Macrurus Fabricii* belongs to a group of the genus that is characterized by the complete development of this fin even in front, its beginning being also situated in front of that of the anal fin. The first ray is about as long as the last ray of the first dorsal fin or slightly shorter than it; the next rays gradually increase in length, though only slightly; and the height of the fin then decreases extremely slowly towards the tip of the tail, where it joins the anal fin.

The anal fin is more than twice as high as the second dorsal fin throughout almost the whole of its length, with a slightly convex margin. Its first ray is about as long as the last ray of the first dorsal fin, and at the middle of the fin the length of the rays is about $^{2}/_{3}$ of the longitudinal diameter of the orbits; from this point the height of this fin too decreases. All the rays are articulated, and all, except the first rays, in the anal fin as well as in the second dorsal fin are bifid at the tip; all may be easily parted into their two lateral halves.

The pectoral fins are situated somewhat in front of (according to SUNDEVALL, vertically below) the beginning of the first dorsal fin. They are obliquely pointed, and their length is somewhat greater than the height of the first dorsal fin. The first ray is thick, but articulated and simple or imperfectly branched at the tip[a]. The third and fourth rays are equal in length and the longest in the fin[b].

The ventral fins are about $^{2}/_{3}$ as long as the pectoral, the first ray, simple but articulated, being elongated to a hairlike tip. Among the branched rays the 4th, 5th, and 6th are equal in length and the longest, thus giving this part of the fins a rounded form.

The scales cover the whole body, except the under surface of the head, the branchiostegal membranes, and the fins. On the head the lateral carinae of the snout and cheeks also mark the boundary of the scales; though scattered scales may be found below the hind part of the suborbital carina. The scales on different parts of the body vary both in size and in form; and they are armed in various ways not only on different parts of the body, but also in different individuals. The smallest scales are set on the head, where they are more firmly attached to the subjacent bones, especially on the longitudinal carinae. In form the scales are quadrangular, rounded (almost circular), or hexagonal. The anterior (inserted) part of each scale is smooth, the outer part is furnished with a high and dentated, longitudinal carina at the middle and, in most cases, with several (3—5 above and below) small carinae, radiating in a backward direction and sometimes dentated like the middle carina. The texture of the scale shows numerous, dense and undulating, concentric striae, but no radiating ones. The lateral line does not pierce any scales; but its opening pores lie on the outside of a row of scales in which, in most cases, the middle carina of the scale is divided (double). In other cases the pore lies below the simple middle carina.

The body is of a grayish silvery or tin colour; the fins are brownish black. The cavity of the mouth, the branchial cavity, and the peritoneum are black.

Macrurus Fabricii is by no means a rare fish off the south of Greenland and occurs along the east coast of North America at least as far south as the neighbourhood of Cape Cod. So early a writer as EGEDE describes it as "like a Torsk, but with sharp prickles and spines over the whole skin, and with a narrow tail or hind part. They are both large and small. The Esquimaux say that they are of good flavour. CRANZ mentions a "species of fish that has a large head and eyes like an owl, and which the Esquimaux call *Ingminniset*, because it bellows[d] when dying. On the coast of Norwegian Finmark, north of Tromsö, the species has been taken occasionally in recent times on longlines, at depths varying between 100 and 300 fathoms. It was unknown there, however, until fifty years ago (1839), when Professor S. LOVÉN brought home to the Royal Museum a specimen, which has been described by SUNDEVALL, from Hammerfest.

The food is probably composed chiefly of small fishes, e. g. the Capelin, and crustaceans, even those with hard shells, to judge by the strength and form of the pharyngeal teeth. But in this case, as in the case of other deep-sea fishes, the stomach is generally turned inside out when the fish is drawn up to the surface, so that it has been impossible to ascertain its contents. The fish takes a bait freely, and is a nuisance, says BROWN-GOODE, to the American fisherman, who hauls in his line in the hope of a better catch than an Onion-fish[c].

The spawning-season of *Macrurus Fabricii* occurs on the coast of Finmark at the end of winter or soon afterwards, for in May COLLETT has met with at least two females full of roe. In Greenland FABRICIUS found that the ovaries of the females were extremely small in the month of May, and he therefore assumed that at this season they had generally finished spawning.

[a] On the other hand, it parts easily into its two lateral halves.

[b] GÜNTHER remarks a difference between the Norwegian and American forms of this species, consisting, according to his specimens, in the much shorter pectoral fins of the former. In one of our specimens (stuffed) from Finmark, however, the length of the pectoral fins is 54 % of that of the head.

[c] On account of the eyes the American fishermen of the present day call this species Onion-fish.

[d] When the air-bladder bursts(?)

MACRURUS RUPESTRIS (SW. SKOLÄSTEN[*]).

Plate XXVII A, fig. 2.

Snout blunt (of a broad pyramidal shape) and like the rest of the head without sharp (with only blunt) carinae; its length less than the least breadth of the interorbital space, which is greater than or equal to $^{1}/_{3}$ (38·2—33·2 % in specimens examined by us, which are between 121 and 885 mm. long) *of the length of the head and greater than the longitudinal diameter of the orbits* (133—111 %) *or more than* $^{2}/_{3}$ (81·6—70·9 %) *of the postorbital length of the head, than* $^{1}/_{3}$ (37·5—33·8 %) *of the distance between the first dorsal fin and the tip of the snout, than* $^{7}/_{10}$ (72—93 %) *of the breadth across the cheeks at the centre of the eyes, or than* $^{4}/_{5}$ (89·6—88·1 %) *of the length of the lower jaw, which is less than* $^{1}/_{2}$ (42·6—37 %) *of the length of the head, or about* $^{2}/_{5}$ (42·2—37·5 %) *of the distance between the first dorsal fin and the tip of the snout, and less than the postorbital length of the head. Mouth nearly terminal and lateral: its breadth at the corners more than* $^{2}/_{3}$ (70—86·5 %) *of the breadth across the cheeks at the centre of the eyes.* Length of the head about $^{1}/_{6}$—$^{1}/_{5}$ (18—20 %) of that of the body, about equal to (105—95 % of) the distance of the first dorsal fin from the tip of the snout, about $^{1}/_{2}$ (54—45 %) of that between the second dorsal and the same point, and about $^{2}/_{3}$ (73·2—61·7 %) of the distance between the anal fin and the tip of the snout. Depth of the body (in adult specimens) at the beginning of the first dorsal fin about $^{1}/_{6}$ of the length, at the beginning of the second dorsal fin about $^{1}/_{10}$ or $^{1}/_{9}$ of the same. Pectoral fins without brachiate base. Length of the base of the first dorsal fin about $^{1}/_{3}$ (28—37 %) of the distance between the two dorsal fins, which is nearly twice the breadth across the cheeks at the centre of the eyes. *6 or 7 scales in a row from the end of the first dorsal fin to the lateral line.* No bare spot (except the anal aperture) in the median line of the belly. *Scales densely covered with spines throughout their free surface, but without carinae. Second ray of the first dorsal fin spiny or (in old specimens) at least granulated on the front surface;* its length in young specimens greater, in old generally less, than $^{2}/_{3}$ of the depth of the body at its base. Length of the barbel under the chin less than (or about equal to) $^{1}/_{6}$ of that of the lower jaw. *Jaw-teeth cardiform, of uniform size or with the teeth in the outer row perceptibly larger than the others.*

R. br. 6; D_1. (1) + $\frac{1}{8-10}$; D_2. 103—172 (190); *A.* 104—193; *P.* 18—23; *V.* $\frac{1}{6-7}$; *Lin. squ. transv.* 26—27 (ad pinn. ventr.); *Vert.* 63—89.

Syn. Berglax (Coryphaena dorso dipterygio, pinna dorsi prima retro), STRÖM, *Søndmørs Beskriv.*, vol. I, p. 267—269, not.

Coryphaenoides rupestris, GUNN. Trondhj. Selsk. Skr., vol. III (1765), p. 50, tab. III, figg. 1 et 2; COLL., Forh. Vid. Selsk. Christ. 1874, Tillaegsh., p. 131; ibid. 1879, No. 1, p. 70; N. Mag. Naturv. Christ., Bd. 29 (1884), p. 95; MALM, *Gbgs. Boh. Fn.*, p. 502; WINTH., Naturh. Tidskr. Kbhvn. ser. 3, vol. XII, p. 36; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 812; GOODE, BEAN, Bull. Mus. Comp. Zool., Harv. Coll., vol. X, p. 197; DAY, *Fish. Gt. Brit., Irel.*, vol. I, p. 335, tab. XCIII; STORM, N. Vid. Selsk. Skr. Trondhj. 1883, p. 57; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 259; GTHR, *Deep Sea Fish., Chall. Exped.*, p. 138.

Macrourus Strœmii, REINH., D. Vid. Selsk. Naturv., Math. Afh., vol. V, p. XIX; SUNDEV., Vet.-Akad. Handl. 1840, p. 11; KR., *Voy. Scand., Lapp., etc.*, GAIM., *Zool., Poiss.*, tab. 11.

Lepidoleprus norvegicus, NILSS., *Prodr. Ichth. Scand.*, p. 51; ID. (*Macrourus*), *Skand. Fn., Fisk.*, p. 600; GTHR (*Coryphaenoides*), *Cat. Brit. Mus., Fish.*, vol. IV, p. 396; LTKN, Vid. Meddel. Naturhist. For. Kbhvn 1872, p. 5 (sep.).

Macrurus rupestris is one of the Macruroids that have the second dorsal fin extremely little developed in front, while behind the fin rises somewhat higher than usual, so that a little in front of the tip of the tail it is only slightly lower than the anal fin at the same point. The eyes are rather small, the longitudinal diameter of the orbits being less than $^{3}/_{10}$ (= 27—23 %) of the length of the head, a sign that the deep-sea character is not so pronounced as in the preceding species. The carinae on the head are blunt, though they occupy the same position as in the preceding species and in dried specimens or those which have long been preserved in spirits, are distinctly prominent. These three characteristics are enough always to render this species easily recognisable among its congeners in our fauna. However, the interspinal bones (the supports of the dorsal rays) are perfectly developed between the muscles of the back even in the space between the two dorsal fins, where no rays are present; and in a young specimen, 121 mm. in length, we observe not only that the second dorsal fin begins with distinct rays considerably further forward than in old specimens and only slightly behind the first third of

[*] = Shoemaker's last.

the body, but also that in the dorsal margin, in front of the first distinct ray of the second dorsal fin, there lies a row of soft, whitish, dermal protuberances, while from each of the posterior among these protuberances, forward to a point $^{3}/_{10}$ of the way along the body from the tip of the snout, there projects the tip of a ray, extremely small and scarcely perceptible. There can be no other explanation of this than that the second dorsal fin originally extended much further forward even than it does in adult specimens, but that its anterior part undergoes a reduction. Still, it is a rule — though with considerable individual variations — as COLLETT has pointed out, that the number of rays in this fin as well as in the anal fin increases with age during the latter period of growth, even while the length of the body increases from half a metre to a metre. This increase — from about 100 to about 200 in the former fin[a] — is in its magnitude an extremely uncommon phenomenon in the class of fishes. COLLETT also connects it with another great abnormity, the increase in the number of the vertebræ — 13—14 abdominal and 49—75 caudal vertebræ — which proceeds according to the same rule and with the same exceptions[b].

The first dorsal fin is set further forward than in the rest of the Scandinavian Macruroids, its beginning lying in front of the end of the first fifth of the body. It moves somewhat further back, however, with age. The length of its base is less than $^{4}/_{5}$ (79—58 %) of the least breadth of the interorbital space. The first ray is as usual rudimentary, the second ray both the longest and the thickest, unarticulated, and measuring rather more than half (50—55 %) the length of the head. The other rays — except the last, which is also simple — decrease in length uniformly, but sharply, the fin thus acquiring a more triangular form than in *Macrurus Fabricii*.

The anal fin begins at a distance from the tip of the snout which in young specimens measures about $^{1}/_{4}$ of the length of the body, in older ones about $^{1}/_{3}$ thereof. It is of fairly uniform height, with slightly concave margin: the first ray is slightly shorter than the next ones, the length of the rays increases or decreases according to the curvature of the belly, and behind the middle of its length the height of the fin is greater than the depth of the body at the same point. Round the tip of the tail the anal fin coalesces with the second dorsal fin into a symmetrical tip. The vent is situated just in front of the beginning of the anal fin.

The pectoral fins are set just in front of the perpendicular from the beginning of the first dorsal fin. They are evenly rounded at the tip, and their length is perceptibly more than $^{1}/_{2}$ (58—61$^{1}/_{2}$ %) of that of the head. The first ray is extremely short, and the ninth (8—10) is the longest.

The ventral fins are situated in old specimens in front of the perpendicular from the beginning of the first dorsal fin; but during youth they lie considerably behind it. The usual removal in a forward direction of these fins thus takes place in this species too, the distance between the foremost point in the insertion of the ventral fins and the beginning of the anal fin in young specimens (12 cm. long) being only slightly more than $^{1}/_{5}$ (22·8 %) of the distance between the anal fin and the tip of the snout, but in old specimens nearly $^{1}/_{3}$ (30 or 31 %) thereof. The first ray is elongated to a long tip, hairlike at the extreme end, which extends to the beginning of the anal fin: the second ray is about $^{2}/_{3}$ as long; and the length of the other rays is such that the margin of the fin is somewhat convex.

The jaw-teeth form a kind of transition from the preceding species to the following one. On the intermaxillary bones (in adult specimens) they are set in a card containing 5 or 6 rows, but behind this card, for the greater part of the length of the bones, they are set in only 2 rows. In the lower jaw the case is similar, but here there is only one row behind. In front the two intermaxillary cards have an empty space between them. The pharyngeal teeth — 2 or 3 rows on the two anterior upper pharyngeals, 4 rows on the posterior upper pharyngeal; 6 rows on the oblong, curved lower pharyngeals, with the largest teeth in the innermost (hindmost) row — are straight and conical, without the sharp break at the apex which characterizes them in *Macrurus Fabricii*.

The anterior nostrils are as usual round, the posterior oblong and set transversely just in front of the orbital margin; but the latter are generally remarkably narrow, this being due to the projection throughout the whole of their length of the marginal membrane in front.

[a] Still, it is not a superfluous remark that mistakes may easily be made in the counting, partly on account of the magnitude of the numbers, and partly because the two lateral halves of the otherwise simple rays easily fall apart, and the rays are thus counted twice over.

[b] Both the rule and the exceptions should be kept in mind, when one has to judge of the systematic significance of the varieties or races which, especially among the *Salmonidæ* and *Clupeidæ*, have been based upon the variations in the number of the vertebræ.

In this species the scales extend over the whole of the head, even below the suborbital ring, on the branches of the lower jaw, and in a large patch on the space between the branches of the lower jaw (*mentum*); only the branchiostegal membrane and the isthmus are as usual bare. The scales[a] are of essentially the same form as in the preceding species, but show no longitudinal carinæ or curves, and are densely covered throughout their free surface with short spines, which are arranged in a quincunx of oblique, curved rows. These spines give the surface of the body a velvety appearance. The lateral line does not pierce any scales in this species either, its opening pores lying in the form of grooves without spines on each scale.

Among the internal organs the liver and the pyloric appendages are especially remarkable for their advanced development. The abdominal cavity, with the peritoneum coloured black in front and chocolate behind, extends to a line with about the ninth ray of the anal fin, and the liver extends equally far back on the left side. The ovary is simple and triangular, with the oviduct in the lower, blunt corner.

The body is plain grayish violet shading into yellow. The fins are of a dark brownish violet, with a dash of the blue tinge of dew. The iris is whitish yellow, shading into silver and rose-pink. The mouth, the pharynx, and the branchial cavity are black.

Macrurus rupestris, which attains a length of at least a metre, has been found not so very seldom — for a deep-sea fish — on the south coast of Norway, up to Helgeland, at depths between 150 and 500 fathoms. According to STORM it is taken very often on long-lines in Trondhjem Fjord, even at the very head of the fjord, but seldom in less than 150 fathoms of water. In a single day in 1880, according to COLLETT, 20 specimens of this species were caught off Björnör (in the south of the Government of Trondhjem, lat. 64° 10′ N.). Off the extreme south of Norway, young specimens between 10 and 12 cm. long were taken off Arendal during the expedition of the Swedish gunboat *Gunhild* in July, 1879, at a depth of 335—370 fathoms and on a bottom of fine, brown clay. It is thus quite at home in these regions. It also penetrates into Christiania Fjord, at least to the latitude of Horten. On the coast of Bohuslän it was first found by FRIES, who has left in the Royal Museum a specimen 78 cm. long, taken in May, 1838. MALM found a stuffed specimen in Uddevalla Museum that had been purchased in the fishmarket there in March, 1872. In recent years Mr. C. A. HANSSON has forwarded to the Royal Museum two specimens. The first, which has been about 83 cm. long, but is now broken off short 16 cm. from the snout (the caudal part is lost), was found floating dead at the surface, between the Koster and Weather Islands, on the 20th of June, 1882. The second specimen, the original of our figure, is a female 885 mm. long, and was taken on a long-line in about 80 fathoms of water, off Svangen in South Ramsö Fjord, twelve miles south-west of Strömstad, on the 5th of November, 1889. In March, 1877, according to WINTHER, two specimens were cast ashore near the Skaw and forwarded to Copenhagen Museum. This is all that is known of the occurrence of the species in the Skager Rack. In the Cattegat (south of the line from the Skaw to Marstrand) it has not yet been found. To the west, according to GÜNTHER, it has been met with by the English *Porcupine* and *Knight Errant* expeditions in 200—500 fathoms of water between the Shetland and Faroe Islands. In 1880, during the *Blake* expedition, according to BROWN-GOODE and BEAN, A. AGASSIZ obtained a specimen 804 mm. long, at a depth of 524 fathoms, in lat. 41°33′ N. and long. 65° 55′ W. It is included among the fishes of Greenland by the younger REINHARDT[b] and LÜTKEN[c].

Macrurus rupestris in all probability leads the same life as other deep-sea fishes, though it seems not to be of so pronounced character as our other *Macruri*, for, as we have mentioned above, it has been taken in 80 fathoms of water. Its food seems to be composed chiefly of crustaceans: Decapods, at least as large as shrimps, and Hyperioids have been found in its stomach. The spawning-season seems to occur in winter, perhaps even in autumn. On the 12th of November COLLETT met with a gravid female off Langesund. The female secured by Mr. C. A. HANSSON from Svangen and the original of our figure had eggs 1 millimetre in diameter in its ovary on the 5th of November; and as, according to COLLETT, the diameter of the ripe eggs is 2 millimetres, it had still some time to wait before depositing its spawn. According to COLLETT the number of the ripe eggs when the roe is deposited is about 12,000 or hardly more than that number.

[a] See KRÖYER's plate in GAIMARD's voyage.
[b] RINK, *Grönland*, Bd. 2, Naturh. Tillæg, p. 25.
[c] *Arctic Manual and Instructions*, 1875, p. 120.

MACRURUS LÆVIS

Fig. 111

Snout blunt but high, only slightly projecting, and like the rest of the head without sharp carinæ; its length less than the least breadth of the interorbital space, which is about equal to $^{1}/_{3}$ (33·1 % in the specimen examined by us, which has probably — when perfect — been about 11 cm. long) *of the length of the head, slightly less than* (93·7 % of) *the longitudinal diameter of the orbits, about* $^{4}/_{9}$ (44·1 %) *of the postorbital length of the head, and more than either* $^{2}/_{7}$ (28·5 %) *of the distance between the first dorsal fin and the tip of the snout or than* $^{7}/_{10}$ (86·5 %) *of the breadth across the cheeks at the centre of the eyes, but less than* $^{2}/_{3}$ (59·8 %) *of the length of the lower jaw, which is more than* $^{1}/_{2}$ (55·3 %) *of the length of the head, nearly* $^{1}/_{5}$ (17·7 %) *of the distance between the first dorsal fin and the tip of the snout, and greater than the postorbital length of the head. Mouth almost terminal and lateral; its breadth at the corners more than* $^{4}/_{5}$ (80·8 %) *of the breadth across the cheeks at the centre of the eyes.* Length of the head somewhat less than $^{1}/_{6}$ of that of the body[a], about $^{6}/_{7}$ (86·3 %) of the distance of the first dorsal fin from the tip of the snout, nearly $^{1}/_{5}$ (17·8 %) of that between the second dorsal fin and the same point, and nearly $^{3}/_{4}$ (73·1 %) of the distance between the anal fin and the tip of the snout. Depth of the body at the beginning of the first dorsal fin about $^{1}/_{7}$ (15 %) of the length of the body, at the beginning of the second dorsal fin about $^{1}/_{10}$ thereof. Pectoral fins with brachiate base. Length of the base of the first dorsal fin about $^{3}/_{5}$ of the distance between the two dorsal fins, which is nearly twice (185 % of) the breadth across the cheeks at the centre of the eyes. *About 14—16 scales in a row from the end of the first dorsal fin to the lateral line.* In the median line of the belly, just in front of the insertions of the ventral fins, we find a transverse, oblong (kidney-shaped) patch without scales and just in front of the vent a similar, but round patch. *Scales spiny throughout their free surface, but without carinæ. Second ray of the first dorsal fin smooth (without spines)*: its height about $^{2}/_{3}$ (69 %) of the depth of the body at its base. Length of the barbel under the chin more than $^{1}/_{3}$ of that of the lower jaw. *Jaw-teeth set in two rows on the intermaxillary bones (the outer row with larger, canine-like teeth), in one row of canine-like teeth in the lower jaw.*

B. br. 7. D_1. $(1) + \frac{1}{10-12}$. D_2 200 (ca); *A.* 200 (ca); *P.* $(1) + \frac{1}{16}$; *V.* $^{1}/_{8}$.

Syn. *Macrourus lævis*, LOWE, Proc. Zool. Soc. Lond. 1843, p. 92; GTHR. (*Malacocephalus*), *Cat. Brit. Mus., Fish.*, vol. IV, p. 397; LTKN, Vid. Meddel. Naturh. For. Kbhvn 1872, p. 4 (sep.); MALM, *Gbgs. Boh. Fn.*, p. 503; WINTH., Nat. Tidskr. Kbhvn, ser. 3, vol. XII, p. 36; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 273; GTHR (*Macrurus*), *Deep Sea Fish. Chall. Exped.*, p. 148, tab. XXXIX, fig. B.

Macrurus lævis, which attains a length of about half a metre, with eyes relatively equal in size to those of *M. Fabricii* (35 % of the length of the head) is evidently a much more pronounced deep-sea fish than *M. rupestris*; and its more scattered, but stronger (canine-like) jaw-teeth and relatively longer jaws are signs of its more predatory habits.

The body is remarkably elongated, this being due, according to GÜNTHER, to the fact that the tail "tapers to a very long and narrow band." But the forepart externally corresponds fairly closely to that of the two preceding species, the depth at the beginning of the first dorsal fin being about $^{9}/_{10}$ (89·7 %) of the length of the head, and at the beginning of the second dorsal fin about $^{2}/_{3}$ (64·7 %) of the same. The breadth of the head straight across the cheeks at the centre of the eyes is less than $^{2}/_{5}$ (38·2 %) of its length.

The smooth spinous ray in the first dorsal fin and the small scales render this species easily recognisable among our *Macruri*. We must remark, however, some (5) raised, but only slightly marked striæ (osseous ridges under the skin) on the operculum and suboperculum, radiating backwards and downwards from the articulation of the former.

The coloration, according to GÜNTHER, is brownish on the head, especially on the gill-cover, with a lustre of silver and gold; the axil of the pectorals, the ventral fins and the belly between them, and the vent are black; the dorsal and pectoral fins are blackish; the anal fin

[a] According to GÜNTHER and LÜTKEN.

is black at the margin. The inside of the mouth is white, the branchial cavity black.

Macrurus lævis has a wide geographical range, but is still extremely rare in the museums. It was discovered off Madeira by LOWE, and the British Museum has acquired another specimen from the same locality through JOHNSON. But the species was not recognised again until LÜTKEN described a specimen that was cast ashore on the north of Jutland near the Skaw and found at the beginning of December, 1871. Long before this time, however, the Museum of Gothenburg had received a specimen through Mr. DEYENBERG. This specimen was dropped on the shore near Lysekil by a seagull on the 10th of November, 1852; and has since been described at length by MALM in his *Göteborgs och Bohusläns Fauna*[a]. Finally the species has again been found off the coast of Pernambuco, where the Challenger Expedition took a specimen at a depth of 350 fathoms[b].

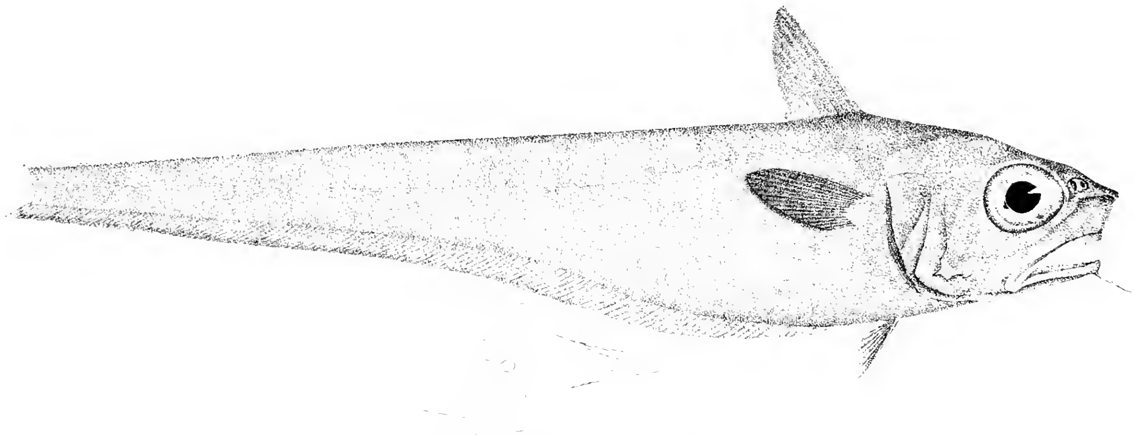

Fig. 141. *Macrurus lævis*, seen from the side, together with the forepart, seen from below. 2/3 of the natural size. Found at Lysekil, on the 10th of November, 1852, by DEYENBERG. The property of the Natural History Museum of Gothenburg.

FAM. OPHIDIIDÆ.

Body of a compressed tadpole-like or Eel-like form, with elongated, more or less whip-like tail, and covered with thin, cycloid scales or naked. All the vertical fins confluent (no distinct caudal, no anterior dorsal fin). *Teeth as a rule present both in the jaws and on the vomer and palatine bones. Gill-openings large: the branchiostegal membranes more or less united to each other, but free from the isthmus. Branchiostegal rays usually 8 or 7*[c]. *Pseudobranchiæ and air-bladder generally present*[d]. *Pyloric appendages only slightly developed or wanting.*

This family consists in great part of deep-sea fishes; and the reductions characteristic of a life of this nature appear here too. But the same reductions in the complete structure of the Anacanthine type also affects those fishes of this family which live in subterranean chasms or lead a kind of commensual life

[a] By the kindness of Dr. STUXBERG, the Curator of the Museum, we have been enabled to make use of this specimen as the original of our figure.

[b] Whether it occurs in the Mediterranean, is still somewhat uncertain, though probable. In his list of the Mediterranean fishes, however, GIGLIOLI gives only a name that might be applied to it; and it is evidently another species that MOREAU has described under this name.

[c] Exceptionally 6 or even 5.

[d] Often wanting, however.

within the body of other animals. Even true surface-fishes or shore-fishes also occur within this family. In the great majority of cases we may rely upon the family-character that the caudal fin is not separated from the other vertical fins; but it very often appears, at least by a closer arrangement of the rays, that here we have the rudiment of a distinct caudal fin, and in some exotic species the caudal fin is free or united to the dorsal and anal fins merely by a short fin-membrane. In most cases the ventral fins are reduced, filamentous, and removed to a greater or less distance in a forward direction, even in front of the shoulder-girdle and below the tongue, as if they were barbels. In other cases these fins are wanting. Some of these fishes in form come very near the *Macruri*, others remind us of the *Phycis*-type, and others again resemble the Blennomorphs and Gobiomorphs.

In general these fishes are small and worthless; but *Genypterus capensis*, which sometimes attains a length of a metre, bears among the inhabitants of Cape Colony the significant name of *Koning van Klipvischen*, and *Brotula multibarbata* is a favourite and expensive dish in Japan.

About 75 species are at present known with more or less certainty and distributed among 33 genera.

The family as now defined and ranged most nearly corresponds to MÜLLER'S[a] family *Ophidini*, with the addition (made by GÜNTHER[b]) of the CUVIERIAN Gadoid genus *Brotula* and its relatives (the subfamily *Brotulinae*), of RICHARDSON'S genus *Machaerium* (subsequently altered for reasons of priority to *Congrogadus*), and of RÜPPEL'S *Haliophis* (the subfamily *Congrogadinae*).

SUBFAMILY OPHIDIINÆ.

Filamentous ventral fins inserted in front of the shoulder-girdle.

The majority of the members of this subfamily are shore-fishes; but the only one that can be of any faunistic interest to us, is a deep-sea fish.

The genus *Ophidium*, which has given its name to the family as well as to the subfamily, is fairly common in the Mediterranean and on the coast of Brazil. In the former locality it has long been known: even PLINY probably referred to it when he mentioned a fish of this name that was employed in the medicine of the ancients, while in BELON'S time[c] the fish was much esteemed by the prelates of Rome as an excellent dish. In more recent times the genus has gained celebrity, through MÜLLER'S[d] and COSTA'S[e] researches, for the singular manner in which the air-bladder is united in front to the spinal column, in the nearest resemblance to the corresponding structure in *Fierasfer*. MÜLLER imagined that within this genus he could make use of anatomical differences as specific distinctions between forms in which no external differences could be detected; but COSTA showed that a great proportion of the former appear as differences dependent on age and sex. One species has a range extending from the Mediterranean out into the Atlantic and up to England, but has not been found in Scandinavian waters.

[a] Abh. K. Akad. Wiss. Berl. 1844, pp. 177 and 202. BONAPARTE had already established a family *Ophidiida* in 1831, but he ranged it among the *Apodes* and included in it the Sand-Eels.

[b] *Cat. Brit. Mus., Fish.*, vol. IV, p. 370.

[c] *La nature et diversité des poissons*. Paris 1555, p. 126.

[d] Abh. K. Akad. Wiss. Berl. 1843, p. 150.

[e] *Fauna del regno di Napoli. Pesci*, part. 1, *Ophidium*, tav. XX, ter. August, 1843.

GENUS RHODICHTHYS.

Body tadpole-like, with fairly deep and broad head and strongly compressed tail, which is increased in depth by the great median height of the vertical fins, the margins of which evenly but sharply converge towards the caudal fin, which is united at the base to the dorsal and anal fins, but for the greater part of its length free. Ventral fins filamentous, bifid in the outer part, and inserted below the posterior part of the copular row of the hyoid bone. Anal aperture situated in front of the pectoral fins, between the lower corners of the gill-openings, at a considerable distance from the beginning of the anal fin. Small, cardiform teeth on the intermaxillary bones and in the lower jaw: vomer and palatine bones toothless. Branchiostegal rays 6. Pyloric appendages 10. No scales; the naked skin transparent. No spines on the head.

This genus is one of the most handsome discoveries made in the depths of the sea by the Norwegian Arctic Expedition. The form of the body reminds us strongly enough of the Great Forked Beard; but the loose, almost gelatinous, and naked, almost transparent body most nearly resembles that of the other true deep-sea fishes within the Ophidioid family. According to COLLETT the ventral fins are "firmly united to the hyoid bone" — the genus is thus referred to this subfamily — but according to the figure these fins are set comparatively far back, considerably further back than in a true *Ophidium*, and LILLJEBORG says they are "attached to the shoulder-girdle." In the latter case the genus ought rather to be ranged among the subfamily *Brotulinæ*. In the form of the body too, as LILLJEBORG has already remarked, it comes very near *Bathyonus*, one of the *Brotulinæ*; but the opercular spine and the scales are wanting, and in *Bathyonus* the vent is situated close to the beginning of the anal fin. The limit between these subfamilies is, however, rather uncertain, fixed as it is according to a character which is an expression for the general rule among the Physoclysts that the ventral fins move forward with increasing age and advancing development of form.

Only one species of the genus is known.

THE ROSE FISH (SW. ROSENFISKEN).

RHODICHTHYS REGINA.

Fig. 142.

Length of the head (in a male nearly 3 dm. long) about $^1/_4$ of that of the body. Greatest depth of the body about $^1/_5$ of its length and almost equal to the distance between the vent and the tip of the snout. Breadth straight across the cheeks greater than the postorbital length of the head and about $^3/_5$ of the entire length of the head. Breadth of the interorbital space about $^2/_5$ of the entire length of the head and about $^3/_4$ of the postorbital length thereof. Outer diameter of the iris $^1/_7$ of the entire length of the head and somewhat more than $^1/_4$ of the postorbital length of the head or than $^4/_9$ of the length of the snout. Mouth broad, both terminal and lateral: the maxillary bones extend somewhat behind the perpendicular from the hind margin of the iris. Lower jaw shorter in front than the upper jaw. Nostrils set far apart, the posterior pair separated from the eyes by a distance equal to the diameter of the latter, the anterior pair about half-way between the posterior and the tip of the snout. Height of the gill-openings equal to the breadth across the cheeks. Distance between the dorsal fin and the tip of the snout slightly greater than the length of the head and about $^4/_5$ of the distance between the anal fin and the same point. Greatest height of the dorsal fin $^3/_{10}$ of the depth of the body at the beginning of the fin: greatest height of the anal fin $^3/_{10}$ of the depth of the body at the beginning of the fin. Depth of the base of the caudal fin rather more than $^1/_3$ of the diameter of the iris. Length of the caudal fin equal to the breadth of the interorbital space. Length of the pectoral fins about equal to the postorbital length of the head. Length of the ventral fins about equal to the distance between the anal fin and the tip of the snout. Coloration dark carnation, with a few lighter, clouded spots: branchiostegal membranes deep crimson: peritoneum, branchial cavity, and pharynx black.

R. br. 6; *D.* 60, *A.* 57; *P.* 11 I. 12; *C.* 10.

Syn. Rhodichthys regina, COLL., Forh. Vid. Selsk. Christ. 1878, No. 14, p. 99; *N. Nordh. Exped., Zool., Fiske*, p. 154, tab. V, figg. 37—39; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 238; GÜNTH. *Deep Sea Fish., Chall. Exped.*, p. 121.

The above description and the appended figure are derived from COLLETT's work on the deep-sea fishes taken by the Norwegian Arctic Expedition. Only one specimen of this species is as yet known. It was taken on the 16th July, 1878, at a depth of 1,280 fathoms, 165 kilometres north east of Jan Mayen Island, about midway between this island, Norwegian Finmark, and Bear Island. The bottom at this depth consisted of *Biloculina*-clay, and the bottom temperature was — 1·4° Celsius. The fish was still alive when it was drawn on board, although the hauling of the trawl had taken several hours; and it was kept alive for some time, but appeared to be extremely sluggish in its movements. The transparency of the body rendered the internal organs visible, so that in the living fish one could see the spinal column, the several divisions of the brain, the labyrinth, the gills, and most of the viscera. In the stomach were found still determinable remains of three crustaceans, *Bythocaris leucopis*, *Pseudomysis abyssi*, and a Hyperioid.

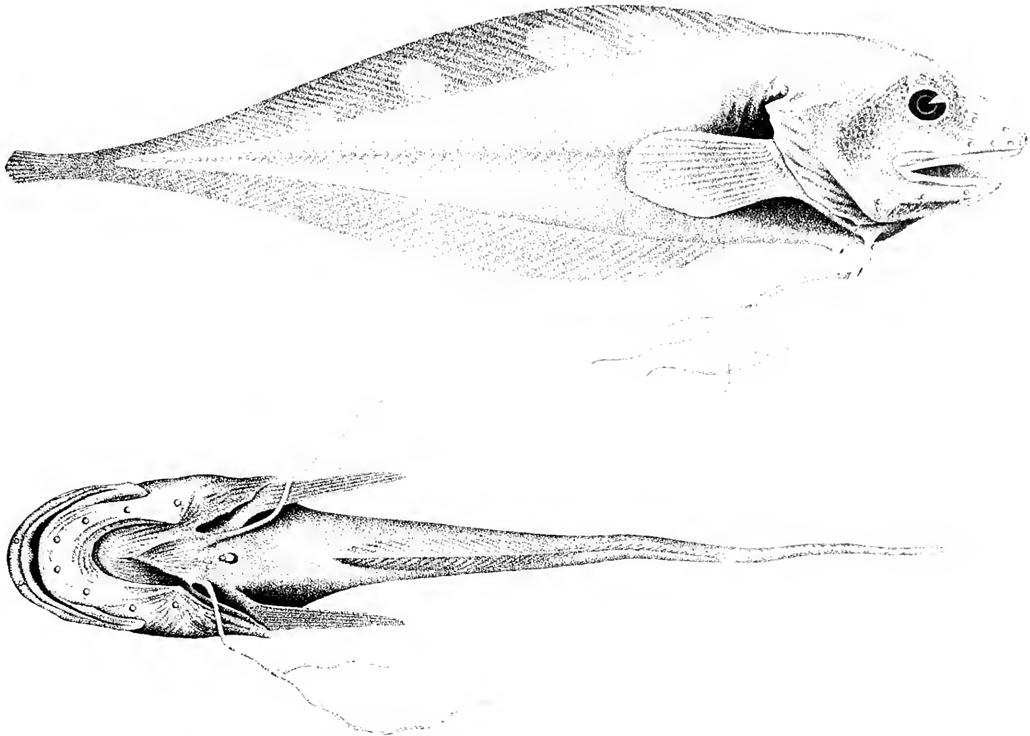

Fig. 142. *Rhodichthys regina*, ♂, $^2/_3$ of the natural size. From a depth of 1,280 fathoms, on a clayey bottom (*Biloculina*-clay with a temperature of — 1·4° Celsius), 465 kilom. N. E. of Jan Mayen I., 19th July, 1878. After COLLETT.

SUBFAMILY FIERASFINÆ[a].

No ventral fins. Body Eel-like, with pointed tail.

"Fishermen say that of this sea-cucumber (Cazzo reale — *Holothuria tubulosa*) are generated the oblong, red, ribbon-like fishes which are called *Cipolle*," wrote COLUMNA[b] at the beginning of the 17th century. So

[a] GTHR, *Cat. Brit. Mus., Fish.*, vol. IV, p. 370.

[b] *De aquatilibus aliisque nonnullis animalibus*, Roma 1616, p. XXXVII

long has it been known that a singular and intimate relation exists between sea-cucumbers and certain fishes of this subfamily which in CUVIER[a] formed the subgenus *Fierasfer* of the genus *Ophidium*. These fishes have the habit of seeking shelter and, to some extent, food inside sea-cucumbers and bivalves, where they lead a parasitic life, feeding upon the minute animals drawn by the current into the respiratory tree of the sea-cucumber or towards the mouth of the bivalve. Now and then they make sallies in search of food, but soon return to their hiding-place.

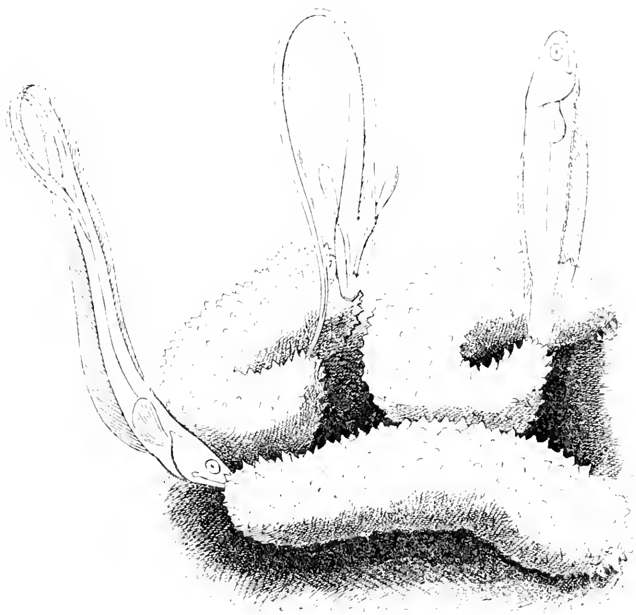

Fig. 143. *Fierasfer acus*, in the act of entering a Holothuria. $^2/_3$ of the natural size. After EMERY.

How this habit has arisen, we can at least conjecture from VERRILL's observation[b] of a species of the preceding subfamily, *Ophidium marginatum*, in Great Egg Harbour on the coast of New Jersey. "We dug two specimens," he writes, "out of the sand near low-water mark, where they burrowed to the depth of a foot or more. When placed upon moist sand they burrowed into it *tail foremost* with surprising rapidity, disappearing in an instant." That species of *Fierasfer* whose habits are best known, the Mediterranean *F. acus*, usually makes its way in the same manner, according to EMERY, tail foremost into the respiratory tree and body cavity of the *Holothuriae*. Soft, almost transparent, and helpless, without weapons of defence, not even with scales to protect its body, and with powers of sight certainly feeble during the daytime, as shown by the contracted pupils, the fish feels its way, with head turned down, until with its snout and with the system of the lateral line it feels the current that passes into the hind part of a Holothuria. Now the fish bends the tip of its tail downwards and inserts it into the cloaca of the sea-cucumber. In adult specimens of this species the tip of the tail is without fin-rays, but the last rays of the dorsal and anal fins lie close to the body at this spot, so that the end of the tail forms a comparatively stiff point, which can be inserted without difficulty into the opening. By the breathing of the sea-cucumber and the undulating movements of the fish itself the tail is now forced farther and farther

[a] *Règne Animal*, ed. 2, tome II, p. 359. In RISSO *Fierasfer* was the specific name of *Fierasfer acus* (*Ophidium imberbe*, LIN., p. p.).
[b] American Naturalist, vol. V (1871), p. 399.

into the respiratory tree, until only the forepart remains outside. The fish now entirely enters the body of the sea-cucumber by means of a few powerful, undulating movements. Now and then it peeps out to breathe, to seize some small crustacean that has come too near, or to evacuate the contents of its intestine through the vent, which is situated far forward. The fish must also, in all probability, leave its place of refuge and lead an independent life during the spawning-season. After the first fish a second, a third, or even a seventh may take up its abode in the same sea-cucumber. One *Fierasfer* seems generally to do no harm to the sea-cucumber; but if several come, it dies after ejecting its entrails, and the fish peep out from the empty skin. Thus, the Fierasfer lives originally in the ramified breathing duct (respiratory tree) of the sea-cucumber; but by the bursting of the walls of this duct it easily gains a passage into the large cavity of the body, where it is frequently found. Some species of the genus lead a similar life in the body cavity of the Indian trepangs, and in all probability gain entrance in the same manner; but the Fierasfers that live within the body of the large starfishes (genus *Culcita*), must certainly pass through the mouth, for in these animals there is no anal aperture (cloaca) to admit of the passage of any fish.

Even though these fishes may derive some nourishment from the fluids in the body of the sea-cucumber in which they live, still they are no true parasites, and seek their food chiefly outside, thus being frequently found swimming freely about. The case may be different in the other genus of this subfamily, *Encheliophis*, which is a native of the waters round the Philippine Islands, and whose parasitic nature seems to be more pronounced and to have involved the loss not only of the ventral, but also of the pectoral fins.

From the Gulf of Panama, on the west coast of Central America[a], PUTNAM has described a species, *Fierasfer dubius*, that hospitates in pearl-mussels, between the mantle and the shell. Here it leads a life so quiet and inoffensive that the mussel sometimes succeeds in enveloping it in a layer of nacre.

The weak sight possessed by these fishes, at least by daylight, is compensated by a special development of the senses of touch and hearing. The system of the lateral line (fig. 144) includes large passages on the head, from the snout round the eyes (the suborbital and supraorbital branches), along the forehead and the top of the head on each side to the temples, and from the under surface of the lower jaw, along the margin of the preoperculum, to the same spot, where the lateral line proper begins. The two lateral halves of the system are united by transverse canals between the eyes and between the temples. The sensory organs lie in large numbers along these canals as well as in a row along each side of the back and in another denser row along each side of the base of the anal fin. The labyrinth is remarkable for its comparatively large otoliths. The powers of hearing are probably strengthened — and sounds perhaps produced, though we have no observations on this head — principally by the connexion

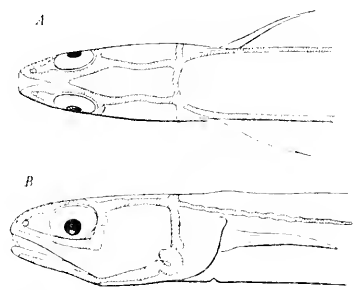

Fig. 144. Cephalic system of the lateral line (Canuiferous canal) in *Fierasfer dentatus*. *A*. from above; *B*. from the left. After EMERY.

(probably common to all the Ophidioids) between the air-bladder, the first vertebræ, and the base of the occiput. In the Cods we have seen an internal connexion between the air-bladder and the transverse processes of the middle and posterior abdominal vertebræ. Here this connexion is removed farther forward; and the first four (or, as in *Fierasfer dentatus*, only the first three) vertebræ with their ribs are modified accordingly. The first vertebra is as usual closely united to the occipital bone, the second is shortened. The first two pairs of ribs retain a greater or less amount of mobility, the third (and in *Fierasfer acus* even the fourth) pair coalesces with the body of the vertebra like ordinary transverse processes. In *Fierasfer acus* the third pair is so much enlarged that it coalesces

[a] According to PUTNAM (Proc. Soc. Nat. Hist. Boston, vol. XVI (1874), p. 343) the same species inhabits Holothurians on the east coast of Central America, in Florida Bay.

not only with its own vertebra, but also with the fourth. The ribs of the latter have assumed the form of disks united to its back. In *Fierasfer dentatus* the third pair is only slightly extended, the second and first pairs all the more so, though far less than the third pair in the former species. To these bones is attached the anterior part of the air-bladder — which extends along the whole dorsal wall of the abdominal cavity, which is much broader in *acus* than in *dentatus* — and here are extended muscles to draw the air-bladder forward, among which the median are especially large and powerful, originating from and coasting the parasphenoid bone and attached to the anterior end of the air-bladder.

The eggs of these fishes are developed floating in the sea, united within a slimy mass, like those of the Angler. Of the spawning (deposition of the eggs) we know only that it takes place at night. The development advances quickly. By the sixth day the yolk is absorbed, and the larva begins to eat. It is now only 3 or 4 mm. long, but already Eel-shaped, and, in *Fierasfer acus*, has a singular appendage on the back, almost as long as itself. This is the first ray of the future dorsal fin, which has early grown into a long, stiff stem, with foliate growths set alternately. Here we again meet with an example of the long appendages which we have already observed on several occasions in the larvae of pelagic fishes, and which help the larvae to support themselves as they float in the water and drift with the current. These appendages probably give the larvae a protective likeness to small Medusae, and perhaps, as EMERY supposes, serve as a lure to entice the small crustaceans (*Entomostraca*) on which the larvae live[a]. This evanescent growth does not appear in the larva of *Fierasfer dentatus*, in which, on the other hand, the body is still more elongated and resembles a long, narrow ribbon[b]. In the case of this larva EMERY has also made the observation that it possesses a considerably greater number of vertebrae than the full-grown fish, which generally has only 95 vertebrae (26 abdominal), while in one larva he found 175 vertebrae. In adult specimens of *Fierasfer dentatus* too, the tip of the tail is often broken off short, and bears a secondary growth, corresponding to a caudal fin, such as we have above seen to be common among the Macruroids. EMERY was therefore quite justified in his suspicion[c] that *Fierasfer dentatus* in later years discards its shelter within the sea-cucumber, or at all events cannot gain entrance in the same manner as its congener, although he subsequently[d] met with a small, but full-grown specimen (with 115 vertebrae) in a *Holothuria tubulosa*.

GENUS FIERASFER.

Pectoral fins present[e]. Branchiostegal rays 7. Pseudobranchiae wanting. Branchiostegal membranes united underneath, but free from the isthmus. The upper jaw projects slightly beyond the lower. Cardiform[f] teeth in the jaws, on the vomer, and on the palatine bones. Anal aperture nearly vertically below the insertions of the pectoral fins. Pyloric appendages rudimentary.

This genus seems to attain the highest point of its development in Indo-Australian waters, where 5 or 6 species are known. One species has been described from the east coast of Africa, one from Central America, and two from Europe. In 1853, during the voyage round the world of the frigate *Eugenie*, Professor H. KINBERG took near the Keeling Islands specimens of *Fierasfer parvipinnis* 31 cm. in length and with a depth of 23 mm. just behind the head. The other species of the genus are considerably smaller.

[a] In KAUP (Ann. Mag. Nat. Hist., ser. 3, vol. VI (1860), p. 272, tab. III, fig. D) this larva has borne the name of *Porobranchus linearis*, in GASCO and subsequently in COSTA (Annario del Museo Zoologico di Napoli, Anno V, tav. I, fig. 1) that of *Vexillifer de Filippi*.

[b] Another characteristic, as yet observed only in the larva of *Fierasfer acus*, is that the tip of the tail ends, as in the Macruroid larvae (*Krohnius*), in a long, filamentous prolongation.

[c] Fn., Fl. Golf. Neap. II, *Monogr. Fierasf.*, p. 18.

[d] Mitth. Zool. Stat. Neap. III, p. 282.

[e] Though sometimes small.

[f] Sometimes set in one row in the jaws.

FIERASFER DENTATUS

Fig. 145.

Among the anterior jaw-teeth we find a pair or two of curved canines both in the upper jaw and the lower. Length of the pectoral fins 1/2 that of the head, which in adult specimens measures about 10 1/2 % of that of the body. Greatest depth of the body (just behind the head) somewhat less than 1/2 (46—48 %) of the length of the head, which is less than the distance between the vent and the tip of the snout (during youth 3/5 to 3/4, in old specimens 4/5 thereof). Longitudinal diameter of the orbits about 1/3 of the length of the lower jaw, which is more than half (about 56 %) of the length of the head, but less than half (about 45 %) of the distance between the vent and the tip of the snout. Postorbital length of the head about 70 % of the entire length of the same. Height of the anal fin, which begins just behind the vent and somewhat behind or vertically below the beginning of the dorsal fin, greater at the middle of its length than either the height of the dorsal fin or the depth of the body at this point, but somewhat less than the greatest depth of the body. The abdominal cavity extends behind the vent for a distance about half as great again as that between the vent and the tip of the snout. Body transparent, during life colourless, save for the whitish, brassy iris and the silvery abdominal cavity.

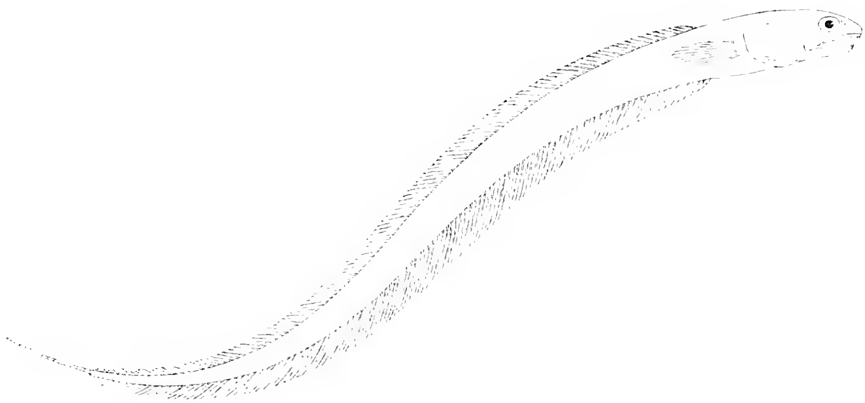

Fig. 145. *Fierasfer dentatus*, natural size. From 100—200 fthms. of water on the Jutland Reef. Taken in 1880 by Fisherman B. WESTERGREN.

R. br. 7; *D.* ca 144—180; *A.* ca 165—180; *P.* 16; *V.* 0; *C.* 0.

Syn. Ophidium dentatum, CUV. (subgen. *Fierasfer*), *Règne Anim.*, ed. 2, tome II, p. 359. GTHR (*Fierasfer*), *Cat. Brit. Mus., Fish.*, vol. IV, p. 383; COUCH, *Fish. Brit. Isl.*, vol. III, p. 133, tab. CLVI; PUTNAM (*Echiodon*), Proc. Boston Soc. Nat. Hist., vol. XVI, p. 346; GIGL. (*Fierasfer*), Espos. Intern. Pesca. Berl. 1880, Sez. Ital., Cat., p. 97; EMERY, Atti Accad. Linc., ser. III, Mem. Cl. Sc. Fis., Math., Natur. vol. VII, p. 183, tab. I, cett.; ID., Fn., Fl. Golf. Neapel, II, p. 46, tab. I, cett.; DAY, *Fish. Gt. Brit., Irel.*, vol. I, p. 328; COLL., Forh. Vid. Selsk. Christ. 1882, No. 19, p. 3 cum tab.; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 234.

Echiodon Drummondi, THOMPS., Trans. Zool. Soc. Lond., vol. II, p. 207, tab. XXXVIII.

Encheliophis tenuis, PUTNAM (larva) l. c., p. 347.

In Scandinavia as everywhere *Fierasfer dentatus* is an extremely rare fish; and its habits, at least when adult, are almost unknown. It was originally described as a Mediterranean form, but even there it is seldom observed. EMERY saw only one adult specimen at Naples, but he mentions at least three larvæ which he procured from Holothuriæ. GIGLIOLI assigns this species to Naples, Messina, and Venice. On the other hand, neither CANESTRINI, MOREAU, nor STEINDACHNER mentions its occurrence in the Mediterranean. In the Atlantic it was first met with by THOMPSON, who received through DRUMMOND a specimen 28 cm. (11 in.) long that had been found on the south coast of Ireland lying dead on the beach after a storm. Through professor S. LOVÉN the Royal Museum received in 1880 a specimen that had been caught by Fisherman B. WESTERGREN "at a depth of from 100 to 200 fathoms on the Jutland Reef," west of the Skaw. This specimen seems to have been taken from the stomach of some larger fish (probably a Cod or Ling) where it had some time undergone the process of digestion, for the skin together with all the fins and a great portion of the tail has been digested, the hindmost of the remaining vertebræ being quite bare. In its present condition the specimen is 188 mm. long, the greatest depth of the body 11 mm., the length of the head 23 mm., the length of the lower jaw 13 mm., the longitudinal diameter of the orbit 4·5 mm., the length of the eye-ball 3·6 mm., the postorbital length of the head 16 mm., and the distance between the tip of the snout and the vent 29 mm. To judge by the length of the head the specimen, when perfect, has been only slightly smaller than the one described by COLLETT. The latter specimen was 225 mm. long: it was found in March, 1881, floating at the surface off Rövaer, outside Stavanger Fjord, and forwarded by Dr. JENSEN to Bergen Museum. These two specimens are up to the present the only finds of the species within the limits of the Scandinavian fauna. According to COUCH (l. c.) the distinguished collector and observer THOMAS EDWARDS found 6 small examples of this species, between 6 and 7 cm. long, in March, 1863, on a sandy bottom off the coast of Banff. They moved through the water, he wrote, like Pipe-fishes, but never attempted to hide among seaweed or under stones, preferring to keep to the sand, where they would lie for hours with the body in an undulating or curved position.

FAM. LYCODIDÆ.

Body elongated, more or less anguilliform, in front terete, behind compressed, naked or covered with thin cycloid scales. All the vertical fins confluent: no separate caudal fin. Jaws (sometimes the palate as well) armed with teeth. Gill-openings vertical and small, the branchiostegal membranes coalescing below with the skin and forming a broad isthmus. Pseudobranchiæ distinct. Air-bladder wanting. Pyloric appendages usually wanting, but sometimes present in a rudimentary form.

This family, which we here range last among the *Anacanthini*, occupies a singular intermediate position between other types. ARTEDI[a] and LINNÆUS[b] referred the only species that they knew, the Eelpout or Viviparous Blenny, to the genus *Blennius*: GISLER[c], the first to discover the occurrence of this species in Scandinavia, regarded it as an intermediate form between *Blennius* and *Ophidion*. CUVIER[d] adhered to ARTEDI's opinion, and REINHARDT[e], the first describer of the types of the second division of the family, acknowledged that *Lycodes* ought to be referred to CUVIER's *Malacopterygii thoracici*, but still ranged the genus beside the Blennies, on the grounds that it was a link between *Anarrhichas* and *Zoarcaeus* (*Enchelyopus*), which latter genus "evidently was an offshoot of the Gadoid family." The same reasoning recurs in MÜLLER[f], who united the *Lycodidæ* to the *Blenniidæ* on account of the pseudobranchiæ. LILLJEBORG[g] has grouped together the osteological characters that separate the *Lycodidæ* from the *Gadidæ*. We notice in particular the absence in the former of the two characteristics of the latter that we have mentioned above, namely the great extent of the styloid bone (a character which is also wanting, however, in the Sand-Eels) and the lobate process on the hind part of the upper margin of the intermaxillary bones (which is also wanting in the Ophidioids). By the majority of their characters, however, the Lycodoids are joined to the other *Onomorphi* as Malacopterygian

[a] *Syn. Pisc.*, p. 45.
[b] *Fn. Suec.*, ed. II, p. 113.
[c] Vet.-Akad. Handl. 1748, p. 42.
[d] *Règne Animal*, ed. II, tome II, p. 240.
[e] Danske Vid. Selsk. Naturv., Math. Afh., Deel 7, p. 147.
[f] Abh. Akad. Wiss. Berlin 1844, p. 165.
[g] *Sveriges och Norges fiskar*, part II, p. 17.

fishes (cf. above, p. 211): they seem to be especially closely allied to an Australian genus among the Ophidioids[a] that has received of GÜNTHER[b] the name of *Congrogadus* and resembles the Lycodoids in the form of the body, the form of the fins, and the absence of the air-bladder.

GILL was the first to give the family its present definition. About 20 or 30 species are recognised and distributed among 8 genera.

GENUS **ENCHELYOPUS.**

Dorsal fin furnished behind with a depression, the rays within which are short and spinous. Ventral fins jugular and rudimentary, with 3 or 4 rays. Palatine and vomerine teeth wanting.

The genus of the Eelpouts, known in its European species since the time of SCHONEVELDE (1624), first excited attention on account of its reproducing itself by the birth of living, viable young. It is equally remarkable, however, for the development of spinous rays at so unusual a spot, corresponding to the posterior part of the dorsal fin in the Sea-cat (cf. above, p. 231) or to the upper margin of the caudal fin in other fishes, a spot where spinous rays also occur.

The oldest post-Linnaean generic name, *Enchelyopus*[d], was adopted by GRONOVIUS in 1763[e] from KLEIN, in whose works it contained a most heterogeneous medley of fishes. The name given by GRONOVIUS was however forgotten, though VALENCIENNES gave a reference to it[f], until it was restored in 1863 by GILL[g]. The genus has been best known by the name of *Zoarces*[h], which was given it in 1829 by CUVIER[i], or *Zoarceus*, as NILSSON wrote the word[j].

The genus belongs exclusively to the seas of the Northern Hemisphere and contains only two species, which are very closely related to each other, one from Europe and one from North America.

THE EELPOUT (SW. TANGLAKEN).

ENCHELYOPUS VIVIPARUS.

Pl. XII, fig. 1.

Rays of the anal fin less than 100. Body slimy and covered with thin, oblong, rounded, cycloid scales, depressed in the skin. Coloration greenish yellow or yellowish brown (lighter on the belly and the under surface of the head) marked across the dorsal fin and the back with dark brown transverse bands, which are more or less distinctly branched below and meet or alternate with a row of similarly coloured spots on the lower part of the sides.

R. br. 6; *D.* (72—80)+(6—10)+(16—21); *A.* 80—88[k]; *P.* 19; *V.* 3; *Vert.* 108—111.

Syn. *Tertia Mustelarum species*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 49; *Mustela Lumpen Antverpiæ dicta*, WILLUGB., *Hist. Pisc.*, p. 120; ART., (*Mustela*), *Gen. Pisc.*, Append., p. 83; (*Blennius*), *Syn. Pisc.*, p. 45; GRONOV., J. F. (*Blennius*), *Act. Upsal.* 1742, p. 87; LIN., *It. Wgoth.*, p. 182; GISL., l. c.; GRONOV., L. T., *Mus. Ichthyol.*, p. 65. *Blennius viviparus*, LIN., *Mus. Ad. Frid.*, p. 69, tab. 32, fig. 3; *Syst. Nat.*, ed. X, tom. I, p. 258; *Fn. Suec.*, ed. II, p. 113; MÜLL., *Zool. Dan.*, tab. LVII; RETZ., *Fn. Suec. Lin.*, p. 325; CUV. (*Zoarces*), l. c.; NILSS. (*Zoarceus*), l. c.; EKSTR., Vet.-Akad. Handl. 1834, p. 48; FLMNG (*Gunnellus*), *Brit. Anim.*, p. 207; CUV., VAL. (*Zoarces*), *Hist. Nat. Poiss.*, vol. XI, p. 454; FR., EKSTR., v. WR. (*Zoarceus*), *Skand. Fisk.*, ed. I, p. 36, tab. 8, fig. 1; PARN. (*Zoarces*), Mem. Wern. Soc., vol. VII, p. 337; KR., *Danm. Fiske*, vol. I, p. 355;

[a] *Macharium*, RICHARDSON, *Voy. Ereb., Terr., Ichthyology*, p. 72, tab. 44, figs. 1—6.

[b] *Cat. Brit. Mus., Fish.*, vol. IV, p. 388; *Intr. Stud. Fish.*, p. 550.

[c] Proc. Acad. Nat. Sc. Philad. 1862, p. 501 and 1863, p. 254.

[d] Eel-like, from ἔγχελυς and ὤψ.

[e] *Zoophyl.*, p. 77. As early as 1760 (Act. Helvet., IV, p. 259) GRONOVIUS applied it to the Eelpout, but then without characterizing the species.

[f] CUV., VAL., *Hist. Nat. Poiss.*, vol. XI, p. 452.

[g] Proc. Acad. Nat. Sc. Philad. 1863, p. 256.

[h] Ζωαρκής, *life-preserving.*

[i] *Règne Anim.*, l. c.

[j] *Prodr. Ichth. Scand.* (1832), p. 104.

[k] Sometimes 89, according to MOREAU.

NILS. (*Zoarcaeus*), *Skand. Fn., Fisk.*, p. 203; SUND., Stockh. L. Hush. Sällsk. Handl., H. 6 (1855) p. 80; GTHR. (*Zoarces*), *Cat. Brit. Mus., Fish.*, vol. III, p. 295; MGRN, *Finl. Fiskfn.* (disp. Helsingf. 1863), p. 21; LINDSTR. (*Zoarcaeus*), *Gotl. Fisk.*, Gotl. L. Hush. Sällsk. Årsber. 1866, p. 15 (sep.); STEIND., Stzber. Akad. Wiss. Wien Naturw. Math. Cl. LVII, I (1868) p. 676; COLL. (*Zoarces*), Forh. Vid. Selsk. Christ. 1874, Tillægsh., p. 78; MALM, *Gbgs. Boh. Fn.*, p. 473; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 23; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 80; DAY, *Fish. Gt. Brit., Irel.*, vol. I, p. 241, tab. LXI, fig. 2; MOR., *Hist. Nat. Poiss. Fr.*, vol. II, p. 156; MELA, *Vert. Fenn.*, p. 292, tab. IX; MÖB., HCKE, *Fisch. Osts.*, p. 61; LILLJ., *Sv., Norg. Fisk.*, vol. I, p. 552; HANSEN, *Zool. Dan., Fiske*, p. 49, tab. VIII, fig. 2; BNCKE, *Handb. Fischz., Fischer.* (M. V. D. BORNE) p. 92.

Blennius Lumpenus, LIN., *Syst. Nat.*, l. c., — ex ART. et WILLUGHB.

Obs. The only constant character we have been able to discover, to distinguish between the European and American Eelpouts, lies in the number of the fin-rays. This character is evidently connected with a greater elongation of the hind part of the body in the American form (*Enchelyopus anguillaris*), especially as this form appears in a specimen 40 cm. long which the Royal Museum has received through the Smithsonian Institution. TODD's figure in BROWN-GOODE (*The Fisheries and Fishery Industries of the United States*, Section I, Plate 67) shows, however, that in this respect the variations may be great in both forms. Even among our Scandinavian Eelpouts it seems to be possible to distinguish between two forms. The first of these forms by the more slender form of the body represents the most advanced development of the male characters, like the American species, has the beginning of the dorsal fin situated further forward (its distance from the tip of the snout less than 16 % of the length of the body), and in several other respects shows traces of the persistency of the juvenile characters. This form occurs, according to the collections of the Royal Museum, on the coast of Finmark and off Kola Peninsula. In the second form, a southern one, which the Museum possesses both from Bohuslän and the Baltic, the region of the anal fin is generally shorter, the head larger, and the beginning of the dorsal fin situated further back. For the sake of brevity we refer the reader to the following table of averages.

	One specimen of *Enchelyopus anguillaris* 399 mm long from Gloucester, Mass.	Average in: 3 specimens from Kola Peninsula between 93 and 108 mm long	3 specimens from N. Finmark and Kola Peninsula between 125 and 201 mm long	4 specimens from the Baltic and Bohuslän between 56 and 92 mm. long	6 specimens from the Baltic and Bohuslän between 218 and 251 mm long	2 specimens from the Baltic respectively 317 and 382 mm long
Length of the body expressed in millimetres	399	99	161	73	226	349
Distance between the dorsal fin and the tip of the snout in % of the length of the body	11.1	14.2	15.1	16.7	17.2	17.0
" " " " " " " " " " " " " " " " distance between the beginning of the anal fin and the tip of the caudal fin	21.1	21.8	24.1	26.6	29.0	28.9
Postorbital length of the head in % of the length of the body	9.5	9.3	9.6	10.3	10.9	10.8
" " " " " " " " " " distance between the beginning of the anal fin and the tip of the caudal fin	11.2	14.4	15.5	16.3	18.1	18.4
Distance between the beginning of the anal fin and the tip of the caudal fin in % of the length of the body	67.0	64.9	62.3	63.0	59.1	58.7

The ordinary length of our common Eelpout is about 30 cm., but we have received specimens from the island-belt of Stockholm that were nearly 40 cm. long. Further south the Eelpout seems to attain a greater size; PARNELL mentions specimens taken off Berwick (at the mouth of the Tweed) that were nearly 2 ft. (61 cm.) in length[a]. The females attain a greater size than the males.

In the form of the body the Eelpout is most like the common Burbot. The depth of the body at the beginning of the anal fin in young specimens (less than 1 dm. long) measures about $8^1/_2$—$9^1/_2$ % of the length of the body, in older specimens about $9^1/_2$—$11^1/_2$ % thereof. The head is small, its length in adult Eelpouts being about 18 or 19 % of that of the body. Underneath it is flat, above rounded, with tumid cheeks and with forehead somewhat compressed laterally and sloping in a steep curve towards the snout. The mouth is of moderate size, with rounded jaws and very tumid lips, which are wrapped round the jaw-bones and entirely cover them. The upper jaw is protrusile to some extent, though only slightly. Both the jaws are of the same length and furnished with conical, small but strong teeth, with rather blunt tip[b]. In the upper jaw these teeth are set in two rows, the anterior (outer) fairly regular and containing about 12 teeth on each of the intermaxillary bones, the posterior (inner) less regular, with shorter teeth, and ending usually at the root of

[a] The American form sometimes attains a length of $3^1/_2$ ft. (107 cm.) and a weight of 12 lbs. (5 kgm.), according to STORER (Mem. Amer. Acad. Arts, Sc., N. Ser., vol. V, p. 264).

[b] The teeth of the American *Enchelyopus* are green, coarser, and still blunter, reminding us strongly of those of the Sea-cat.

the 7th or 8th tooth in the anterior row. In the lower jaw the form of the teeth is the same, and they are set in almost the same manner; but the posterior row is somewhat longer and ends only a little sooner than the anterior row. There are no teeth on the palate or the tongue, which is flat, rounded, and fleshy, but scarcely free at all. The palatal folds within the jaws are well-developed, but not at all deep. In the pharynx we find above on each side three small, transversely-set pharyngeals, set with short, conical teeth in more or less curved rows, convex in front, the middle pair of pharyngeals with two rows of teeth, the anterior[a] and the posterior pairs with only one. The lower pharyngeals are longer, pointed at both ends, and furnished with three longitudinal rows of short and blunt teeth. The gill-rakers are scattered — 16 on each of the first pair of branchial arches — and resemble short, pointed papillae, each with a small, sharp, osseous spine within it. The branchiostegal membrane is united underneath to the corresponding membrane on the other side, but coalesces entirely with the skin of the isthmus (the breast), leaving no free margin behind, though the margin may be distinguished. The gill-openings extend downward somewhat beyond the lower end of the insertions of the pectoral fins and are separated from it by a distance about equal to the length of the snout; while above they reach over a part of the upper margin of the operculum, the skin of which is prolonged behind into a blunt point. The eyes are comparatively small, rather prominent, and set in front of the middle of the head and high up, the distance between them being about equal to the breadth of either eye. They lie in planes that converge somewhat in a forward and upward direction. The nostrils, one on each side, are set as in the Sea-cat at about the middle of the length of the snout, and resemble fairly high, flexible, dermal tubes with even margin. The eye is surrounded as usual by a ring of muciferous pores, belonging to the cephalic system of the lateral line. One of these pores, the second in the frontorostral branch of this system of ducts, has been regarded as a posterior nostril. The first pore of this branch lies just in front of the nostril. Through both these pores a fine hair may be passed into the duct beneath the skin, far back and above the eyes. The lower jaw is also coasted by a row of similar and distinct pores.

The body proper (the trunk) is cylindrical, with pendent belly, especially in gravid females. The Eel-like tail, which ends in a point, is strongly compressed laterally. During life the fish is coated with a thick layer of mucus, partly concealing the thin, scattered scales, which lie depressed in the skin without touching each other. These scales are almost circular or oblong, and smooth-margined, with fine, concentric striae, in the outer part dense, in the inner part (nearer the nucleus) scattered, and grooves radiating in all directions. The lateral line is not very distinct. The head is scaleless.

The vent lies just in front of the beginning of the anal fin, a little in front of the middle of the body (cf. the above table), and further forward in young specimens, as in the American form, than in old. Behind it is furnished with a papilla, most distinct in the males, similar to that we have above remarked in the Cottoids.

The dorsal fin is low, begins just behind the occiput (cf. the above table), and extends, imperceptibly diminishing in height, back to the extreme end of the tail; but a little in front of this point it shows a more or less broad depression or incision, which is supported by spinous rays, an extremely singular variation of the other soft rays, and characteristic of this genus. The number of these spinous rays varies between 6 and 10[b]. In front of the depression the dorsal fin contains about 80 rays, all weak and articulated, and all, with the exception of the first rays, branched at the tip. These rays are united by a fairly thick, slimy skin, which is strewn at the base of the fin with scales similar to those which clothe the body. These scales extend higher up in the posterior part of the fin than in the anterior. The anal fin is of exactly the same structure, form, and extent in a backward direction as the dorsal; but is without any incision, coalescing completely and without the least break with the caudal fin. At the base the anal fin is strewn with scales in the same manner as the dorsal. From 70 to 80 rays may be counted with tolerable ease; but behind these the remaining rays lie so close to each other that their number can hardly be fixed with certainty.

The pectoral fins are fairly large — their length from the upper angle of the fin varying between 11 and 13 % of that of the body — and broad, with rounded

[a] EKSTRÖM and FRIES have seen two rows of teeth on the anterior pair as well.

[b] In the American *Enchelyopus anguillaris* their number may rise to at least 16.

tip. They are made up of 19 branched rays and a thick membrane. The ventral fins are rather small and lie close to each other, in front of the pectoral fins. They contain 3 rays, which are branched at the tip and very difficult to distinguish.

The only external difference between the sexes that we have been able to discover, is that the males are generally smaller and more slender than the females.

The coloration of the Eelpout is not very diversified. The ground-colour of the entire fish is yellowish brown, the under surface of the head and belly being grayish yellow. On the sides of the body, back to the depression in the dorsal fin, we find two rows of more or less distinct transverse spots, 13—15 in each row. The spots of the lower row alternate more or less regularly with those of the upper and at the upper corner touch the latter, which advance some way over the dorsal fin. Behind the incision in this fin the spots grow gradually less distinct towards the end of the tail. The outer rim of the dorsal fin is black. The outer margin of the anal fin is flame-yellow, like the tips of the ventral fins. The pectoral fins are darker than the others and edged with more dirty yellow. Several blackish spots occur on the upper part of the head, between the eyes and the tip of the snout, and on the cheeks, growing rather more indistinct on the gill-cover. The iris is dark brown, with a fine, light yellow ring round the pupil.

The internal organs remind us more of the *Cotti* than of the Cods. The œsophagus and stomach are short, the bottom of the latter extending hardly beyond a line with the middle of the pectoral fins when folded, and bending downwards to form a short pyloric part, turned in a forward direction, at the end of which we find two short, saccate bulbs or rudimentary pyloric appendages, one on each side. At the middle of its length the intestine forms a winding bend, a curved double coil. At first sight the liver seems to consist of one single lobe, which curves upwards and surrounds the small gall-bladder, the stomach, and the œsophagus; but this lobe is divided distinctly enough into three parts, with the middle (outermost) lobe shortest and the right lobe longest. The spleen lies just behind the bottom of the stomach and is small and flat, at the upper (dorsal and also left) end pointed, at the lower end rounded. The air-bladder is wanting. The testes of the male are smooth and oblong, lie close to each other, and at the spawning season grow far forward, close to the kidneys. The most remarkable of the internal organs of the Eelpout is the ovary of the female. On opening a female which is not gravid we find the ovary, which is simple and of oval form, lying right under the kidneys and along the spinal column. It is of thin texture and partly filled with yellow eggs of the size of a pin's head. On examining the ovary after the beginning of the period of gestation, when the ovary serves as a uterus, we find the walls firmer and penetrated by a great number of bloodvessels, while to the inner surface are attached small, oblong, transparent vesicles, which contain a clear fluid and a tiny embryo floating in the fluid. At the last stage we find the sac enormously distended and full of closely packed young specimens lying free within the ovary itself. The vesicles have collapsed, but are still attached to the walls. During this period we generally find a great number of the young expelled into the abdominal cavity itself by the bursting of the ovary. In a female 31 cm. long we have found altogether 196 young, each 37 mm. in length. Seventy-five of them lay in the abdominal cavity, the rest within the ovary. In another female, 322 mm. in length, we have counted 262 young. Other writers state the number of the young at over 300.

The Eelpout seems to arrive at maturity early, for distinct eggs have been found in specimens only 15 cm. long. Its faculty of giving birth to living young presupposes an actual copulation between the sexes, as well as the fertilization of the eggs within the body of the mother. However, no such copulation has yet been observed; nor can any certain time of year positively be given as the spawning-season of the Eelpout, for at almost all seasons we may find gravid and parturient females and at the same time others that contain only small eggs. The former are most often met with, however, in December and January. This agrees with BENECKE's statement (l. c.) that during the spring and summer months — from March to August — the males have bright orange fins and wear a kind of festal dress.

BREHM has observed in a salt-water aquarium the manner in which the Eelpout gives birth to its young. "The fish," he says[a], "which even at other times is sluggish, seeks a certain spot in the aquarium several hours before parturition and stays there motionless, until all

[a] BREHM's *Thierleben*, 2:te Aufl., *Die Fische*, p. 138.

or at least most of the young have been excluded. The fry creep forth, head first, one after another, and sink down to the right and left of the tail of the mother-fish, which she keeps in a somewhat elevated position. Now that they have reached the bottom, they lie there several hours, perhaps a whole day, without perceptibly moving or rising. If there are several Eelpouts in the same aquarium, one may observe, to one's surprise, two or more of them swim close up to the mother-fish and press her on both sides, apparently to assist the operation, but in reality only to devour the young as soon as they appear. The mother does not hesitate to follow their example if she is not sufficiently supplied with other food. In most cases the Eelpout brings forth all her young at a birth; but it sometimes happens that only a part of them are born at first and the rest, or even only some of the rest, one or more days later[a].

The food of the Eelpout consists chiefly of mollusks, crustaceans, and worms, but also of small fishes. It lives in water of moderate depth on shores where it finds a stony bottom overgrown with seaweed. Hence it is known as *Tanglake* or *Stenlake* (*tang*, tang, *lake*, Burbot), which are its ordinary names on the coast of the Baltic, where its outward resemblance to the Burbot has thus attracted most attention. In other localities its slight likeness to the Eel and the long-known fact that, unlike most of the Teleosts, it brings forth its young alive, have given rise to the ancient and popular belief that the Eelpout is the mother of the Eel, and have bestowed upon it various names. Thus, in German it is still called *Aalmutter*, in Danish *Aalekone*, *Aalemoder*, or *Aalekus*, and in Bohuslän generally *Alkussa* or simply *Kussa*. Its manner of life has also contributed in a high degree to its comparison with the Eel. It lives in scattered and solitary specimens, is found everywhere, but seldom in numbers, and conceals itself under stones, among seaweed, and in crevices in the bottom. All round the coasts of Scandinavia it is common, from Varanger Fjord[a] along Norway and Sweden into the Baltic and up to the island-belt of Tornea. On the Danish coast and on all the coasts and banks of the North Sea the Eelpout is a common fish; but west and south of the English Channel it is rare, though STEINDACHNER states (l. c.) that it has been met with in the neighbourhood of Cadiz. The Eelpout also makes its way occasionally into fresh water. It has been taken for instance, according to BREHM, in the Havel off Spandau.

The flesh of the Eelpout is firm, white, and in flavour not unlike that of the Eel. Still it is not eaten in many places, a circumstance which seems to be due entirely or at least most usually to the green colour of the bones, which becomes deeper and deeper during the process of boiling and excites the groundless suspicion that the flesh is poisonous. There is no special fishery for the Eelpout: it is taken only by accident and generally while the fisherman is drawing the seine for other fish. (EKSTRÖM, FRIES, SMITT.)

GENUS **LYCODES**.

Vertical fins similar in structure throughout their length. Ventral fins jugular and rudimentary, with 2—6[b] rays. Jaws, palatine bones, and the head of the vomer furnished with teeth.

This genus, which was founded in 1831 by V. REINHARDT[c], is extremely closely allied to the preceding one in form and the changes of form as well as in the distribution of colour on the body. Externally the absence of the depression in the margin of the dorsal fin is a readily perceivable difference from the Eelpouts, but both genera are identical in all other respects, if we except the more backward beginning of the dorsal fin in *Lycodes*, where the distance between the beginning of this fin and the tip of the snout is always

[a] The Royal Museum has received from the White Sea through Lieutenant H. SANDEBERG an Eelpout 19 cm. long which is remarkable for the extraordinary height of the anterior part of the dorsal fin.

[b] The latter number in *Lycodes macrops*, according to VAILLANT, who, however, describes these rays as simple (*Exped. Scient. du Travailleur et du Talisman, Poiss.*, p. 307), while in other species they are known to be branched.

[c] Overs. Vid. Selsk. Forh. *Kbhvn* 1830—31, p. LXXIV. It was not until 1858 — Naturv., Math. Afh., Deel VII, p. 147, published by the same society — that the genus was completely determined and characterized. The name of *Lycodes* (wolflike, Gr. *λύκος*) is derived from the resemblance of the fish to *Anarrhichas lupus*.

perceptibly more than half (at least 55 %) of the distance between the anal fin and the latter.

The changes caused by age in the coloration of *Lycodes* are extraordinarily great. All the fry — with the exception of one species — are adorned with a handsome, regular marking (see for example figs. 148 and 150) of selliform, dark-margined spots across the dorsal fin and the back. On the hindmost part of the tail these spots are generally prolonged downwards, forming transverse bands across the dorsal fin, the body, and the anal fin. The spaces between the spots grow lighter and lighter, being sometimes milk-white on the dorsal fin and the back, and the same light colour sometimes appears in the form of an ocellated spot within one or another of the selliform spots. With age, however, these selliform spots coalesce below, and the boundary between them and the coloration of the rest of the body is effaced, being sometimes replaced by a network of darker colour, starting from the original dark-coloured margin of the spots. These changes of coloration are also common to other kindred genera within the family, and strongly remind us of the distribution of the spots in the Eelpouts, in all its irregularity.

The dentition of the palatine bones and of the head of the vomer in *Lycodes* — a character which is wanting in the Eelpouts — is here counterbalanced by a negative character, the absence of transverse palatal folds behind the rows of teeth in the jaws. The nostrils are simple and tubular in this genus also, but the snout is more elongated and of a looser structure, this being due to the still greater development of the cavities belonging to the cephalic system of the lateral line. The extension of this system over the body is singular enough. No less than three lateral lines may appear on each side of the body — but, as far as we know, no more than two in the same individual. These lines are generally wanting in young specimens and are again effaced in old. In most cases two lateral lines start from each temporal region, one — corresponding to the ordinary mediolateral line — in a slight curve downwards to the middle of the side, or even down to the anal region and then along the base of the anal fin, the other — a dorsal line — usually with larger but more scattered pores and seldom extending farther than to a line with the vent or a little behind it. Sometimes again a ventral branch starts from the anterior part of the mediolateral line, its structure being the same as that of the latter. LÜTKEN, who was the first[a] to draw attention to all these differences, based upon them a system of determining the species within the genus; but GÜNTHER has pointed out[b] the systematic difficulties involved in a strict adherence to characters derived from this relation, characters which at different ages and in different individuals show variations, the cause of which is as yet unknown, and which also in many cases defy observation. GÜNTHER passes the same judgment upon the characters which have been drawn from the extent of the scales in these fishes.

Ever since RICHARDSON described his *Lycodes mucosus* from Northumberland Sound[c], we have known that scales may be wanting within this genus in individuals up to a length of 28 cm. In 1874[d] BLEEKER founded the genus *Lycodalepis* to emphasise this character, which, according to BEAN[e], may be persistent in the species just mentioned even at a length of 43 cm. However, to the best of our judgment and with the knowledge we now possess of the changes of growth and sexual differences within the genus, this species can scarcely be distinguished, except perhaps as a local variety, from *Lycodes Turneri*, the form described by BEAN[f] and TURNER[g] from Alaska, or from the form brought home by the Vega Expedition[h] from the entrance of Chatanga Bay (Siberia, E. of Cape Tscheljuskin). The latter form is in all probability identical with the form subsequently described by LÜTKEN[i] under COLLETT'S name of *Lycodes Lütkenii*, which GÜNTHER

[a] Vid. Meddel. Naturh. For. Kbhvn 1879—80, p. 329. KRÖYER, however, had already remarked a dorsal and a mediolateral line in his *Lycodes perspicillum* (Naturh. Tidskr. Kbhvn, ser. III, vol. I, (1862), p. 292).

[b] *Deep Sea Fish.*, Chall. Exped., p. 79.

[c] *The Last of the Arctic Voyages*, vol. II, p. 362.

[d] Versl., Med. Akad. Wet. Amster., 2 R., 8 Del, p. 369.

[e] Bull. U. S. Nat. Mus., No. 15, p. 113.

[f] Proc. U. S. Nat. Mus., vol. I, p. 463.

[g] *Contrib. Nat. Hist. Alaska*, Arct. Ser. Publ. Sign. Serv. U. S. Army, No. II, p. 93, Pl. 4.

[h] Gr. Intern. Fisher. Exhib. London 1883, Swed. Catal., p. 176.

[i] *Kara-Havets Fiske*, Dijmphna-Togtets Zool.-bot. Udb., p. 14, Tab. XVI. In the largest of these specimens LÜTKEN remarked a considerably greater number (13—15) of palatine teeth than in *Lycodes mucosus* (7, both according to RICHARDSON'S figure and in the specimen from Chatanga Bay). But the great resemblance in other respects between these nominal species forces us to the conclusion that this difference is individual and may depend on circumstances of age or sex, unless indeed it belongs to a local variety.

had unhesitatingly referred to the old Reinhardtian species *Lycodes reticulatus*. This form, which belongs to Kara Sea, is furnished when 225 mm. long, according to LÜTKEN, with scales over the whole tail and the greater part of the back behind the beginning of the dorsal fin; but the above-mentioned specimen from Chatanga Bay, which we proposed in 1882 to refer to *Lycodes mucosus*, is entirely scaleless at a length of 246 mm. The individual variations in this respect seem to be so great that we must abandon the attempt to base the determination of the species upon the presence or absence of scales. No more reliance can be placed on the proposed determination — here as in the Gobies — based on the greater or less extent of the scaly covering in a forward direction, over the trunk and head, in those forms which are furnished with scales at an early age and retain them at all subsequent ages.

The differentiation of the species within this genus from each other is a more advanced development of the specific difference which seems to be present, but can scarcely be regarded as fixed, within the preceding genus. A trace of the most essential difference between the European and the American Eelpout may be found, as we have seen above, in the two forms that can be distinguished with tolerable ease among the European Eelpouts, and may be reduced to a greater or less elongation of the caudal part of the body, in combination with a greater or less number of vertebrae. So also within the genus *Lycodes* we can distinguish between two main groups of forms, the first with comparatively shorter body, like that of the Eelpout or even deeper than it, the second with exceedingly elongated, more Anguilliform body. Within these groups the most general specific difference lies in the same relation, conjoined with the varying size of the head, originally a distinction of sex and age, for the relative length of the head generally increases with age and is always greater in the males than in the females.

The genus is composed exclusively of deep-sea fishes, most of them living at depths of from 300 to 500 fathoms or more, and at least one species taken in 1,333 fathoms of water. During youth, however, they are met with nearer land and in shallower water, sometimes at a depth of only 50 or 30 fathoms. For the scientific elucidation of these forms we have principally to thank COLLETT and LÜTKEN. To the generality of fishermen the genus is unknown, and it has no popular name; LILLJEBORG has proposed the Swedish names of *ålbrosmar* or *ållubbar* (Eel-Torsks).

The species that belong to the Scandinavian fauna may be distinguished in the following manner:

A: Depth of the body at the beginning of the anal fin more than 8 % of its length. Branchiostegal rays 6
- *a*: Body plain, without spots . . . *Lycodes frigidus.*
- *b*: Coloration light with dark-edged, selliform spots in the fry, in adult specimens dark with light transverse spots or light with dark transverse spots
  - *α*: Length of the head more than 39 % of that of the tail from the beginning of the anal fin to the tip of the last fin-rays . . . *Lycodes reticulatus.*
  - *β*: Length of the head less than 39 % of that of the tail from the beginning of the anal fin to the tip of the last fin-rays . . . *Lycodes Vahlii.*

B: Depth of the body at the beginning of the anal fin less than 8 % of its length. Branchiostegal rays 5.
- *α*: Length of the head at least about $^1/_4$ (more than 23 %) of that of the tail from the beginning of the anal fin to the tip of the last fin-rays . . . *Lycodes Sarsii.*
- *β*: Length of the head at most about $^1/_5$ (scarcely more than 20 %) of that of the tail from the beginning of the anal fin to the tip of the last fin-rays . . . *Lycodes muraena.*

LYCODES FRIGIDUS.

Fig. 146.

Coloration plain, reddish gray-brown. Body in quite full-grown specimens entirely covered with scales forward to the head and a little way over the bases of the vertical fins, in younger specimens naked on the middle of the belly, on the fins, and on a strip along their bases. Depth of the body at the beginning of the anal fin in adult specimens $10\frac{1}{2}$—11 % of the length of the body. One ventro-lateral line, continuous and with dense pores; one dorso-lateral line, with scattered pores (both often indistinct). Head depressed (flattened) in front; its length more than $\frac{1}{2}$ the distance between the anal fin and the tip of the snout, and in quite full-grown specimens (more than 3 dm. in length) 42—47 %, in younger ones 35—42 %, of the length of the tail from the beginning of the anal fin to the end of the last fin-rays.

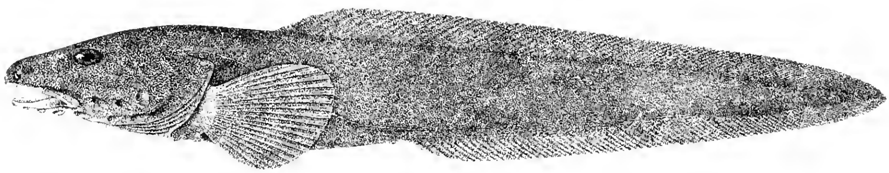

Fig. 146. *Lycodes frigidus*, from the Norwegian Arctic Expedition. $\frac{1}{2}$ the natural size. The property of the Museum of Christiania University.

R. br. 6; *D.* 99—104; *A.* 85—90; *P.* 20—21; *V.* 2 (4?).

Syn. *Lycodes Vahlii*, COLL., Forh. Vid. Selsk. Christ. 1878, No. 4, p. 11.
Lycodes frigidus, ID., ibid., No. 14, p. 45; *Norsk. Nordh. Exped., Fiske*, p. 96, tab. III, figg. 23 et 24. LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 19; GTHR. *Deep Sea Fish.*, Challeng. Exped., part. LVII, p. 79.

This species is known almost exclusively from the collections of the Norwegian Arctic Expedition and COLLETT's description of them. It is said to attain a length of almost 51 cm. Its principal characteristic lies in the coloration, for in other respects it partly coincides with *Lycodes reticulatus* and partly ranks as an intermediate form between the latter and *Lycodes Vahlii*. To judge from our knowledge of the other species only male specimens, sterile or with the organs of generation at rest, have been found. In the other forms of this group of the genus the length of the head in the males is greater, in the females less, than half the distance between the anal fin and the tip of the snout. Our knowledge of *Lycodes frigidus* does not, therefore, preclude the possibility that by this specific name are designated a number of sterile and perhaps hybrid individuals of one or other of the two following species. Among the fifteen more or less adult individuals described by COLLETT all the younger ones, with the exception of the youngest (118 mm. long), are identical, according to the measurements given, in their most essential characters with *Lycodes Vahlii*, but the older specimens (more than 3 dm. long) with *L. reticulatus*[1]. It also seems no easy task to distinguish from *L. frigidus* the specimen 56 cm. long that GÜNTHER (l. c., p. 77 and Plate XIII) has referred to the last-mentioned species.

On the coast of Scandinavia only three specimens, all young, have been found. At first two specimens, respectively 37 and 62 mm. in length, were taken in the month of June by the Norwegian Expedition of 1887, on the banks off Helgeland and Lofoden, at depths of 350 and 157 fathoms and on a clayey bottom. A third specimen, 148 mm. in length, which is referred by the coloration to this species, but in other respects entirely agrees with the young of *Lycodes Vahlii*, was taken in 1889 by Dr. CARL AURIVILLIUS, in between 40 and 10 fathoms of water, on a clayey bottom at Orsta and Börsas in the inner part of Gullmar Fjord (Bohuslän). The other known specimens have been found in 260—1,333 fathoms of water, off the extreme north of Norway, Bear Island, and Spitzbergen. COLLETT gives a list of a number of crustaceans and some parts of a cuttle-fish as having been found in the stomach of this species, and remarks that several of the former belonged to such species as generally live in the surface regions of the open sea, but have thus been shown also to inhabit the deepest abysses of the ocean. All the specimens taken by the Norwegian Expedition, except one, were caught in ice-cold water; and it was this circumstance that suggested to COLLETT the name of *frigidus*. The expedition kept some of them alive for a time in a vessel on board. These specimens were extremely sluggish, preferring to lie still at the bottom of the vessel and in a bent position, like that usually assumed by the Eelpout and the Sea-snails. When thrown into alcohol, however, they became extremely violent and proved, like most bottom-fishes, to be extraordinarily tenacious of life.

LYCODES RETICULATUS.

Figs. 147 and 148.

Coloration in the fry more or less light, brownish yellow, with selliform spots on the trunk and tail and a scutiform figure, containing two light, frontal spots, on the top of the head, in older specimens orange or paler, with light or even white transverse bands between the darker ones on the trunk and tail and light or even white spots on the top of the head, in the oldest specimens of a more undiversified grayish brown, with the traces of the dark transverse bands on the sides and also the head crossed by a network of black streaks. The covering of scales appears at different ages and occupies different extents of the body, but when complete extends over the greater part of the trunk and tail, and of the base of the dorsal fin, leaving the head, the belly, the base of the anal fin, and the anterior part of the base of the dorsal fin naked. One medio-lateral and one dorso-lateral line (both often indistinct). Depth of the body at the beginning of the anal fin about 9—14 % of its own length. Head depressed in front: its length more than 39 % (as a rule 42—58 %) of the length of the tail from the beginning of the anal fin to the tip of the last fin-rays.

R. br. 6; *D.* (80) 91—95; *A.* (63) 70—78; *P.* (16) 19—23; *V.* 4; *Vert.* 95—97 (= 23—25 + *c*).

Syn. *Lycodes reticulatus*, REINH. D. Vid. Selsk. Naturv., Math. Afh. Kbhvn, vol. 7, p. 167, tab. VI; GTHR, *Cat. Brit. Mus., Fish.*, vol. IV, p. 320; COLL., Forh. Vid. Selsk. Christ. 1878, No. 14, p. 59; LTKN, Vid. Meddel. Naturh. For. Kbhvn 1879—1880, pp. 318 et 330; GTHR, *Deep Sea Fish.*, Chall. Exped., part. LVII (Zool., vol. XXII), p. 77, tab. XIII; LTKN, Dijmphna-Togt. Zool. Bot. Udb., p. 136, tab. XVII, figs. 4—5.

[1] An estimates of the averages, according to COLLETT's measurements of these specimens, gives the following results:

Average in		Length of the body varying between 148 and 238 mm — 6 specimens	Length of the body varying between 270 and 570 mm — 9 specimens
Length of the head	in % of the length of the body	22.2	21.8
Depth of the body at the beginning of the dorsal fin	" "	10.7	14.[illegible]
Distance between the dorsal fin and the tip of the snout	" "	25.6	30.2
" " " vent	" "	39.[illegible]	44
Length of the head in % of the distance between the vent and the tip of the last fin-rays		37.0	44.7

Lycodes seminudus, Reinh., l. c., p. 223; Lütk., Vid. Meddel., l. c., p. 325; Coll., *N. Nordh. Exped., Zool., Fiske*, p. 113, tab. IV, fig. 28.

Lycodes perspicillum, Kr., Overs. Vid. Selsk. Forh. Kblvn 1844, p. 140; *Voy. Scand., Lap.* etc. (Gaim.) tab. 7; Naturh. Tidskr. Kblvn. ser. III, vol. 1, p. 289.

Lycodes mucosus, Richards., *Last. Arct. Voy.* (Belcher), vol. 2, p. 362, tab. XXVI. Bean, Proc. U. S. Nat. Mus., vol. 1, p. 465 (♂?); Id., Bull. U. S. Nat. Mus., No. 15, p. 112. Smitt, Gt. Intern. Fish. Exhib. London, 1883, Swed. Catal., p. 176.

Lycodes Rossi, Malm, Öfvers. Vet. Akad. Forh. 1864, p. 516.

Lycodes Turneri, Bean, Proc. U. S. Nat. Mus., vol. 1, p. 463 (♀?), ibid., vol. IV, p. 244 (*Turnerii*); Turner, *Contrib. Nat. Hist. Alaska*, Arct. Ser. Publ. Sign. Serv. U. S. Army, No. II, p. 93, tab. 4.

by the Knight Errant Expedition at a depth of 608 fathoms in Faroe Channel; and as the other finds extend all round the world in the extreme north, it is quite

Fig. 148. *Lycodes reticulatus, Rossii*, twice the natural size. Taken in 1861, in Treurenberg Bay, Spitzbergen, at a depth of 5 fathoms.

probable that some similar find may once be made in Scandinavian waters. The species seems to be capable of ascending fairly high towards the coast, for the Swed-

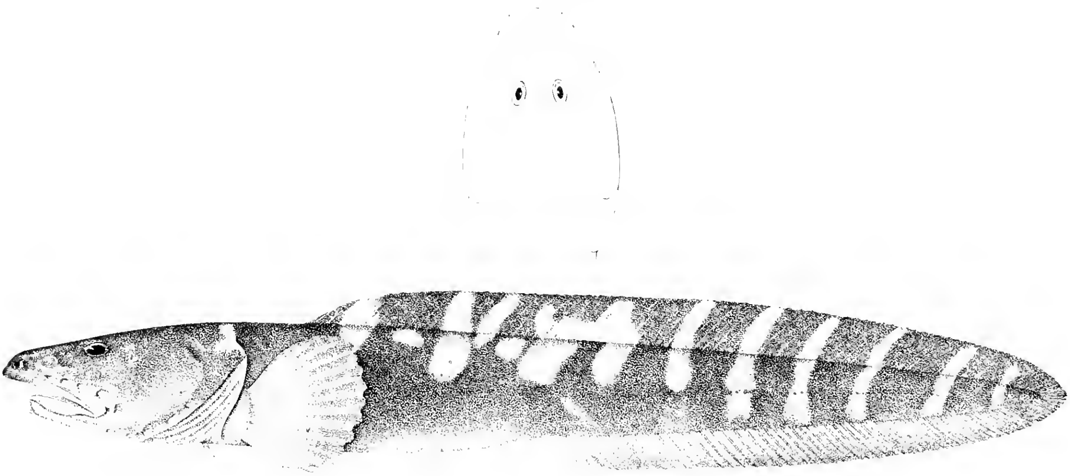

Fig. 147. *Lycodes reticulatus, Turnerii*. 3/4 of the natural size. From the entrance of Chatanga Bay (lat. 75° N.; long. 113° 30′ E. Gr.), 24th Aug., 1878; Vega Expedition.

Lycodes Lütkenii, Coll., *N. Nordh. Exped., Fiske*, p. 103, tab. III, fig. 25; Lütkn, Dijmph.-Togt, Zool. Bot. Udb., p. 128, tab. XVI.

? *Lycodes pallidus*, Lütkn, l. c., p. 134, tab. XVII, figg. 1—3 (nec Coll.).

? *Lycodes coccineus*, Bean, Proc. U. S. Nat. Mus., vol. 4, p. 144 (= *L. seminudus*).

From different regions in all parts of the Arctic Ocean a number of more or less diverging forms of this species have been described under different specific names. On the grounds already given, and if we take into account the great variations to which the majority of the specific characters hitherto adopted are demonstrably subject, these forms may well be comprised within one species, even if it should prove in the future that some one or other of them be constant. According to Günther (*Deep Sea Fishes*, l. c.), one of these forms was found

ish Spitzbergen Expedition of 1861 took a young specimen 33 mm. long in 5 fathoms of water in Treurenberg Bay, and the Vega Expedition found their specimen on a bottom of clay mixed with stones, at a depth of 15 fathoms in Chatanga Bay, where the bottom-temperature, however, was —0·8° Cels. (30·5° Fahr.). The numerous specimens found by the Dijmphna Expedition in Kara Sea were taken at depths of 46—106 fathoms. One of the two specimens which Krøyer received from Greenland, and which were taken with a dredge by Captain Holbøll, was 67 mm. long and was caught in 90 fathoms of water, the other 40 mm. long and caught in 30 fathoms of water. Of the older specimens which have come into the possession of Copenhagen Museum at different periods since the time of Reinhardt, Krøyer writes: "They are generally found in the stomach of Greenland Sharks[1] and other fishes that live at great depths. We may remark, as an exception, that one of the specimens was accompanied by the information that it had been caught at the surface, where it had been found in an exhausted state. It had probably been driven up from the bottom by some accident or other. The contents of the stomach of these specimens consisted chiefly of crustaceans. In the gape of the larger of his specimens KRØYER found a *Sipunculus*, an Annelid that lives in the loose bottom of the sea. It seems probable that the larger specimens — for the species may attain a length of at least 56 cm. — in general live on larger prey and more substantial food. COLLETT found in the stomach of his specimen, a female 37 cm. long, a partly digested *Cottunculus microps* 11 cm. in length and fragments of smaller fish, the species of which could not be determined.

LYCODES VAHLII

Figs. 149 and 150.

Coloration, which changes with age essentially as in the preceding species, brownish black, with the light transverse bands crossed in the older specimens with black streaks and spots or finally disappearing. The covering of scales varying as in the preceding species, but extending, when complete, forward over the occiput (sometimes with scattered scales on the forehead as well), on the belly to the ventral fins, on the vertical fins out to their margin, and over a third of the inner surface of the pectoral fins. One mediolateral and one ventro-lateral line (both often indistinct). Depth of the body at the beginning of the anal fin about $8^1/_2$—$13^1/_2$ % of its own length. Head convex even in front, its length less than 39 % (as a rule 30—38 %) of that of the tail from the beginning of the anal fin to the tip of the last fin-rays.

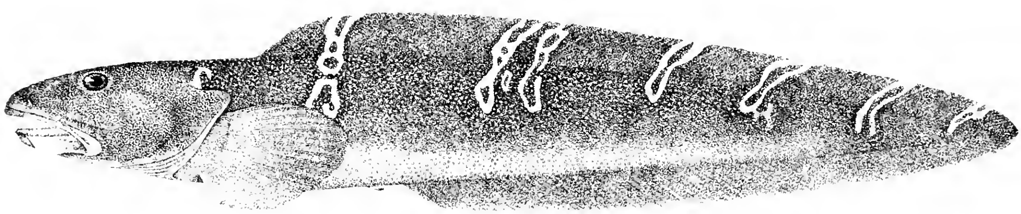

Fig. 149. *Lycodes Vahlii, Esmarkii*, $^1/_3$ of the natural size. Taken in Varanger Fjord on the 30th of May, 1882. The property of the Museum of Christiania University.

R. br. 6; *D.* (96) 100—118, *A.* (82) 90—102; *P.* 18—23; *V.* (3) 4—5. *Vert.* 112—118 (—23—25 + c).

Syn. *Lycodes Vahlii*, REINH., D. Vid. Selsk. Naturv. Math. Afh., vol. V, Overs. p. LXXV; ID., ibid., vol. VII, p. 153, tab. V. GTHR, *Cat. Brit. Mus., Fish.*, vol. IV, p. 319; ESM., Skand. Naturf. M. Christ. 1868, Forh., p. 524; COLL., Forh. Vid. Selsk. Christ. 1878, No. 4, p. 11 et No. 14, p. 54; LTKN, Vid. Meddel. Naturh. For. Kblhvn 1879—80, pp. 311 et 329; BR. G. et BEAN, Proc. U. S. Nat. Mus., vol. 2, p. 209; BR. GOODE, *Fisher., Fisher. Industr. U. S.*, Sect. I, pl. 67.

Lycodes gracilis, SARS, Forh. Vid. Selsk. Christ. 1866, p. 40, tab. I, figg. 1—3; COLL., *N. Nordh. Exped., Zool., Fiske*, p. 106.

Lycodes Esmarkii, COLL., Forh. Vid. Selsk. Christ. 1874, Tillaegsh., p. 95; LTKN, l. c., p. 316; COLL., *N. Nordh. Exped., Zool., Fiske*, p. 84, tab. II, figg. 19—21, tab. III, fig. 22; N. Mag. Naturv. Christ., Bd. 29, p. 73; LILLJ., *Sv., Norg. Fiskar*, vol. II, p. 6; GTHR, *Deep Sea Fish.*, Chall. Exped. part. LVII (Zool., vol. XXII), p. 77.

? *Lycodes pallidus*, COLL., Forh. Vid. Selsk. Christ. 1878, No. 14, p. 70; *N. Nordh. Exped., Zool., Fiske*, p. 110, tab. III, figg. 26, 27.

? *Lycodes lugubris*, LTKN, Vid. Meddel. Naturh. For. Kblhvn 1879—80, pp. 315 et 330.

The character that essentially distinguishes Esmark's *Lycodes* — as this species has been called in recent times — from *L. reticulatus*, lies in the greater elongation of the tail. With this character is connected the greater number of the vertebrae and also, in general, of the rays of the vertical fins. Here, as in the preceding species, however, the latter number is difficult to fix

[1] *Laemargus borealis.*

with certainty; and a more trustworthy expression of the character may always be found in the proportion between the length of the head and that of the tail. In its adult state this species is also better equipped with scales, though the variations seem to be quite as great as in the preceding species. On the grounds given above, and as constant characters of form are an indispensable condition of systematic clearness, we combine under one specific name the two forms, *Lycodes Vahlii* and *L. Esmarkii*, which have recently been distinguished on account of the difference in the dentition as stated by LÜTKEN.

In form the body resembles that of the Eelpout, with the characteristics common to all the *Lycodes*. The head, which with its flat under surface presents in the adult fishes the form of a cone longitudinally bisected and somewhat obtuse at the tip, generally measures in young specimens and in the females rather less, in the males rather more, than 22 % of the length of the body, varying in this manner between $18\frac{1}{2}$ and $23\frac{1}{2}$ % thereof. The only noteworthy irregularity in its conical shape is formed by the more or less tumid cheeks (the masticatory muscles). In young specimens the large muciferous cavities along the upper and lower jaws are especially distinct, generally in the form of hollow depressions; but in the older specimens these depressions disappear. On each side of the snout, at about the middle of its depth and nearer to the tip of the snout than to the eye, lies a single tubular nostril. The eye is oblong and not very sharply marked off from the surrounding skin, which coalesces with the transparent cornea. The length of the eye varies between about 7 % (in the fry) and 2 % of that of the body (the latter proportion in the most developed individuals). Its position is such that in the fry the postorbital length of the head measures about 44 % of its entire length, in adult specimens about 55 % thereof, with all the variations lying between these two percentages. The sides of the occiput end each in an obtusely pointed and triangular, opercular flap, which in old specimens lies a little above and behind the upper end of the root of the pectoral fin and sometimes measures at the upper, free margin nearly half the length of the remainder of the postorbital part. The lower angle of the gill-opening lies on a level with the lower angle of the pectoral fin and in a line with the preoperculum, the breadth of the isthmus between the two gill-openings being about equal to the length of the nose between the nostril and the eye. The length of the lower jaw varies, according to our measurements, between about 10 and $11\frac{1}{2}$ % of that of the body[*], and is generally somewhat less than in the preceding species. The cleft of the mouth is horizontal; it extends in young specimens hardly any distance, if at all, behind the perpendicular from the anterior margin of the eye, but in old specimens distinctly beyond this line. In old specimens the hind extremity of the maxillary bones lies in a line with the posterior part of the eye, the distance between the tip of the snout and this extremity measuring in the fry about 7 % of the length of the body, in old specimens up to at least $11\frac{1}{2}$ % thereof. This elongation of the labial parts involves a more advanced development of the teeth. The teeth in the jaws and on the palate are strong, almost cylindrical, more less curved, and rather scattered. They are largest in the anterior part of the intermaxillary bones and of the lower jaw, and are here set in old specimens in three or even four rows, in young in only two, the number of the rows decreasing behind until at last there is only one row or sometimes, in the lower jaw, two. The foremost teeth in the jaws are directed straight forward. The rows of intermaxillary teeth do not extend further back, even in old specimens, than to about a line with the middle of the snout, while in the lower jaw the rows extend beyond the corners of the mouth. On the other hand, the foremost intermaxillary teeth are set under the projecting part of the snout, in front of the tip of the lower jaw. On the head of the vomer we find from 5 to 8 teeth of more conical form, arranged transversely in a triangular group. On the palatine bones, according to COLLETT, *Lycodes Esmarkii* always has 9—11 teeth in a single or irregularly double row; while in *L. Vahlii*, according to LÜTKEN, these bones are set with 11—14 teeth in the females and with somewhat fewer than 20 in the males, always in a double row. Such is the tenour of the proposed specific distinction, or in other words: "The row of palatine teeth is never longer than the intermaxillary row, but in most cases (especially in adult specimens) considerably shorter, sometimes scarcely half as long" (COLL., of *Lycodes Esmarkii*), and: "The row of palatine teeth is generally longer than the intermaxillary row, at least only slightly, if at all, shorter

[*] According to GOODE and BEAN (l. c.) the length of the lower jaw in a female 540 mm. long was $9\frac{1}{2}$ % of that of the body and in a male 632 mm. long $10\frac{1}{2}$ % thereof.

than it" (LÜTK., of *Lycodes Vahlii*). In the first place, however, this character is subject, according to COLLETT's measurements, to considerable variations — even in the same specimen, a male 58 cm. long, which has been kindly lent me for examination by Professor COLLETT, the row of palatine teeth on one side differs from that on the other, the right containing 8 teeth, the left 12. In the second place, we have here to deal with a sexual character, as both LÜTKEN and COLLETT have pointed out: the males in general have longer rows of teeth than the females, both on the intermaxillaries and on the palatine bones. Thus, when we remember that in *Lycodes Esmarkii* the four rows of teeth, or at least three of them, according to COLLETT's measurements (*Nordh. Exped.*, l. c., p. 90), may be equal in length to each other even in specimens 3 dm. long, the character can scarcely be regarded as a universally valid distinction between the two proposed species.

The body, which just behind the head is terete, about as broad as deep, is gradually compressed later-

Fig. 150. *Lycodes Vahlii, gracilis*, twice the natural size. Taken at Dröbak in 1866 by M. SARS. The property of the Zoological Museum of Christiania University.

ally from this point. The depth at the beginning of the anal fin is $10-13\frac{1}{2}$ % of the length of the body in old specimens, but only about $8\frac{1}{3}$ % thereof in the fry, assuming that we are right in referring to this species, the fry of which are otherwise unknown, the *Lycodes gracilis* of M. SARS (fig. 150). The type-specimen of this proposed species has been placed at our disposal for purposes of examination by the kindness of Professor COLLETT. In all essential characters of form the relation of this specimen to *Lycodes perspicillum* and *L. Rossi* — the assumed fry of the preceding species — is the same as that of *Lycodes Vahlii* to *L. reticulatus* in their adult state. The distance between the dorsal fin and the tip of the snout is 23 %[a], the distance between the anal fin and the latter somewhat more than 38 %[b], and the length of the tail 61 %[c] of the length of the body. The length of the head is only 34 %[d] of that of the tail.

In this species as in the preceding one, the pectoral fins are broad and rounded, the membrane being especially thick below. Their length from the upper angle of the insertion varies between about 11 and $12\frac{1}{2}$ % of that of the body. The ventral fins are set just behind the line between the lower angles of the gill-openings, and so near each other that the distance between them is scarcely equal to the breadth of their base. They are of an oblong, triangular shape, and their length in the male is about equal to the longitudinal diameter of the eyes, in the female, according to LILLJEBORG, only $\frac{2}{3}$ thereof. The skin is so thick that it is difficult to count the rays without dissection: BROWN-GOODE and BEAN state the number at 3[e], REINHARDT and COLLETT at 4, LILLJEBORG at 5.

The vertical fins are of fairly uniform height, but ascend anteriorly in a rounded slope and coalesce behind into a sharp (in young specimens) or rather obtuse (in older ones) point. The anal fin is somewhat lower than the dorsal, and its length about $\frac{4}{5}$ of that of the latter. The longest rays of the dorsal fin, which are situated above the anterior part of the anal fin, measure about half the depth of the body at the beginning of the latter. In the dorsal fin, according to REINHARDT, only the first ray is simple, with the exception of the rays that occupy the extreme tip of the tail; in the anal fin, according to LILLJEBORG, the first three rays are simple.

The scales resemble those of the Eelpout in form and structure. They are thin, flexible, and in general elliptical, with extremely thin, central nucleus of the same form and dense, fine, concentric striæ (ridges), which are prettily broken by numerous, straight, radiating grooves over the whole surface. When they are allowed to dry under the thin skin that covers them, we therefore see, in old specimens, small, fine notches all round the margin of each scale, the traces of the ends of the grooves at the edge. The scales of the lateral line are more circular, with the nucleus thickened and with a canaliculate duct, contracted and almost closed at the middle by the growth of the margins towards each other. Scales of this structure appear even where the lateral line is externally invisible. The longest axis of the scale generally lies transversely across the body. In a male 58 cm. long one of the largest scales

[a] In *L. perspicillum* and *L. Rossi* $26\frac{1}{2}-29$ %.
[b] „ „ „ „ „ „ $43\frac{1}{3}-46$ %.
[c] „ „ „ „ „ „ $55\frac{1}{2}-53$ %.
[d] „ „ „ „ „ „ 46—40 %.
[e] SARS found the same number in his *Lycodes gracilis*.

is 3 mm. long (deep) and 2 mm. broad, one of the scales of the lower lateral line $2\frac{1}{2}$ mm. deep and 2 mm. broad.

The internal organs, which are described at length by REINHARDT, resemble those of the Eelpout in all essential respects, only that here the stomach is somewhat longer. The peritoneum, as well as the pharynx and palate, is black. In the preceding species it is white. The abdominal cavity occupies $\frac{1}{4}$ of the length of the body, and the length of the intestine is $\frac{3}{5}$ of the latter. The pyloric appendages of this species are very rudimentary. In the preceding species they are about as large as in the Eelpout. The testes, are, as usual, two, but the ovary is simple. In adult females the ripe eggs are as large as those of the Salmon, according to COLLETT, or about 6 mm. in diameter, but comparatively few in number, "hardly more than 1,200 in each individual." The spawning-season occurs, according to the same writer, probably during the first months of spring. In the intestine REINHARDT found entire shells of digested mussels, COLLETT crushed sea-urchins, starfish, and sea-anemones, as well as fragments of worms and crustaceans.

When this species has passed through the early stages of growth, it is of a deep brownish black, with from 5 to 8 whitish yellow, transverse bands across the dorsal fin and down the sides, the posterior bands extending farthest down, and the hindmost ones of all advancing even over the anal fin. Two spots of the same light colour as the transverse bands are set beside each other on the occiput, just as in the preceding species. The head is grayish brown, with the opercular flap shading into black. The white scales shine through the thin skin that covers them. Such is the appearance of the fish, according to COLLETT, until it attains a length of about 4 dm. The black ground-colour now begins to encroach upon the transverse bands of whitish yellow, which are thus broken up, on the dorsal fin into narrow stripes, on the back into confluent, ocellated spots, and often joined in pairs in their lower parts so as to form garland-like figures. In the same way the occipital spots may be gathered into a transverse band between the gill-openings. *Lycodes Vahlii*, it is said, may finally assume an almost plain, brownish black tint.

ESMARK'S *Lycodes* seems to be fairly common in the deep water off the extreme north of Norway, where its presence was first discovered in 1861 by ESMARK. COLLETT enumerates 22 large specimens, between 58 and $70\frac{1}{2}$ cm. long, as having been taken in recent times, principally during the years 1881—83, in most cases on long-lines in Varanger Fjord and at depths of about 100—250 fathoms. The species has also been found by the Norwegian Arctic Expedition in 260—459 fathoms of water, west of the northern part of Spitzbergen, and at a depth of 350 fathoms off Bodö. GUNTHER states that it has been met with in Faroe Channel; and the small specimen from Dröbaksund in Christiania Fjord, that was taken in 1866 by M. SARS in 50 or 60 fathoms of water, in all probability belongs to this species. BROWN-GOODE and BEAN have described it from La Have Bank (42° 43' N. lat.) and the Grand Banks on the east coast of North America. REINHARDT'S type-specimens were from Greenland. It is thus an Arctic deep-sea fish with a fairly extensive range to the south.

LYCODES SARSII.

Fig. 151.

Coloration grayish brown, with regular, brownish black, transverse spots on the back and the upper half of the sides and also lower down on the hind part of the tail. A blackish brown, longitudinal band forward along the snout from each of the eyes. Scales scattered, and extending from the occiput along the dorsal side to the beginning of the last third of the tail. Depth of the body at the beginning of the anal fin about 6 or 7 % of its own length. Tip of the tail blunt. Length of the head more than 22 % (23—26 %) of the length of the tail from the beginning of the anal fin to the tip of the last fin-rays.

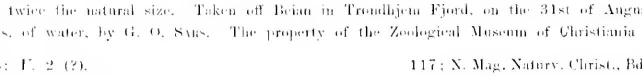

Fig. 151. *Lycodes Sarsii*, twice the natural size. Taken off Beian in Trondhjem Fjord, on the 31st of August, 1882, in between 80 and 200 fthms. of water, by G. O. SARS. The property of the Zoological Museum of Christiania University.

R. br. 5; *P.* 15—16; *V.* 2 (?).

Syn. *Lycodes Sarsii*, COLL., Forh. Vid. Selsk. Christ. 1871, p. 62; ibid. 1874, Tillaegsh., p. 102; *N. Nordh. Exped., Zool., Fiske*, p. 117; N. Mag. Naturv. Christ., Bd. 29 (1884), p. 78, tab. I, figg. 3—4; LILLJ., *Sv. Norg. Fish.*, vol. II, p. 23; GTHR. *Deep Sea Fish.*, Chall. Exped., part. LVII. (Zool., vol. XXII), p. 80.

Anguilla Kieneri, GTHR., Ann., Mag. Nat. Hist., ser. IV, vol. XIII, (1874), p. 139; DAY (*Zoarces*), Proc. Zool. Soc. Lond., 1882, p. 536.

Lycodes Sarsii would seem to be the smallest Scandinavian species of the genus, for the largest specimen among those found by SARS in Norway was only 62 mm. long, and the specimen described by GÜNTHER from the *Porcupine* Expedition measured 85 mm. As yet, however, it may be doubtful whether the species is really distinct from *Lycodes Verrillii*, which has been described by BROWN-GOODE and BEAN[a] from the deep water off Nova Scotia and New England, and which attains a length of at least 18 cm. According to COLLETT, however, the latter form is distinguished by the extension of the scaly covering over the lower part of the body as well, the collection of the spots into more regular transverse bands across the sides, the pointed tail, and the stronger teeth, peculiarities all of which, as we have seen in the preceding forms of the genus, may appear as differences dependent on age and sex.

The slender, Anguilliform body distinguishes *Lycodes Sarsii* from the preceding forms of the genus. The greatest depth of the body, just behind the head, is about $^1/_{12}$ (8·4—8·1 %), and its depth at the beginning of the anal fin $^1/_{15}$ or $^1/_{16}$ (about $6^1/_2$ %) of its length. Its breadth in front is equal to, behind only slightly less than its depth, the terete shape being distinctly persistent back to the hindmost part of the tail. The length of the head is about $^1/_6$ (16 or 17 %) of that of the body. It is of a rounded quadrilateral, parallelopiped form, reminding us of the head of the common snake, with comparatively short and roundish snout. In a specimen 62 mm. long the length of the eye is $^3/_{10}$, and that of the postorbital part a little more than $^1/_2$ of the length of the head. The large muciferous cavities along the upper and lower jaws — the row of the latter being continued back to the inferior corner of the preoperculum — suggest that in this specimen the characters of youth have been persistent. The beginning of the dorsal fin lies at the end of the first quarter of the body, that of the anal fin just in front of the end of its first third, the length of the tail thus measuring not quite 70 % of that of the body. The length of the pectoral fins is about equal to the postorbital length of the head: these fins are blackish brown at the upper margin. The ventral fins are conical and of about the same length as the eye. They are set in front of the line between the lower angles of the gill-openings. Without dissection it is difficult to determine the number of their rays; but they seem to contain at least three rays each.

Lycodes Sarsii was discovered in 1869 by Prof. G. O. SARS, and was described in 1871 by COLLETT from a young specimen 43 mm. long, taken at a depth of between 100 and 150 fathoms in Hardanger Fjord. In 1882 SARS again met with the species during his dredging operations at a depth of between 80 and 200 fathoms off Beian outside Trondhjem Fjord, where he took three specimens between 57 and 62 mm. long. During the Porcupine Expedition of 1869 WYVILLE-THOMPSON took a specimen 85 mm. long "in the North Atlantic at a depth of 180 fathoms." Whether it is identical in species with *Lycodes Verrillii*, a form quite common, according to BROWN-GOODE and BEAN, on the east coast of North America, may still remain an open question. In any case it is up to the present one of the rarest forms in the Scandinavian fauna.

LYCODES MURÆNA.

Fig. 152.

Body plain grayish brown. Scales scattered and irregularly distributed, but extending, when complete, over the whole body except the head and fins. Depth of the body at the beginning of the anal fin about 4 % of its own length. Tail pointed. Length of the head less than 21 % ($19^1/_2$—16 %) of that of the tail from the beginning of the anal fin to the tip of the last fin-rays.

R. br. 5. *D.* 101—118; *A.* 87—103; *P.* 13—17; *V.* 3 (?).

Syn. *Lycodes muræna*, COLL., Forh. Vid. Selsk. Christ. 1878, No. 4, p. 15 et No. 14, p. 74; *N. Nordh. Exped., Zool., Fiske*, p. 116, tab. IV, figg. 29—31; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 25; GTHR, *Deep Sea Fish.*, Challeng. Exped., part. LVII (*Zool.*, vol. XXII), p. 79, tab. XII, fig. A.

This species is still more elongated than the preceding one, the caudal part being prolonged to such

[a] Amer. Journ. Sc., Arts, vol. XVI (1877) p. 474. Bull. Ess. Inst., vol. XI (1879) p. 9. Proc. U. S. Nat. Mus., vol. 3 (1880), p. 477.

an extent that the distance between the anal fin and the tip of the snout is only about 28 % of the length of the body. The form of the body is otherwise the same, almost terete throughout, evenly tapering back from the occiput, and with no distinct lateral compression before the end of the tail. According to COLLETT, the depth at the beginning of the dorsal fin is $4\frac{1}{2}$—5 %, and at the beginning of the anal fin 3—4 % of the length of the body. The head is more depressed and broader, with longer snout, than in the preceding species: its length is 14—12 % of that of the body. Half of its length is occupied by the postorbital part; and in a specimen 2 dm. long the eye occupies $\frac{1}{5}$ (in younger specimens nearly $\frac{1}{4}$) of the length of the head. Even in specimens 2 dm. long the muciferous cavities along the jaws and the lower margin of the preoperculum are as distinct as in the preceding species. The dorsal fin begins further forward than in the preceding species, the distance between it and the tip of the snout being at most about $\frac{1}{5}$ (less than 21 %) of the length of the body or $\frac{3}{4}$ (in the preceding species at least $\frac{1}{3}$) of the distance between the anal fin and the tip of the snout, which distance here measures about 26—28 %[a] of the length of the body. The pectoral fins are obtusely rounded, and their length is about 9—$8\frac{1}{3}$ % of that of the body. The ventral fins are of the same form and position as in the preceding species, and their length too, in a specimen 2 dm. long, is about equal to that of the eye. The same remark applies to the number of their rays as in the preceding species. Sometimes, according to COLLETT, we may trace two lateral lines, one ventral and one median, though the pores in the latter are rather scattered.

Of *Lycodes muræna* as of *L. Sarsii* only four specimens are yet known in the North, and only one of these can lay claim to a place within the Scandinavian fauna. This specimen was found by the Norwegian Arctic Expedition in June, 1877, at a depth of 350 fathoms off Helgeland. In 1878 the same expedition took two specimens in 159 fathoms of water, west of the northern part of Spitzbergen, and one specimen in 658 fathoms, west of Bear Island. In Faroe Channel, however, the English *Knight-Errant* Expedition of 1882 took several examples of this species at depths of between 540 and 608 fathoms. *Lycodes muræna* thus seems to be one of those Arctic species which in deep water have a range extending to the south through the cold layers of the ocean. Its manner of life is otherwise unknown, but in all probability resembles that of the other bottom-fishes, among which it passes its time resting on the cold clay or buried in its shelter. In the stomach COLLETT has found fragments of crustaceans (*Themisto* and *Nannoniscus*).

The largest specimens known measure nearly 23 cm. (9 in.), according to GÜNTHER.

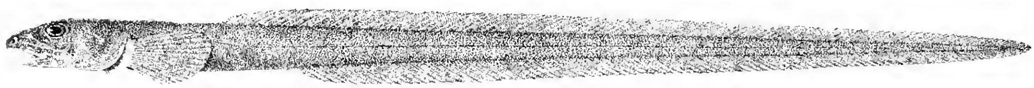

Fig. 152. *Lycodes muræna*, natural size, from the Norwegian Arctic Expedition. The property of the Museum of Christiania University.

PHYSOCLYSTI PLECTOGNATHI.

Physoclysts in which the intermaxillary bones are usually firmly united to the maxillaries, and in which the dental and articular parts of the lower jaw are also more or less perfectly confluent. Branchial arches complete, and their lamellæ pectinated. No externally visible interclavicles.

We now approach those groups among the Physoclysts that, each in its own manner, remind us in a higher degree than the fishes we have already examined, of the piscine types of primeval times, the Ganoids. One universal feature that strikes us in the following Physoclysts, is the marked ossification of the dermal system as opposed to the weaker ossification of the endoskeleton. Those parts of the endoskeleton that

[a] According to GÜNTHER'S figure (l. c.) 30 %.

have originally started from the dermal system, as for example the clavicles, here in many cases have the character of Ganoid scaly or scutate growths in the skin. This fairly prominent touch of resemblance to the Ganoids has induced scientists long to retain the majority of the following Physoclysts among the lowest, least modern Teleosts, though the characters by which both the Plectognates and the *Lophobranchii* have been distinguished ever since the time of CUVIER, are evidently later modifications (higher metamorphosic degrees) of the Teleostean type.

The Plectognates compose an order fairly rich in forms, varying both in the form of the body and, still more, in the texture of its covering. Some of them, most of the Balistoids, are of a fairly regular piscine form, others of a polygonal form, which has given them the name of Coffer-fishes, others again, the Gymnodonts, of an elongated saccate or globular form. Some have hard, granulated scales, densely imbricated, juxtaposed to each other like a mosaic, or firmly united to a carapace that may cover the greater part of the body, others small, spiny scales or, in their stead, loose, mobile spines, sometimes of considerable size, which are erected in self-defence. All the Plectognates have a comparatively small, but well-armed mouth, with strong, but few teeth, the strength of which is increased by the firm support afforded them by the coalescence and reduction of the component parts of the jaws. The short jaw bones form the tip of the facial part of the head, which part is generally considerably elongated and also deepened. This elongation chiefly affects the ethmoid bone, the extent of which on the upper surface of the cranium may rival that of the frontal bones, and the parasphenoid bone (the sphenoid bone of fishes), but is accompanied by the elongation of the preoperculum and interoperculum[a]. The last-mentioned bone has a narrow, terete shaft, which extends from the hind inferior angle of the lower jaw along the inside of the lower anterior prong of the preoperculum, just as the latter extends back from the outer surface of the process with which the lower jaw articulates, on the quadrate bone. The deepening of the facial part depends chiefly on the great vertical extension of the parasphenoid bone and the pterygoid arch. Sometimes, it is true, as in the Balistoids, the palatine bone on each side may be a small, terete, and more or less mobile bone, bifid at the top and united to the ethmoid bone by ligaments. But in other cases, as in the genus *Tetrodon*, it resembles the pterygoid bone in form and is firmly united to the lower surface of the ethmoid bone. Both the palatine bones and the vomer are toothless; and the pharyngeals, which are free, may, it is true, be armed with teeth, as in the Balistoids and Tetrodonts, but may also be destitute of teeth, as in the Coffer-fishes. The shoulder-girdle is generally well-developed. The post-temporal bone is indeed insignificant, being confluent with the mastoid bone, and the supraclavicular bone shows scarcely anything unusual in its development; but the clavicular bone proper, though sometimes of ordinary form, may extend so far inwards in some of the Plectognates, as in the Coffer-fishes, that the bone of one side is contiguous to that of the other throughout the depth of the median plane of the abdominal cavity, thus forming a kind of diaphragm of bone with only a round, more or less tubular hole in the middle for the passage of the œsophagus. The shoulder-girdle of the Coffer-fishes is still further extended, below the coracoid bones, by a pair of large 'interclavicles,' of which in the preceding fishes we have found scarcely a trace, but which we shall again meet in the Sticklebacks in the form of Ganoid plates. In *Balistes* the clavicle extends so high up that with its upper extremity it touches the cranium, at the styloid bone, just within and under the articular surface of the supraclavicular bone.

In ARTEDI the Plectognates formed the framework of the order which he called *Branchiostegi* (i. e. *with hidden gills*, a reference to the narrow gill-openings just above or in front of the insertions of the pectoral fins); and the principal character of the order, according to its founder, lay in the absence of special branchiostegal membranes. In general, however, the exact opposite is the case; the opercular apparatus is by no means imperfect in these fishes. The operculum and suboperculum are small, it is true, in the Balistoids and Coffer-fishes, but of normal size in the Tetrodonts. The advanced development of the preoperculum has been mentioned above. The hyoid arches, to which the branchiostegal membranes with their 4—6 rays[b] are attached, have gained in breadth what they have lost in length; and in most cases one of the rays in each membrane, usually the innermost, is considerably stronger than the others, sometimes, as in *Tetrodon*, several times

[a] This elongation and deepening is most marked in the Sclerodermi (see below); in the Gymnodonts it is less prominent.

[b] Sometimes 3, according to BLEEKER.

as broad and expanded like a wing. But the branchiostegal membranes are entirely hidden under the common dermal covering, so that the Artedian character of the order holds good as an external one. The pelvic bones are generally wanting, but sometimes present, as in the Balistoids, in which case they are united into a large, scythe-shaped bone, inferiorly bounding and supporting the abdominal cavity, even when the pectoral fins have disappeared or have been reduced to a spiny, osseous projection at the hind extremity of this bone. The remainder of the skeleton is marked not only by its weak ossification, but also by the small number of the vertebrae, which may sometimes (in the Coffer-fishes) sink to 14 and never exceeds 30. Sometimes, as in the Tetrodonts, the upper spinous processes (neural spines) of the first 5 or 6 vertebrae are longitudinally cleft in two, with the halves laterally extended. Ribs are wanting in most cases, but present in the Balistoids. As the caudal fin is frequently of extraordinary size — though with few, less than 13, branched rays —, its insertion in the skeleton has also undergone proportionate increase in strength and firmness, partly by means of large hypural bones, which are firmly united in the Coffer-fishes into a compressed tip, hard as ivory, partly by high and longitudinally extended, neural and haemal spines on the last caudal vertebrae. Sometimes however, as in the Sunfishes, the caudal fin is a secondary growth and finds an extremely feeble support in the more or less atrophied tip of the tail.

In spite of the considerable differences that occur both in the form and covering and also in the internal structure, the Plectognates together form a natural group, with persistent traces of the Ganoid type, which give them an appearance unusual in the fauna of our day. The nearest approach to the preceding forms we find, as COPE has already pointed out[a], in a comparison between the Balistoids (especially the genus *Triacanthus*, with its free maxillaries) and the Leather-fishes (*Acanthuridæ*, a family within the comprehensive series of Mackerel-fishes), with the same form of body, the same elongation and deepening of the forepart of the head and shortening of the jawbones, the same union of the posttemporal and mastoid bones, and the same length of the pelvic bones, which in the Acanthuroids, however, are not confluent. Set side by side with the skeleton of an *Acanthurus* the skeleton of a *Balistes* seems at the first glance to claim a position within the same family. The systematic separation between the Plectognates and the other Physoclysts is thus by no means too great to admit of their being ranged side by side with each other.

About 200 species of Plectognates are known. The greatest wealth of forms belongs to the tropical seas; but one or two species penetrate into rivers, or even pass their whole life there. To man these fishes are of only slight value. Their flesh is in general not eaten[b], and many of them are even poisonous. They attract attention, however, both by their extraordinary form and often by their beauty of colour, as well as by their singular manner of life. Most of them are shore-fishes, but some belong to the surface-regions of the ocean; they do not include any deep-sea forms of pronounced character, although two species have been met with below the 100-fathoms line[c]. Most of them are rendered incapable of any vigorous motion by their hard and stiff dermal covering or by their clumsy form. By the small size of the gape most of them are compelled to find subsistence in small animals or in pieces torn from larger ones. Their food consists chiefly of corallines, jelly-fishes, worms, or mollusks. The lively colours that adorn many of them are reminiscences of their life in the coral-groves, where they associate with scaly-finned Chaetodonts of no less varied hues, or among the seaweeds with their shifting colours. The species of plainer dress resemble the sand in colour, or are attired for a life in the open sea. Their powerful teeth may well serve to protect them from attack, but as a rule they have quite other weapons of defence. Many of them have been famed from ancient times for their faculty of filling the œsophagus, which is capable of extraordinary distension, with air. In this manner the body is expanded, sometimes to a perfect globe, and the dermal spines are erected in all directions into a front of pointed spikes. "One day," wrote DARWIN from Bahia in 1832[d], "I was amused by watching the habits

[a] Trans. Amer. Philos. Soc., Philad., vol. XIV, n. ser., p. 458.

[b] According to SCHLEGEL (SIEB., *Fn. Japon.*), however, several of these fishes are eaten by the Japanese: one *Tetrodon* is even stated to compose the principal food of the poorer classes during winter, while the fisherman is forbidden, under pain of heavy penalties, to expose for sale other species of the same genus.

[c] Both these finds, however (see GÜNTHER, *Deep Sea Fish. Chall. Exped.*, p. 266), may have entered the trawl while it was being sunk or hauled in.

[d] *A Naturalist's Voyage* (London, ed. 1884) p. 13.

of the *Diodon* (*Chilomycterus*) *antennatus*, which was caught swimming near the shore. This fish is well known to possess the singular power of distending itself into a nearly spherical form. After having been taken out of water for a short time, and then again immersed in it, a considerable quantity both of water and air is absorbed by the mouth, and perhaps likewise by the branchial orifices. This process is effected by two methods; the air is swallowed, and is then forced into the cavity of the body, its return being prevented by a muscular contraction which is externally visible; but the water, I observed, enters in a gentle stream through the mouth, which is kept wide open and motionless: this latter action must, therefore, depend on suction. The skin about the abdomen is much looser than that on the back; hence during the inflation, the lower surface becomes far more distended than the upper; and the fish, in consequence, floats with its back downwards. CUVIER doubts whether the *Diodon* in this position, is able to swim; but not only can it thus move forward in a straight line, but it can turn round to either side. This latter movement is effected solely by the aid of the pectoral fins, the tail being collapsed, and not used. From the body being buoyed up with so much air, the branchial openings were out of water; but a stream drawn in by the mouth constantly flows through them.

"The fish, having remained in this distended state for a short time, generally expelled the air and water with considerable force from the branchial apertures and mouth. It could emit, at will, a certain portion of the water; and it appears, therefore, probable that this fluid is taken in partly for the sake of regulating its specific gravity.

"This *Diodon* possessed several means of defence. It could give a severe bite, and could eject water from its mouth to some distance, at the same time making a curious noise by the movement of its jaws. By the inflation of its body, the papillae, with which the skin is covered, become erect and pointed. But the most curious circumstance is, that it secretes from the skin of its belly, when handled, a most beautiful carmine-red fibrous matter, which stains ivory and paper in so permanent a manner, that the tint is retained with all its brightness to the present day. I am quite ignorant of the nature and use of this secretion. I have heard from Dr. ALLAN of Forres, that he has frequently found a Diodon, floating alive and distended, in the stomach of the Shark; and that on several occasions he has known it eat its way, not only through the coats of the stomach, but through the sides of the monster, which has thus been killed. Who would ever have imagined that a little soft fish could have destroyed the great and savage Shark?

The power here mentioned by DARWIN, that of producing sounds, is one of the faculties highly characteristic of these fishes. The Plectognates have long been known as the most assiduous musicians of the ocean. Now it is the jaws, now the articular surfaces of the spinous rays in the dorsal or ventral fins, where these fins contain such rays, that make a snapping, ringing, grating, or laughing noise[a]; now it is the hissing sound of water and air driven out of the body; now it is the air-bladder whose vibrations may be distinctly heard like the beating of a drum[b]. For this purpose the air-bladder is attached, in the drumming Balistoids, to the shoulder-girdle on each side and to special, large dermal plates just above the upper angle of the pectoral fin. By the quivering movements that accompany the violent contraction (cf. above, p. 193) of the ventral parts of the lateral muscles, the postclavicular bones, which are inserted in these muscles, are set in a vibrating motion which is transferred to the wall of the air-bladder and to the air contained therein, from which the sound is transmitted to the said osseous plates in the skin above the angle of the pectoral fin, and through their medium to the outer world. All the snapping, ringing, grating, laughing, or hissing sounds are probably intended, here as in other fishes which have this power, in the first place to frighten away some approaching foe. The notes or drumming noises of the air-bladder may also conduce to the same result, or may be produced by the death-throes of the fish. But, as SORENSEN has remarked, the sonorous tones that compose the song of these fishes, undoubtedly serve in other cases, especially during the spawning-season, as call-notes.

CUVIER[c] divided the Plectognates into two families, the first with free teeth in the jaws and usually with hard (plate-like) dermal covering — hence the name of *les Sclerodermes*, from σκληρός, *hard* and δέρμα, *skin* — the second with the jaw-teeth confluent and forming

[a] Cf. SORENSEN, *Om Lydorganer hos Fiske*, Kjøbenhavn, 1884.

[b] Cf. MÖBIUS, *Balistes aculeatus, ein trommelnder Fisch*, Stzber. Akad. Wiss. Berl. 1889, p. 999.

[c] *Règne Animal*, ed. 1. tom. II. pp. 145 and 149; ed. 2. tom. II. pp. 365 and 371.

composite dental growths, one or two in each jaw, which project like a beak beyond the lips — hence the name of *les Gymnodontes*, from γυμνός, *naked* and ὀδούς, *tooth*. Of these families the latter is distinctly more perfectly Plectognate in its characters. At the present time we generally follow BONAPARTE[a] and divide these fishes into four families, two within each of the Cuvierian families[b]. Only two species, each representing a distinct family, have been found within the limits of the Scandinavian fauna.

FAM. ORTHAGORISCIDÆ.

Gymnodonts with stunted trunk, body compressed laterally (round or elliptical) and not distensive, and contiguous vertical fins. Dental disks of the jaws undivided. Pseudobranchiæ large. Air-bladder[c], pelvic bones, and ventral fins wanting.

With an appearance as though they were of the normal piscine form but with truncate tail, these *Lagg-bukar* (*Tun-bellies*) — as RETZIUS called them together with the rest of the Gymnodonts — deservedly excite attention even by their external characters. In form and appearance they remind us somewhat of the Opah; but merely a casual examination is enough to show that they are of an entirely different type. They really rank among the most singular piscine forms. The stunted appearance of the body depends, it is true, on the comparatively small number of the vertebræ (16 or 17); but this number may be still smaller in the Coffer-fishes. The short form of the body is really caused by its depth posteriorly, this being due to a prominent development of the upper and lower arches of the vertebræ, with their spinous processes, in the caudal part of the body, and of the interneural spines of the dorsal fin and the interhaemal spines of the anal fin (fig. 153). This deviation from the other Plectognates is connected with an extremely unusual course of development.

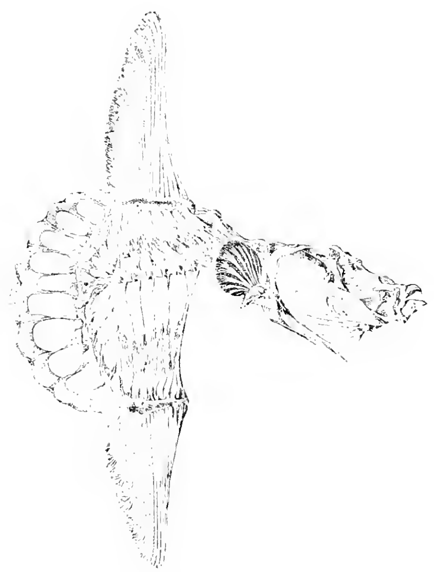

Fig. 153. Skeleton of *Orthagoriscus mola*, $^1/_{12}$ of the natural size. After WELLENBERG.

In the middle of the last century KÖLREUTER[d] gave an excellent description and a figure of no small merit, considering the period of its execution, of a fish 16 mm. long and $19^1/_2$ mm. deep, "which at a casual glance might easily be taken for a head cut off from the trunk, and nothing more." Closer examination soon showed, however, that this specimen was a young form of *Orthagoriscus* (*Tetrodon*) *mola*, as LINNÆUS[e] interpreted this find. But the most singular circumstance was that it had no caudal fin whatever. In another specimen, $40^1/_2$ mm. long and $49^1/_2$ mm. deep, on the other hand, KÖLREUTER found a distinct, crenulated caudal lobe along the hind margin of the fish, uniting the dorsal fin to the anal. Since that time these small fishes have been met with on numerous

[a] *Catalogo metodico dei pesci europei*, p. 87.

[b] BLEEKER (*Atlas Ichthyologique*, tome V) divided the Plectognates into three orders and these again into 6 families corresponding to GÜNTHER's subfamilies: *Ostracionina*; *Triacanthina*, *Balistina*; *Triodontina*, *Tetrodontina*, *Molina*.

[c] COSTA (*Fn. d. Regn. di Napoli*, tav. 63 e 64) describes and figures a rudimentary air-bladder in *Orthagoriscus mola*.

[d] Nov. Comment. Acad. Sc. Petrop., vol. X (1766), p. 337, tab. VIII, figs. 2 and 3. *Mola aculeata, limbo abdominis producto, attenuato, carnoso.*

[e] *Syst. nat.*, ed. XII, tom. 1, part. 2, Add. (in fine).

occasions, and the late development of the caudal fin has been fully demonstrated (fig. 154). According to LÜTKEN[a], however, we have a still earlier developmental

A. B.

Fig. 154. Larvæ of *Orthagoriscus mola*: *A*. at a length of 18 mm., *B*. at a length of 32 mm. After GÜNTHER.

stage of *Orthagoriscus* in the form named by RICHARDSON *Ostracion boops* (fig. 155), after the larval specimens taken at the surface of the South Atlantic and

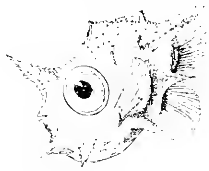

Fig. 155. *Ostracion boops*, RICHARDSON. Powerfully magnified. After GÜNTHER.

figured by HOOKER. These larvæ are of a still more curious form, with their large eyes and their equipment of large spines, such as those we have seen above on the heads of several Acanthopterygian larvæ, notably within the great series of the Scombromorphs, and with small spines besides on the dorsal side. The difference between them and KÖLREUTER's larvæ, however, is not so great as to prevent us from easily recognising the corresponding position of the large spines. As in the younger of KÖLREUTER's larvæ we here find one large spine at the middle of the forehead between the eyes; three at the sharp dorsal margin, the hindmost of which, just in front of the dorsal fin, is the largest; one[b] on each side above the eyes, as well as on each side of the hind part of the body between the dorsal and anal fins. Whether the other spines correspond exactly in both larvæ, is a more difficult point to decide. The caudal fin is still less developed than in the younger of KÖLREUTER's larvæ. As the development advances, the large spines are said to become comparatively smaller, but the small spines, the papillæ with radiating striæ, to extend densely and evenly over the whole body. The transition to the *Orthagoriscus* form is thus not far distant[c].

If we compare these youngest forms of *Orthagoriscus* with the normal forms of piscine larvæ, the greatest difference lies in the fact that here the caudal fin, which otherwise is the first fin to appear — as it also is the original organ of motion in all vertebrates —, is developed last of all the fins. This difference has left its mark not only on the structure of the skeleton, but also on the development of the muscles. Here the original and, in later life, the most powerful organs of motion are the dorsal and anal fins. Their supporting bones (the interneural and interhæmal bones) and their motory muscles exercise a determinant influence on the development of the whole trunk.

In dissecting an *Orthagoriscus*[d] we have first to cut through the enormously thick skin, which is lined with a strong tendinous membrane (*aponeuros*). Within the latter, on the sides of the body, we make the remarkable observation (fig. 156) that the muscles most highly developed in other fishes, the large lateral muscles of the body, are here apparently wanting. Between the spinal column and the skin runs, as usual, in a horizontal direction, a fibrous membrane (*sf*), which here is especially strong, and divides the visible muscular mass, just as in other cases it divides the large lateral muscles of the body, into two halves, an upper and a lower. But by far the greater part of this muscular mass is here composed of the flexors of the dorsal (*mpd*) and anal (*mpa*) fins. The flexors of the dorsal fin, divided into two layers of different colour and firmness — a surface-layer and an under-layer — run from the occiput, from the spinal column with its superior processes and interneural bones, and from the upper surface of the horizontal fibrous membrane (*sf*), and are attached by a special sinew to each side of the basal

[a] See GÜNTHER, Ann. Mag. Nat. Hist., ser. 4, vol. VIII (1871), p. 320, note.

[b] In KÖLREUTER's larva two.

[c] According to LÜTKEN's opinion of KÖLREUTER's larvæ. Still we should observe that the larvæ of *Diodon* correspond just as closely to RICHARDSON's larvæ, especially in the position of the large spines; but in the former the end of the notochord projects between the dorsal and anal fins. A larva of this description, 2 mm. long and of ellipsoidal form, which was taken at the surface "between Java and the Cape of Good Hope," has been obtained by the Royal Museum through Captain PÖHL of Hamburg. In the same jar (and therefore taken probably at the same time) lay another larva, 4 mm. long and of more distinct *Diodon* form, but still, like the preceding one, with the dorsal and anal fins and the tip of the tail between them all situated on the ventral side.

[d] Cf. WAHLGREN, *Några anteckningar om en stor klumpfisk*, Lunds Univ. Årsskrift, tom. IV.

part of each ray in the dorsal fin. The flexors of the anal fin, also divided into a surface-layer and an under-layer, originate from the bodies of the hindmost abdominal vertebræ, from the caudal vertebræ with their inferior processes and interhæmal bones, and from the under surface of the horizontal fibrous membrane, and are attached to the rays of the anal fin in the same manner as we have just described in the case of the flexors of the dorsal fin. The flexors of the caudal fin

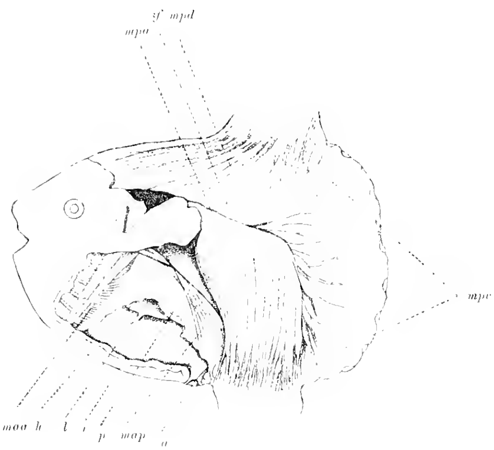

Fig. 156. Position of the muscles and viscera in *Orthagoriscus mola*, on a reduced scale. After CLELAND.

mpa, the flexors of the anal fin (*musculi pinnæ analis*); *sf*, the fibrous dividing membrane (*septum fibrosum*); *mpd*, the flexors of the dorsal fin (*musculi pinnæ dorsalis*); *maa*, the anterior abdominal muscle (*m. abdominalis anterior*); *h*, the liver; *l*, the ligament between the intestinal sac and the liver; *i*, the peritoneal investment of the intestines (intestinal sac); *p*, the peritoneum, opened and partly removed; *map*, the posterior abdominal muscle (*m. abd. posterior*); *a*, the vent; *mpc*, the flexors of the caudal fin (*m. pinnæ caudalis*).

(*mpc*) form no compact muscular mass; each of the rays in the caudal fin is furnished on each side with a special, ventricose muscle, and these muscles start partly from the bodies of the hindmost vertebræ, partly from the supporting bones of the caudal fin (the hindmost interneural and interhæmal bones), partly from the superior and inferior folds of the horizontal, intermuscular, fibrous membrane (*sf*). Of the system of the large lateral muscles there remain only two abdominal muscles, belonging to the under-layer of the system, the first (*map*) starting from the top of the clavicle, the second (*maa*) from the coracoid bone, and both attached to the outer surface of the strong peritoneum (*p*). So great is the modification both of the skeleton and of the musculature that has accompanied the late development of the caudal fin, and rendered the dorsal and anal fins the principal organs of locomotion. These two fins have attached to themselves, from the very beginning, the great mass of muscles and supporting bones; while the caudal fin has become a secondary organ, which has been forced to adapt its development to pre-existent circumstances, and which has thus sunk almost to an adipose fin, though thin osseous rods have been developed to rays within it. The influences of this revolution in the development of the organs of motion have also affected the central nervous system. The family is remarkable, from an anatomical point of view, not only for the insignificant size of the brain[a], which is extraordinarily small, even within the class of fishes, but also for the fact that the spinal marrow, soon after its passage through the occipital foramen, ramifies in the well-known "horsetail form" (*cauda equina*), without being continued any further in the form of a continuous chord within the spinal canal[b].

Whether more than two species may be distinguished with certainty within this family, must still be regarded as a doubtful question. RANZANI's attempt[c] to establish 16 species, distributed among 6 genera, has long ago been abandoned as futile; and PUTNAM's evidence in favour of the opinion that the young specimens described by KOLREUTER, PALLAS, and others belong to a distinct species of a separate genus[d], seems to require further confirmation. It has also been proposed[e] to refer the two established species to two distinct genera, one of which, *Ranzania*, with more elongated body and with the dermal covering smooth but divided into hexagonal plates, has been met with on the English coast, but never, up to the present time, within the limits of the Scandinavian fauna.

[a] In large specimens of *Orthagoriscus mola*, according to HARTING, the brain may weigh no more than $^1/_{71820}$, i. e. not quite 0·000014, of the total weight of the body.

[b] ARSAKY, *De piscium cerebro et medulla spinali*, Halle 1813, p. 4, tab. III, fig. 10.

[c] Nov. Comm. Acad. Scient. Inst. Bonon. III (1839).

[d] Proc. Amer. Assoc. Adv. Sc., 19th Meeting (1870), p. 255.

[e] STEENSTRUP and LÜTKEN, Overs. Vid. Selsk. Forh. Kbhvn 1863, p. 42.

GENUS ORTHAGORISCUS.

Body round or of a short elliptical form. Skin rough with dense, fine spines and papillæ. Distance between the dorsal fin and the tip of the snout (in adult specimens) less than $^3/_4$ of the length of the body.

The name of this genus[a], according to RONDELET'S[b] interpretation of PLINY, is of classical origin and derived from its power of producing grunting sounds. The name was introduced by SCHNEIDER[c] into the post-Linnæan nomenclature. RONDELET'S contemporary SALVIANUS did not approve of his interpretation, and gave the Sunfishes another name, *Mola* (millstone), with reference to the round form of the body and derived from the popular language of Marseilles. This generic name was adopted by JOHNSTON[d] and WILLUGHBY[e], but in LINNÆUS it passed into a specific designation[f].

Orthagoriscus is distinguished from the other genus of the family not only by the different covering of the body, but also by a special direction of development, which brings about a secondary increase of comparatively considerable extent in the region of the caudal fin, and involves an elongation of the body that causes the apparent removal in a forward direction with age of the dorsal and anal fins. The above-mentioned uncertainty with regard to the distinction of the species within this genus depends partly on our imperfect knowledge of the earlier stages of the development, partly on a singular form of the caudal fin, with a pointed upper lobe, which has been observed both in younger individuals (fig. 154, *B*) and in older ones[g], without enabling us as yet to decide whether it is of incidental (individual) description or of some other signification. In the Scandinavian fauna, however, this uncertainty is of no importance.

THE SHORT SUNFISH (SW. KLUMPFISKEN).

ORTHAGORISCUS MOLA

Plate XXVII, fig. 4.

Pectoral fins rounded in old specimens; their length at most about $^1/_7$ (14 or 15 %) of that of the body. Coloration bluish gray, on the back darker and brownish, growing lighter with a silvery lustre down the sides, on the belly whitish. Fins brownish.

R. br. 6; *D.* 17—18[h]; *A.* 15—17[i]; *P.* 11—13[k]; *V.* 0; *C.* 11—14; *Vert.* 16 *l.* 17.

Syn. *Ostracion* cathetoplateus subrotundus inermis asper, pinnis pectoralibus horizontalibus, foraminibus quatuor in capite. ART., *Gen.*, p. 61; *Syn.*, p. 83.

Tetrodon Mola. LIN., *Syst. Nat.*, ed. X, tom. I, p. 334; PALL. (*Diodon*), *Spicil. Zool.*, tom. I, fasc. VIII, p. 39, tab. IV, fig. 7; RETZ. (*Tetrodon*), Vet. Akad. Handl. 1785, p. 115, tab. IV; BL. (*Diodon*), *Naturg. Ausl. Fisch.*, pt. I, p. 75, tab. CXXVIII; RETZ. (*Tetrodon*), *Fn. Suec. Lin.*, p. 310; SCHN. (*Orthagoriscus*), l. c.; NILSS., *Prodr. Ichth. Scand.*, p. 111; WELLENBERGH, *Observ. Anat. de O. mola*, disp. Lugd. Bat. 1840; SCHLEG., *Fn. Japon., Poiss.*, p. 288, tab. CXXVII; COSTA, Fn. Regn. Nap., Pesci, pt. 2, *Plettogn. Gymnod.*, tab. LXIII et LXIV; EKSTR., Gbgs. Vet., Vitt. Samh. Handl. 1850, p. 40; KR., *Danm. Fiske*, vol. III, p. 732, NILSS., *Skand. Fn., Fisk.*, p. 697; CLELAND, Nat. Hist. Review 1862, p. 170, tab. V et VI; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 317; COLL., Vid. Selsk. Forh. Christ. 1874, Tillægsh., p. 203; ibid. 1879, No. 1, p. 101; N. Mag. Naturv. Christ., Bd. 29 (1884), p. 114; MALM, *Gbgs. Boh. Fn.*, p. 599; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 54; MOR.,

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[a] Ὀρθαγορίσκος, *sucking-pig.*

[b] *De Piscibus*, lib. XV, cap. VII, p. 425.

[c] *Syst. Ichthyol.* BLOCHII, posth., pp. LVII and 510.

[d] *Historia naturalis de piscibus et cetis*, lib. 1, tit. 1, cap. III, art. II, punct. VIII.

[e] *Historia Piscium*, lib. 4, sect. III, cap. VI, p. 151.

[f] CUVIER is stated, it is true, in his anatomical lectures — in 1798, according to STEENSTRUP and LÜTKEN, in 1800, according to GILL; thus prior to the appearances of SCHNEIDER'S work quoted above — to have advocated the resumption of *Mola* as a generic name (*Mola rotunda*); but in his systematic works he recognised *Orthagoriscus*.

[g] MONACO, Bull. Soc. Zool. Fr., tome XIV (1889), p. 17.

[h] Sometimes 16, according to KRØYER and MOREAU; sometimes as many as 20, according to LILLJEBORG.

[i] Sometimes 14, according to STEENSTRUP and LÜTKEN; sometimes 18, according to LILLJEBORG.

[k] Sometimes 14, according to RETZIUS.

Hist. Nat. Poiss. Fr., tom. II. p. 74; MÖB., HEKE, *Fisch. Osts.*, p. 101; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II. p. 272, tab. CXLVIII; BR. GOODE, *Fisher., Fisher Industr. U. S.*, sect. 1. p. 169, tab. 35; LILLJ., *Sv.*, *Norg. Fisk.*, vol. 3, p. 425.

Orthagoriscus hispidus, SCHN., l. c., p. 511 (juv., ex PALL., l. c.); CUV., *R. anim.*, ed. 1, tom. 2, p. 149 = *O. spinosus*, ID., ed. 2, tom. 2, p. 370; RICH., *Voy Sulph.*, *Zool.*, vol. I. p. 125, tab. LXII, figg. 10—12.

Cephalus brevis, SHAW, *Gen. Zool.*, vol. V. p. 437, tab. 175.

Diplanchias nasus, RAFIN., *Caratt. Alc. N. Gen.*, p. 17; STP., LTKN (*Mola*), Overs. Vid. Selsk. Forh. Kbhvn 1863, p. 36; LTKN, Förh. Skand. Naturf. M. Sthlm 1863, p. 378; WAHLGR. *N. Art. Mola nasus*, Lunds Univ. Årsskr., tom. IV (1867) cum tab.

Ozodura orsini, *Oz. ursini*, *Tympanomium planci*, *Diplanchias nasus*, *Trematopsis Willughbii*, *Orthagoriscus Retzii*, *Ort. ghini*, *Ort. Rondeletii*, *Orth. Blochii*, *Ort. redi*, *Ort. aculeatus*, RANZANI, l. c.

Ostracion boops, RICH., *Ichthyol. Voy. Ereb.*, *Terr.*, pag. 52, tab. XXX, figg. 18—21; juv. hujus speciei sec. LTKN, GTHR, Ann. Mag. Nat. Hist., ser. 4, vol. VIII (1871), p. 320, not.

Orthagoriscus ozodura, HARTING, *Notices Zool.* etc., Verh. Akad. Wet. Amsterdam, D. XI (1868).

This Sunfish attains a length of at least 8 feet ($2^1/_2$ metres). The largest specimen of which, to the best of our knowledge, we can speak with positive certainty, was exhibited from New South Wales at the Fisheries Exhibition of 1883 in London, and measured 8 feet in length and 12 feet in depth from the tip of the dorsal fin to that of the anal[a]. In young specimens the form of the body is almost circular. At a length of $4^1/_2$—$5^1/_2$ dm. the depth of the body is about $^2/_3$ (69[b]—64 %) of the length, at a length of about 2 m., about $^1/_2$ or 48 % thereof. Thus, the body is elongated with age to an elliptical form, with the depth fairly uniform at the middle, while the hind part ends more abruptly, but the forepart is somewhat prolonged, forming a short muzzle. The thickness is fairly constant, being greatest above and behind the eyes, where it measures about $^1/_4$ of the greatest depth, and decreasing without a break, slowly behind and more suddenly in front. In old specimens, however, on each side above the eye and back to the perpendicular from the beginning of the insertions of the pectoral fins, we find a longitudinal, blunt ridge; and a similar ridge may appear below the gill-opening and the pectoral fin. In this manner the section of the body at the gill-openings is rendered more or less distinctly hexagonal, with the upper and lower angles acute, the latter more so. Both the dorsal and the ventral edges are sharp and carinated, the former from the forehead behind the eyes back to a point a little in front of the beginning of the dorsal fin, the latter from a point a little behind the lower jaw back to the vent. The forehead, on the other hand, is convex; and the tip of the snout is furnished in old specimens with a rough and sclerous, mobile, round pad, which projects some distance above and in front of the mouth. At the ventral margin, a little below and behind the lower jaw, we find in old specimens a similar osseous growth in the skin, consisting of two, or even three, fusiform, bony plates, set in a row one after another. In old specimens, too, the ventral profile is distinctly more arcuate than the dorsal. The base of the caudal fin passes evenly into the body, so that the fin projects like an attenuated dermal margin at the end of the sharply rounded (convex) hind edge of the body. In young specimens the caudal fin is united above and below to the lower posterior angle of the dorsal fin and the upper posterior angle of the anal fin; but in old specimens it is distinctly separated from these fins. Its form, though, as we have mentioned above, it may sometimes present a singular abnormity — perhaps a malformation or the cicatrice of a wound — in general corresponds to that of the hind margin of the body; but at the margin, opposite the tip of each ray, we find a round incision, which is more or less completely filled by a compressed, osseous growth. The dorsal and anal fins rise in the form of acute-angled triangles — though usually with the apex rounded — with the anterior margin thick but in profile concave, the posterior sharp (attenuated) and convex. These two fins cannot be depressed like normal fins in their longitudinal direction (the second dorsal and the anal fins of the Tunnies, for example, are also stiff when pressed in this direction); but they are highly flexible laterally, and their movement in this direction[c] is assisted by the texture of the skin. This last organ, which is covered with numbers of stiff wrinkles and ridges, crossing one another in irregular squares,

[a] RONDELET states, it is true (l. c.), that the Sunfish may attain a length of 6 cubits ($2^3/_4$ m.) or more; but this assertion has not been confirmed, to the best of our knowledge, in modern times, unless we accept LACEPÈDE's statement that in 1735, on the Irish coast, a Sunfish 25 feet long was found, "which consequently appeared at night like a shining disk more than 400 square feet in area" (*Hist. Nat. Poiss.*, tom. I, p. 511).

[b] Sometimes 72, according to KROYER.

[c] With respect to the musculature see above.

is extraordinarily thick over the greater part of the body. In a Sunfish 965 mm. long the skin on the trunk, according to CLELAND, was about 25 mm. thick[a]. The rigidity of the skin is increased by the spiny and nodose, small, osseous tubercles[b] which are densely spread over its surface, and which give the skin both on the body and the fins a shagreened appearance. But a rather broad band of thinner and looser skin, with more granulated or even smooth surface, runs on each side, along the very margin of the body, from the vent along the bases of the anal, caudal, and dorsal fins. This band of flexible and movable skin, which is folded round the bases of the dorsal and anal fins, admits of the bending of these two fins at right angles to the sides of the body. The first six rays in these fins are thick and stiff, neither articulated nor branched, and suddenly increase in length, thus forming the greater part of the anterior margin of the fin — only the apex belongs to the seventh ray, which is branched. The posterior rays, again, suddenly decrease in length behind, are branched, and expand backwards at the tip like a fan. Thus, the whole of this apparatus forms, together with the caudal fin, a swimming-blade, elastic behind, which by alternate movements to right and left of the dorsal and anal fins drives the fish forward, just as a boat is propelled by sculling. The comparatively short pectoral fins, which, as well as the other fins, are rough with small osseous tubercles on both sides, are of rounded form, with the first and last rays simple, the others multifid at the tip, and the middle ones (the fifth and sixth) longest. They are set halfway up the body and just behind the middle point between the tip of the snout and the beginning of the dorsal or the anal fin. They are inserted horizontally, as in the Opah, and move up and down, their true function thus being probably to maintain the equilibrium of the body. Just in front of the insertion of the pectoral fin, with height about equal to the length of this insertion, lies the transversely set gill-opening on each side of the body, elliptical in shape, but pointed at both ends, and with the anterior half covered with a thin skin[c], which is a continuation of the true branchiostegal membrane, while the anterior margin is formed by the skin itself, which covers the operculum. These small openings are the only external boundaries between the head and the body. This circumstance has caused the comparison of the whole fish to a swimming head[d].

The head of the Sunfish (from the tip of the snout to the gill-openings) measures in young specimens ($^1/_2$—1 metre long) between $^1/_3$ and $^3/_{10}$ of the length of the body. In older specimens, which acquire a more elongated form of body, it becomes comparatively somewhat smaller, sinking to at least 29 % of the length of the body[e]. In old specimens, which have their short snout tipped with the hard osseous disk, this disk forms the extreme end of the snout. In young specimens the mouth is set exactly at the tip of the snout, and shows between the thin lips, which only partially hide them, its two white dental disks, that of the upper jaw hooked at the tip, that of the lower jaw even. Behind (within) these disks we find in young specimens 4 or 5 similar disks or rows of divided, transverse disks, close behind each other, which are gradually worn away in course of time, until they disappear. The gape is small, as in all the Plectognates; in a Sunfish 47 cm. long it can be opened to a height of only 33 mm. and measures 24 mm. in breadth, or rather less than the longitudinal diameter of the eye. The eyes are set very low, in comparison with their position in the rest of the Plectognates, but much nearer to the dorsal margin than to the ventral[f]; their

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[a] In a large Sunfish dissected by TURNER and GOODSIR (Nat. Hist. Review 1862, p. 185) the skin varied in thickness on different parts of the body between 6 and 100—127 mm. In another specimen, which was unusually large, GOODSIR found the thickness of the skin at certain spots to be 152 mm.

[b] The osseous tubercles vary in size, large and small being interspersed with each other: but even the largest ones in large Sunfish are scarcely of the size of small pins' heads. At the base they bear radiating striæ, and are irregularly incised and dentated at the margin, the teeth of one tubercle fitting into the incisions in the next.

[c] When this membrane lies in folds, or when it bursts — as often happens in stuffed specimens — it may appear as though there were two gill-openings on each side; and this is perhaps the explanation of the character of two gill-openings on each side that was given by RAFINESQUE to his genus *Diplanchias*.

[d] "Der schwimmende Kopf": BLOCH, l. c. From the form of the snout and the small size of the mouth the fish also acquires a singular resemblance, which has struck many, to the human head.

[e] According to CAMPBELL's measurements of a specimen 236 cm. long (Proc. Nat. Hist. Soc. Glasg., vol. V, 1881—82, p. 178) this percentage may sink to 24·7.

[f] In the specimen which HASTING examined, he found (l. c.) an asymmetry in the position of the eye (the right eye — like the right pectoral fin — situated perceptibly higher than the left), which he proposed to explain by the habit possessed by these fishes, of lying at the surface and swimming on one side. Cf. above, on *Trachypterus*, p. 319.

inferior margin lies in the line between the mouth and the upper corner of the gill-opening, and the distance between them and the tip of the snout is somewhat greater than that between them and the gill-openings. Externally they are rather small, somewhat oblong (elliptical) in form, with a longitudinal diameter of about 16 or 17 % of the length of the head or $\frac{1}{3}$ of the breadth of the interorbital space. The eyeballs themselves, however, are remarkable for their great size; in HASTING's specimen, which was nearly $1\frac{1}{2}$ m. long, the transverse diameter of the eyes was $6\frac{1}{2}$ cm. A most remarkable point in the eyes of the Sunfish is the inner eyelid, the mobile, nictitating membrane, pierced in the middle, with which this fish is furnished according to CUVIER and OWEN[a]. A similar nictitating membrane is common, it is true, among the Sharks and finds its analogue, to a certain extent, in the motionless, adipose membrane of the Mackerels, the Gray Mullets, and other Teleosts. But here this membrane is furnished with a special closing muscle (sphincter) and five radiating opening muscles, the latter of which originate from the bottom of the orbit. The nostrils are very small, the anterior in each pair elliptical and transversely-set, the posterior round. They are set on about a level with the centre of the eyes and rather near each other, the anterior one at a distance from the tip of the snout that measures about $\frac{2}{3}$—$\frac{3}{4}$ of the length of the latter.

The tongue, according to KRØYER, is very large and fleshy, rather like the human tongue, but with very short and flat papillæ. Both the tongue and the palate are sharp as a rasp, almost as sharp as the skin of the body. In front of the tongue we find in the lower jaw (but not in the upper) a large, transverse fold (velum). The gill-rakers are only slightly developed and not dentated. The fourth branchial arch coalesces with the clavicular arch[b]. The upper pharyngeals form on each side an almond-shaped disk, set with three transverse rows of 5—8 pointed, scattered and narrow, but fairly large, curved teeth; the lower pharyngeals are toothless.

The abdominal cavity is lined with a firm, hard, and white peritoneum (fig. 156, *p*). The liver (*h*), which is of a rounded, oval shape, occupies about half, or even nearly the whole, of the abdominal cavity on the left side, but has only a small lobe to the right. The gall-bladder (fig. 157, *cf*) is large and has a long duct, which opens into the stomach (*v*). The latter, which is scarcely divided externally from the short œsophagus, extends along the greater part of the dorsal wall of the abdominal cavity, and under the end of this wall passes, without external boundary but with an internal contraction, into the intestine, which first runs straight forward and then, with several bends within its special peritoneal (mesenteric) sac (fig. 156, *i*), coils backwards and forwards, until it passes straight down into the rectum (*r*) and pierces the thick wall of the abdominal cavity at the vent (fig. 156, *a*). The entire intestinal canal is about $3\frac{1}{2}$—5 times as long as the body, and is especially remarkable for its thick wall. The spleen is of a flat, rounded shape, dark reddish blue in colour, and lies between the liver and the stomach. The urinary bladder (fig. 157, *vu*) is large and of an elongated

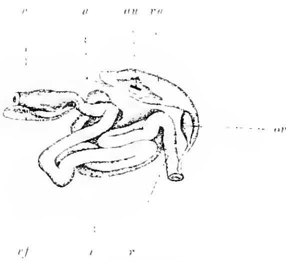

Fig. 157. Intestinal canal of *Orthagoriscus mola*, on a reduced scale. After CLELAND.

v, the stomach; *u*, the ureter; *au*, the fissure-like mouth of the urethra in the wall of the urinary bladder; *vu*, the urinary bladder; *ov*, the ovary; *r*, the rectum; *i*, the intestine; *cf*, the gall-bladder.

pear-shape. Its upper wall is pierced by the ureters (*u*), subsequent to their union. In front of this bladder lies the simple[c] ovary (*ov*), with the oviduct following the front side of the urethra down to the common urogenital aperture behind the vent. The rudimentary air-bladder, which was discovered by COSTA, occupies an oblique position, high up at about the middle of the length of the abdominal cavity.

In the leading features of its coloration the Sunfish shows itself to be a strictly pelagic fish. VON WRIGHT's figure tells us better than words the appearance of a Sunfish about half a metre long; but if we compare this figure with COSTA's figure of a somewhat older fish, we find that quite a considerable variation may occur in the colour. The ground-colour is bluish gray,

[a] CUVIER, *Leçons d'Anat. Comp.* (ed. DUMERIL) tome II, p. 434; (ed. MECKEL) tome II, p. 437; OWEN, *Comp., Anat., Physiol.*, vol. I, p. 336.

[b] According to KRØYER. According to CLELAND it is free.

[c] According to CLELAND and WAHLGREN. According to COSTA there are two distinct ovaries.

shading on the back into slate-gray or brown, down the sides and on the belly into white, and with a silvery lustre, brightest in old specimens. On the sides of the head, in front of and below the eyes, as well as on the chin and throat, we see irregular, clouded spots of reddish brown or gray. The dorsal and anal fins are brown, blackish at the tips. The pectoral fins are also brown, but, according to COSTA, crossed by transverse bands of grayish white. The pupil is bluish, the iris, according to most descriptions, silvery with yellow or red inner margin and with a spot of the same colour above and below.

Both in the internal organs of the Sunfish and on its gills and skin there live an extraordinary number of parasites, quite justifying, in the case of old specimens at least, the appellation of living "*hôtels garnis*" which has been bestowed upon them[a]. The skin of large specimens is coated with a layer of tough slime, two-fifths of an inch thick, in which there crawl lice of the family *Caligidæ*, and to which parasitic crustaceans of the genus *Penella* — on which Cirrhipeds of the genus *Conchoderma* may be found — and Trematods of the families *Tristomidæ* and *Monostomidæ* attach themselves. The gills are infested with Caligoids of the genus *Læmargus* and Trematods of the family *Distomidæ*, the eyes with *Filariæ*. In the muscles and, in still greater numbers, in the liver we find roundworms of the order *Acanthocephali*, and in the intestine, which is generally full of a fetid, tough, grayish white mucus, roundworms of the genus *Ascaris* and flatworms of the genera *Distoma*, *Tetrarhynchus*, and *Bothriocephalus*.

Of the daily life of the Sunfish we have but little information. All we know with certainty, is that it is strictly a pelagic fish. It has been most often met with lying on one side at the surface of the sea — we have already made the same observation in the case of several deep-sea fishes — to which the fish has been supposed to ascend in fine weather in order to bask in the sun[b]. Its lethargy on most of these occasions, however, may well be due to its having wandered from its proper home. Still, it has sometimes appeared nearer land and swimming forward, with the dorsal fin above the water, as GOSSE[c] relates of a Sunfish, 137 cm. long, that was taken in the Bristol Channel off Ilfracombe. "It was slowly moving at the time of its discovery, with a waving motion from side to side, "like a man sculling a boat," to use the comparison of the sailor who helped to take it; the back-fin appearing above water. The fish permitted the boat to come close up without exhibiting alarm, nor was he even disturbed when her side came into contact with his bulky person. The fellows made a bowline-knot, and slipped it over his head, tightening it before his dorsal and anal, so that the knot came in the middle of his side. Thus they hauled him in, not without a wetting, for with a flapping action of his ample fins (again a sort of sculling) he *scooped up* the water and threw it over them and into the boat. He survived his introduction to the public about an hour." One of the largest specimens that have been found on the English coast, 19 dm. in length, was caught off Chesil Bank (Dorset) in June, 1846[d]. This specimen was more active from the very first, and swam straight into the middle of the Mackerel-nets. The first net burst; but in the outer net the progress of the fish was checked; and with the help of 40 persons the catch was hauled ashore. "Here it dashed about the pebbles, according to the fishermen's account, like a shower of grape. It expired in about three hours, after uttering "hideous groans," like those of a horse dying of the staggers."

During the summer and autumn of 1850 the Sunfish was observed in the English Channel more often than usual; and from a comparison of these observations NEWMAN[e] came to the conclusion that these fishes had migrated thither from the west. The first find was recorded on the Cornish coast on the 9th of June, the last off Dover on the 8th of September. During his expedition with the *Hirondelle* in 1886 the Prince of MONACO in the month of September fell in with a number of Sunfish in company, not far south of Great Sole Bank, outside the entrance of the Channel. All of them were of insignificant size. The larger Sunfish he found in more scattered companies, but nearly always several not far from each other, in the open Atlantic east and north of the Azores. The Sunfish thus seems to be to a certain degree gregarious, at least during youth. Though it is usually sluggish and helpless, as it lies at the surface,

[a] MALARD, Le Naturaliste, 2e série, No. 46 (1er févr. 1889).
[b] Hence, perhaps, the name of Sunfish.
[c] Zoologist, 1852, p. 3579.
[d] Proc. Zool. Soc. 1849, p. 6.
[e] Zoologist 1850, preface, p. XI.

glittering in the sunshine or, in the darkness of night, shining with phosphorescent lustre, motionless and drifting with wind and tide — perhaps dazed or senseless after a too sudden ascent from deep water, as is the case with the true deep-sea fishes —, still it sometimes shows considerable activity in its movements. On such occasions it may be seen leaping high out of the water, as DAY tells us on the authority of COUCH's notes and of the verbal statement of DUNN. A large Sunfish that had been harpooned in the open Atlantic by the crew of the *Hirondelle*, had such power in its fins that, when it took to flight on feeling the blow of the harpoon, it almost succeeded in drawing boat and all with it down to the depths.

That the Sunfish also visits comparatively shallow water off sandbanks, islands, or the coast of the mainland, appears from the fact that its intestine-like stomach has frequently been found to contain *Zostera* and algæ, even those that only grow at a depth of a few fathoms. Still, its proper food is probably animal, though varied by these vegetable substances. Among the fragments of these plants KRØYER found in its stomach and intestine the scales of some fish, which he supposed to have been the Sole, together with *Sertulariæ* and *Ophiuræ*. WAHLGREN enumerates, besides the vegetable substances, fragments both of crustaceans and shellfish among the contents of the specimen he examined. KOREN and COLLETT found numerous Medusæ in the stomach of the Sunfish; and this slimy food may perhaps explain the composition of the fetid fluid, like thin gruel, of which the intestine is generally full. On some occasions the Sunfish has taken a hook baited with ordinary Mackerel-bait or even with worms.

The Sunfish has long been known in the Mediterranean and was found on the coast of England (Cornwall) by WILLUGHBY and RAY. BLOCH includes it among the fishes of the Cape of Good Hope. SCHLEGEL gives an excellent figure of the species from Japan; and RAMSAY exhibited in London, as we have mentioned above, an unusually large specimen of the Sunfish from Port Jackson[a] (Australia). Its range is, therefore, extensive, probably embracing all the tropical and temperate seas. In Scandinavia it must be regarded as rather rare. In Sweden and Denmark it has most often been found dead, floating at the surface or cast ashore, during late autumn or winter. Under these circumstances it has been met with not only in the Cattegat, but also in the Sound (a specimen 57 cm. long, in November, 1784, according to RETZIUS), the Great Belt (a specimen about 18 dm. long, secured by FIEDLER in November, 1862), and Flensburg Bay (MÖBIUS and HEINCKE, soon after 1860). The Royal Museum has received from Bohuslän two specimens about 43 cm. long, the first taken by Professor F. SUNDEVALL in October, 1834, the second by Prof. S. LOVÉN in 1856. Gothenburg Museum, according to MALM, possesses 4 specimens from this locality, between 40 and 55 cm. long and taken from October to December inclusive. The specimen 11 dm. long described by WAHLBERG, stranded in November, 1866 off the fishing-village of Träslöf, just south of Varberg. On the coast of Norway, according to COLLETT, the Sunfish is more frequent in its occurrence and has been found alive, even near the Swedish frontier, off Fredrikshald, in October, 1870. Several large specimens have been taken off Bergen and in Trondhjem Fjord. Even off the extreme north of Norway, in Alten Fjord, a Sunfish 11 dm. long has been found[b].

[a] Gt. Intern. Fish. Exhib., London 1883, Cat. Exhib. N. S. Wales, p. 46.

[b] While this sheet was in the press, I received through Mr. C. A. HANSSON a fresh specimen, 40 cm. in length, caught off Lesund, at the entrance of Dynekil, a fjord in the northernmost part of Bohuslän, on the 6th September, 1892. I here give the principal measurements of this specimen:

Length of the body from the tip of the snout to the middle of the margin of the caudal fin	492 mm.
„ „ „ head „ „ „ „ „ „ „ „ „ „ „ „ front margin of the gill-opening, in % of the length of the body	29.9 „
Greatest depth of the body (at the anal aperture), in % of the length of the body	66.7 „
„ thickness „ „ head (at the temples)	18.9 „
Distance from the tip of the snout to the beginning of the dorsal fin, in % of the length of the body	67.1 „
„ „ „ „ „ „ „ „ „ „ „ „ anal „ „ „ „ „ „ „ „ „	70.7 „
Length of the base of the dorsal fin, in % of the length of the body	19.8 „
„ „ „ „ „ „ anal „ „ „ „ „ „ „ „ „	19.8 „
„ „ „ longest ray „ „ dorsal „ „ „ „ „ „ „ „ „	42.2 „
„ „ „ „ „ „ „ anal „ „ „ „ „ „ „ „ „	40.8 „
„ „ „ middle „ „ „ caudal „ „ „ „ „ „ „ „ „	12.6 „
Distance between the anal aperture and the beginning of the anal fin, in % of the length of the body	6.5 „
Length of the pectoral fins, in % of the length of the body	12.6 „
„ „ „ snout, in % of the length of the head	49.3 „
„ „ „ orbit, „ „ „ „ „ „ „ „ „	17.1 „
„ „ „ postorbital part of the head, in % of the length of the head	38.4 „
Height of the orbit, in % of the length of the head	14.3 „
Longitudinal diameter of the cornea, in % of the length of the head	13.2 „
Vertical „ „ „ „ „ „ „ „ „ „ „ „	12.9 „
Breadth of the interorbital space, in % of the length of the head	55.8 „

The iris was blue, with white inner and outer margins of a faint golden lustre. The left eye (but not the right) had a white spot in the lower part thereof. The pupil was of a little deeper blue than the iris.

The Sunfish is seldom, if ever, used as food. All its various parasites and the slimy coat of its body render it repulsive to the ordinary fisherman; and the phosphorescent light that radiates from it in the dark, has caused it to be suspected of injurious properties. According to Risso[a], however, the liver is eaten in the north of Italy, though no great value is set upon it: and in *The Field* (4th Feb., 1882) we are told how a person was cheated into the belief that he was eating the most delicious turtle soup, which was really made of the flesh of the Sunfish. The only economical value of the Sunfish lies in the oil into which the flesh and liver are boiled down, or the glue extracted from the bones and gristle.

Fam. BALISTIDÆ.

Sclerodermis with hard scales or scale-like plates (not continuous carapaces) and with two dorsal fins, the first (more or less fully developed) with spinous rays. Caudal fin with 10 branched rays, and one simple ray at each margin.

This family is composed of fishes of far less singular appearance than the preceding one. Its members are the least abnormal of the Plectognates; and their primeval characters are veiled in a great number of them by an undeniable beauty of colour — several of the Balistoids belong to the most handsomely coloured fishes of the modern period. The dermal covering, however, varies considerably not only between genus and genus, but also in several forms during the changes of growth. Sometimes the scales are extremely small and hardly visible to the naked eye; and the juvenile forms may be armed with spines, especially on the sides of the tail, which remind us of the equipment of the *Acanthuri*, but in many forms disappear with age. The dermal covering is not the only character that distinguishes these fishes from the other Sclerodermis, the family of the Coffer-fishes (*Ostraciontidæ*): they are also marked by the presence of an anterior, spinous-rayed dorsal fin — though this fin may sometimes consist of a single spinous ray —, by the compressed form of the body, and by their stronger, rodent-like jaw-teeth.

The family belongs properly to the tropical seas — Jordan and Gilbert have estimated the number of the species at about 100 — and may be divided into three subfamilies: the *Triacanthinæ*, furnished with ventral fins and with the jaw-bones only loosely united; the *Monacanthinæ*, without ventral fins, or with only one rudimentary ventral ray, with extremely small scales, with at most two rays in the first dorsal fin, the membrane of which is also rudimentary, and with only 6 teeth in the lower jaw; and the *Balistinæ*.

Subfamily BALISTINÆ.

Ventral fins wanting or represented merely by one fixed or mobile spine on the end of the pelvic bones, which are confluent. First dorsal fin with three spinous rays. Caudal fin rounded or with S-shaped hind margin. Scales middle-sized or large, more or less plate-like. Upper jaw with 8 teeth in an outer row and 6 in a dense row within (behind) the former. Lower jaw with 8 teeth in a single row. Both the upper and the lower pharyngeals furnished with teeth. Branchiostegal rays 6 or 5. Vertebræ 17.

Linnæus called these fishes *Filare*[b] (Filers), a Swedish expression for the later name of *Sclerodermi*. In English they are called *File-fishes*, from the rough front surface of the first ray of the anterior dorsal fin.

Even by the external characters this subfamily is easily distinguished from the other Balistoids. The comparatively large scales of the body separate it both from the *Triacanthinæ* and the *Monacanthinæ*; in the structure of the first dorsal fin it ranks between them; in the absence of ventral fins and in the rounding (at least at the middle of the margin) of the caudal fin it has characters in common with the *Monacanthinæ*, which have fewer jaw-teeth, and in which we find either one single row of teeth on the lower pharyngeals or no teeth at all on the pharyngeal bones. In a *Melichthys* (*Balistes*) *bunira* from Ascension we find the lower pha-

[a] *Eur. Mér.*, tom. III, p. 174.
[b] *Mus. Ad. Fred.*, tom. I, p. 57.

ryngeals like branchial arches, only shorter and thicker than the ceratobranchial bones, and furnished with three rows of teeth, the outermost consisting of cylindrical teeth, the middle row of pointed ones, but all these teeth considerably shorter than those of the innermost row, which are larger, compressed, and claw-shaped. Two of the three upper pharyngeals are thick and united into one bone, which bears two rows of claw-shaped teeth, at the base broad but compressed, at the tip sharply pointed. The skeleton of this species contains 7 abdominal and 10 caudal vertebræ, including the urostyle.

Within the subfamily of the *Balistinæ*, of which about 30 species have been described, BLEEKER established 4 genera, differing in the form of the base of the caudal fin and in the form and colour of the jaw-teeth. The forms are so closely allied, however, that a division into genera can be defended only as an expedient to facilitate a general survey of the subfamily.

Among the peculiarities of the skeleton, besides those mentioned above, the strong supporting apparatus of the first dorsal fin, with the articulation of the first spinous ray, which is the principal defensive weapon of these fishes, is especially remarkable. The supporting apparatus, which is evidently formed by the coalescence and more advanced development of the elements of the first interspinal bones, consists of three bones[a], the hindmost of which is wand-like and lies in a backward and downward direction, so that its hind extremity rests against the lower part of the first interspinal bone of the second dorsal fin — which bone is here supported on the front of the upper spinous process (neural spine) of the fifth abdominal vertebra — while the anterior (upper) extremity articulates firmly with the lower end of the middle bone in the supporting apparatus. This bone is triangular, with one angle directed downwards, but longitudinally cloven, its two wing-like halves forming an angle open above and being firmly united in front and below to the first and largest bone in the supporting apparatus. This last bone is canaliculate, but its long bottom is sharply carinated, thus forming together with the middle bone a kind of boat, with the bows pointing backwards and split (open) and with a large, elliptical hole — crossed, however, by a narrow, transverse bridge of bone — in the posterior part of each side, but with the middle of its stern (turned forward in the fish) touching the middle ridge of the cranium (*spina occipitalis*) above the hind part of the orbits. The hind part of the gunwale (in the fish the fore part) is furnished with articular cavities, one on each side, for the lateral articular processes of the first spinous ray, and from the middle of the bottom, in the stern, rises a tap-like process with rounded head, over which glides the base of this ray, with its concave centre. In front of this process (i. e. behind it in the longitudinal direction of the fish) rises from the keel of the boat another tap-like and round-topped process, over the head of which the cloven base of the second spinous ray glides to and fro. The back of the first spinous ray is concave (canaliculate). The front of the second spinous ray is tumid at the base, and this swelling drops into the groove of the first spinous ray, when the rays are erected. In this manner the first ray is locked fast, and any attempt to force it back merely exerts a pressure on the second ray, which is thus kept all the more firmly fixed to its tap-like articular process, and effectually hinders any backward curvature of the first ray. In order to attain this result the second spinous ray must be drawn back, an operation which is performed partly by means of special muscles, partly by a ligament which unites this ray within the fin-membrane to the third spinous ray[b]. In the *Monacanthinæ*, which are without the third spinous ray, the supporting apparatus is also less developed; and in the *Triacanthinæ* the first interspinal bones are only slightly metamorphosed.

[a] Cf. HOLLARD, Ann. Sc. Natur., troisième serie, Zoolog., tom. XX, p. 102; SØRENSEN, *Om Lydorganer hos Fiske*, p. 50.

[b] Hence, according to JOHNSTON (*De Piscibus*, p. 110), the generic name of *Balistes* (catapult). The Italians, he says, called one of these fishes *pesce balestra*, because a slight pull at the third spinous ray was enough to overcome the rigidity of the first ray and to depress it, just as a light touch of the hammer or trigger in the lock of a cross-bow sufficed to discharge the weapon. This name reappears in the English name of *Trigger-fishes* as applied to these forms. *Balistes* was introduced into zoological nomenclature, without any special explanation, by ARTEDI, first in SEBA'S *Thesaurus*, tom. 3, p. 63 and again in *Gen. Piscium*, p. 53.

Genus BALISTES.

Peduncle of the caudal fin laterally compressed. Jaw-teeth white, those in the lower jaw and in the outer row in the upper jaw obliquely incised or claw-shaped: no prominent canines. Lips fleshy and naked. First dorsal fin completely separated from the second, its membrane falling short of the first ray of the second dorsal fin. Rays of the second dorsal fin less than 30.

Such are the characters by which Bleeker[a] has defined the true File-fishes, which are distinguished from all the other members of the family by their comparatively thick and also naked lips[b]. The greater number of these forms are furnished behind the gill-openings, on each side above the angle of the pectoral fin, with the plates whose connexion with the air-bladder has been pointed out, as we have mentioned above, by Möbius. One or perhaps two species are, however, known, which are without these special axillary plates, and on this account Bleeker proposed to establish a subgenus *Canthidermis*, borrowing the name, but not its application, from Swainson[c]. To this subgenus we should then refer

THE SPOTTED FILE-FISH (Sw. Spättbalisten[d] or Flackfilaren[e]).

BALISTES MACULATUS.

Fig. 155.

No special axillary plates. Scaly covering of the cheeks even, unbroken by any longitudinal, naked strips. A longitudinal hollow in front of each eye just below the naked, oblong depression in which the two small, oval nostrils are situated[f]. Tail unarmed, but the scales on the sides of the body furnished during youth on the free part of their surface with rows of pointed spines and at the middle (at the tip of the next scale in front) with one rather more prominent spine: in older specimens all the scales granulated on the free part of their surface, and the scales on the sides of the body retaining only blunt stumps of the spines, among which those at the middle of each scale are larger and somewhat elongated, together seeming to form longitudinal rows of low carinæ. About 32 scales in an oblique transverse row from the vent to the first dorsal fin. The quadrangular, elongated scales of the ventral side proper lie in about 14 obliquely longitudinal rows, the upper ones containing about 17 scales between the base of the pectoral fin and the anal region. Length of the head in adult specimens $^1/_4$, breadth of the interorbital space about $^1/_{10}$, length of the snout about 15 %, distance between the first dorsal fin and the tip of the snout 28 or 29 %, distance between the second dorsal fin and the tip of the snout 49 or 50 %, distance between the anal fin and the same point 55 or 56 % of the length of the body. Second dorsal and anal fins in front high[g] with the posterior outer (resp. upper or lower) margin concave. Length of the caudal fin at the middle equal to that of the snout[h]. Length of the pectoral fins $^1/_{11}$ of that of the body. Pelvic spine short, sometimes firmly united to the pelvis. Greatest depth of the body in young specimens rather more than $^1/_2$, in old rather less than $^1/_3$ of its length. Least depth of the body equal in adult specimens to the length of the pectoral fins. Greatest thickness equal to the length of the snout. Coloration brown or blue, with light blue spots, somewhat smaller than the eyes, scattered over the whole body, the second dorsal fin, the caudal fin, and the anal fin. In young specimens the spots are smaller, indistinct, and interspersed with darker spots. The fish is sometimes plain brown or black.

[a] *Atl. Ichth. Ind. Or. Néerl.*, tom. V, p. 98.

[b] Linnæus's *Balistes ringens* is thus excluded from this genus; in its case the lips are extremely thin and lie within the scaly dermal fold that extends outside the roots of the teeth in both jaws.

[c] *Nat. Hist. Fish., Amph., Rept.*, vol. II, p. 194

[d] Malm, *Gbgs. Boh. Fn.*

[e] Lilljeborg, *Sv., Norg. Fisk.*

[f] The anterior larger than the posterior: between them a longitudinal dermal flap, which partly covers the posterior nostril.

[g] The length of the longest ray (the 6th or 7th) in the former fin about $17^1/_2$ % of that of the body, in the latter fin (the 5th or 6th ray) 16 or 17 % thereof, or respectively 73 % of the base of the second dorsal fin and 84 % of the base of the anal fin — in each case in specimens between 27 and 30 cm. in length. In younger specimens these fins are more rounded.

[h] In young specimens the caudal fin is sharply rounded; in older ones the outer corners are prolonged into pointed, but short lobes.

R. br. 6; *D.* 3/24—26; *A.* 21—24; *P.* 15, (14) 1; *C.* 1+10+1; *L. lat.* 46—56.

Syn. *Guaperua longa*, LISTER in App. ad WILLUGHB., *Hist. Pisc.*, p. 21, tab. I, 20.

Balistes maculatus, BL., *Naturg. Ausl. Fisch.*, pt. II, p. 25, tab. CLI; BLKR, *Atl. Ichth. Ind. Or. Néerl.*, tom. V, p. 122, tab. CCXVIII, fig. 4; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 213; MALM, Öfvers. Vet. Akad. Förh. 1875, No. 7, p. 8; *Gbgs.*, *Boh. Fn.*, p. 599; DAY, *Fish. Ind.*, p. 687, tab. CLXXV, fig. 3; *Fish. Gt. Brit., Irel.*, vol. II, p. 267, tab. CXLV; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 420.

Balistes brevissimus + *Bal. angulosus* (?) + *Bal. maculatus* + *Bal longissimus*, HOLLARD, Ann. Sc. Nat., 4 ser., Zool., tom. I, pp. 56—62, tab. 3, figg. 1—4.

The Spotted File-fish attains a length of at least 4 dm., and is distinguished, when adult, among its congeners by its elongated form and by the comparatively great height and almost falciform shape of the second dorsal and the anal fins. It is one of the first-discovered species of the genus, and its range extends over the tropical and subtropical seas of both hemispheres. In the West Indies it has long been known, together with another species, under the name of *Sabuco;* and from these regions it sometimes strays to the coasts of North-western Europe. It has once been found, according to GÜNTHER, off Polperro in Cornwall; and in Uddevalla Museum is preserved a stuffed specimen, 272 mm. long, which is said to have been taken during the autumn of 1857 off "Saltkällan, at the head of Gullmar Fjord, whence it was forwarded fresh to the said museum". Of its habits we have no special information. In the Scandinavian fauna it is interesting only as a rarity, having wandered to our waters probably in the same manner as *Antennarius histrio*, merely a casual visitor to Scandinavian regions.

In Scandinavia the File-fish, of course, possesses no economical importance; and it is not used in any manner, to the best of our knowledge, in its true habitat. The other European species of the genus, *Balistes capriscus*, a form belonging to the warmer regions of the Atlantic and the Pacific, not very rare in the Mediterranean, and once or twice met with on the coasts of Great Britain and Ireland, is also one of the least useful fishes. According to CANESTRINI[a] it is not eaten in Italy. The flesh of the whole genus, as we have mentioned above, is also suspected of possessing poisonous properties. In those tropical regions where the species are most plentiful, the natives suppose that these poisonous properties are due to the food of the fishes and are especially dangerous when the fishes live on coralline animals. DAY describes[b], according to MEUNIER's observations at Mauritius, the symptoms caused by the eating of File-fishes. The poison operates immediately upon the nerves of the stomach and causes violent spasmodic convulsions in its walls. Soon afterwards, these convulsions spread to the muscles of the whole body. The tongue swells, the eyes stare, the breath grows difficult, and the patient dies in the most acute agony. Powerful emetics, followed by oleaginous substances and emulsions, are the best antidotes. Other species of the genus, however, enjoy a good reputation.

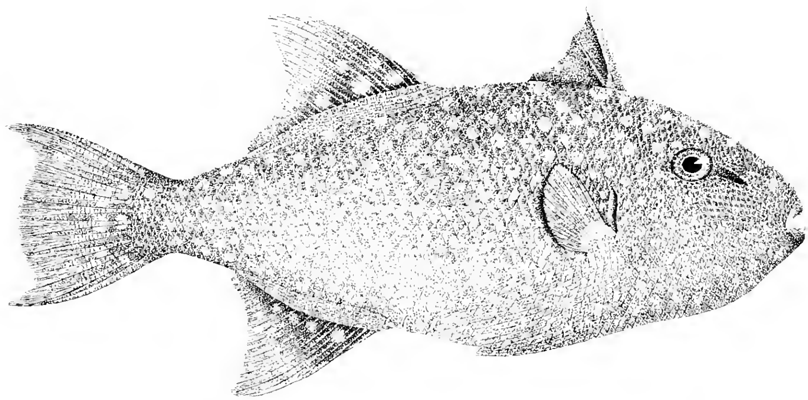

Fig. 155. *Balistes maculatus*, 1/2 the natural size. Valparaiso, the *Eugenie* Expedition.

[a] *Fauna Italica*, pt. III, *Pesci*, p. 147.

[b] *Fishes of India*, p. 686

PHYSOCLYSTI HEMIBRANCHII.

Physoclysts with free jawbones and pectinated gills, but with the branchial arches more or less imperfect and with large and externally visible interclavicles.

Here, as in the case of the Plectognates, the systematic difference from the other Physoclysts is not at all too great to admit of the arrangement of these fishes in a series of families corresponding to the series already adopted among the Physoclysts and ranged beside these series. This was also the approximate rank assigned to them by the writer who first treated of the combination of these fishes into a systematic whole: in 1861, in his arrangement of the Acanthopterygians[a], GÜNTHER adopted a twelfth division, *Acanthopterygii gasterosteiformes*, including the Sticklebacks and Flute-mouths with their nearest relatives, and a thirteenth division, *Acanthopterygii centrisciformes*, containing the family of the Trumpet-fishes. After PARKER'S[b] demonstration in 1868 of the morphological significance of the interclavicles of the Sticklebacks as traces of the Ganoid type, COPE[c] united GÜNTHER'S two divisions into an order *Hemibranchii*, "connecting the *Lophobranchii* with ordinary fishes."

All these fishes have abdominal ventral fins, and are thus ranged comparatively low in the scale of development of the Physoclysts. Their principal character also lies, as we have shown above, in the circumstance that several of the bones which in more typical Physoclysts entirely partake in the structure of the endoskeleton, are here wholly or partly dermal, appearing in the form of growths belonging to the exoskeleton. This structural feature is fairly common among fishes. Scales, differing usually in size, shape, or thickness from the other scales of the body, are in one fish the precursors of a still further alteration in a kindred form, a difference which, during the development of the form-series, leads to the result that the modified scales creep, so to speak, into the body and join themselves to parts of the endoskeleton, and finally, when the transformation has reached its highest point, lie like covering (membrane) bones outside other bones, or even enter in the form of independent bones into the endoskeleton. A great portion of the skeleton of the Vertebrates has originated in this manner. The most beautiful and most perfect example of this is given by the human clavicles, the development of which has been traced by PARKER (l. c.) from their first origin, at which period they are morphologically analogous to two lateral plates in the Sturgeons or the Cuirassed Siluroids[d]. The interclavicles which we have above remarked in certain Plectognates, are of similar origin. They occur, it is true, in several other Physoclysts as well, but in an extremely reduced form and as parts of the endoskeleton.

Here, in the *Hemibranchii*, as well as in the *Lophobranchii*, they still preserve distinctly the character of dermal plates. Thus, in the Three-spined Stickleback (fig. 156, *C*) for example, they have the form of two parallel, ventral scutes, contiguous in front, separated behind, on the outside granulated and striated, like the other dermal plates of the body, on the inside supporting, in front, the lower ends of the clavicles, and behind, the lower margins of the coracoid bones or more correctly, according to PARKER, of their covering bones, the procoracoids, which are also said to be of dermal origin.

The same relative position to the rest of the skeleton is here occupied by the pelvic bones or rather, according to the same interpretation, by the covering bones of the pelvic bones proper. These bones lie in the Sticklebacks immediately behind the interclavicles, or even project some distance between them; and in the Three-spined Stickleback (fig. 157, *A*, *es*) they are marked by the large, ascending process that meets the lateral plates of the body in the skin. The character which in COPE has been chosen to give the *Hemibranchii* their name, lies in the absence or persistent cartilaginous structure of one or more of the upper parts of the branchial arches (the epibranchial and upper pha-

[a] *System. Synops. Fam. Acanthopt. Fish.*, Cat. Brit. Mus., Fish., p. VIII.

[b] Ray. Soc., *Shoulder Girdle and Sternum*, p. 40.

[c] *Ichthyology of the Lesser Antilles*, Trans. Amer. Phil. Soc., Philad., n. ser., vol. XIV, pp. 456 et 457.

[d] Cf. SMITT, *Ur de högre djurens utvecklingshistoria*, p. 218.

ryngeal bones) on each side. Another character of more general validity — which indicates the low rank of these fishes among the Teleosts — is the imperfect ramification and, in some cases, the defective transverse division (articulation) of the soft fin-rays.

The form of the body is very variable in the *Hemibranchii*. The Sticklebacks, which possess the ordinary, most typically piscine form, are so like the Horse-Mackerels that they have been ranged beside the latter by many systematists. All the others are of more singular form, elongated like the Garpikes or laterally compressed, and all with the head prolonged into a long, tubular or conical snout, at the end of which the small mouth is situated. This prolongation, however, does not depend here, as in the Garpikes, on the elongation of the jaws, but corresponds more exactly to the structure we have remarked above in certain Plectognates, here affecting the ethmoid bone, the three pairs of pterygoid bones, the preoperculum, and the interoperculum, which together form the greater part of the long rostral tube, special suborbital bones, on the other

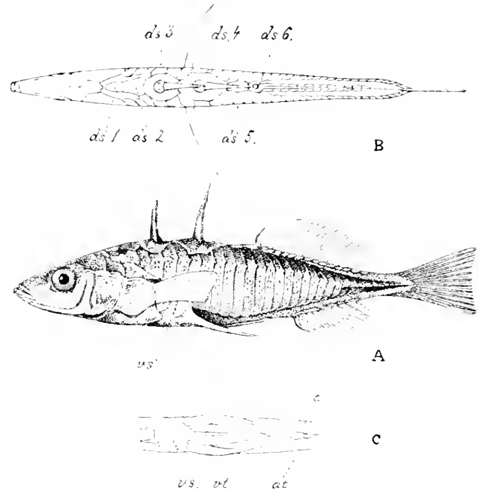

Fig. 157. *Gasterosteus aculeatus, trachurus*, natural size. From Eckernförde Bay. *A*: from the side; *B*: from above; *C*: ventral and anal regions: *ds*, dorsal plates; *vs*, plate of the ventral fin (pelvic bone), in *A* its ascending lateral process; *a*, vent; *at*, anal spine; *vt*, ventral spine. After HEINCKE.

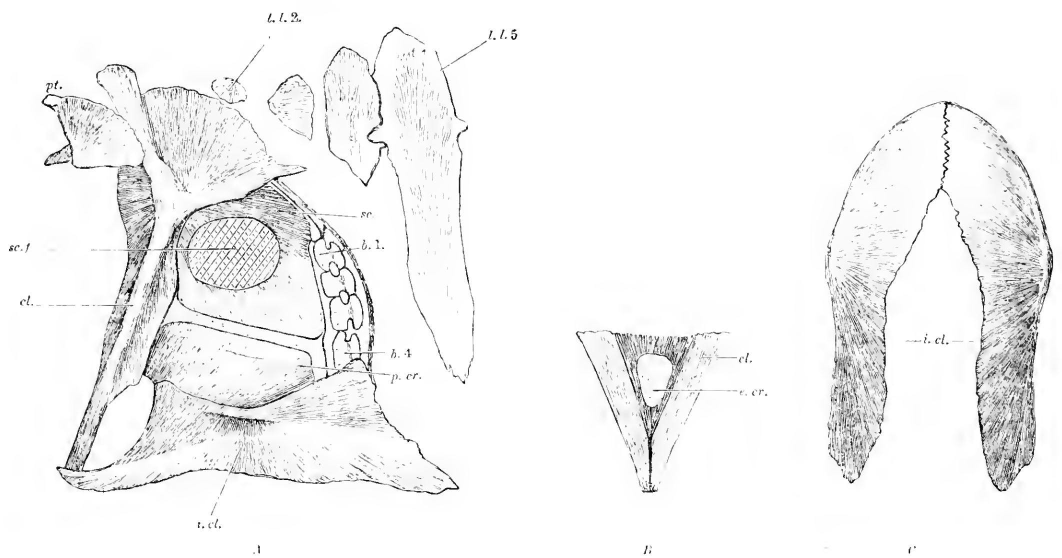

Fig. 156. Shoulder-girdle of *Gasterosteus aculeatus*; magn. 9 or 10 diam.; after PARKER.

A: Bones of the left side, seen from without. *pt*, posttemporal bone (Ganoid plate of the first dermal ring); *l.l.2*, first lateral plate (Ganoid plate of the second dermal ring); *l.l.5*, fourth lateral plate; *cl*, clavicles; *sc*, scapula; *sc.f*, scapular fenestra. *b.1*, first basal bone of the pectoral fin; *b.4*, fourth basal bone; *p.cr*, ossified part of the coracoid bone (praecoracoideum, according to PARKER); *i.cl*, interclavicles.

B: Section of the lower part of the clavicular arch, to show the cartilaginous part of the coracoid bones (*e.cr*, epicoracoideum, according to PARKER) between the clavicles.

C: Interclavicles, seen from the ventral side, with the anterior end up.

hand, being wanting. We find a trace of this elongation in one of our Sticklebacks, the Fifteen-spined species. The other families of the *Hemibranchii* (the Flute-mouths, *Fistulariidæ*, and the Trumpet-fishes, *Centriscidæ*) are also distinguished from the Sticklebacks by the elongation and, in some cases, the coalescence of the first four or even the first six vertebræ. In this manner the forepart of the body receives an increase of strength which is still further advanced in the Trumpet-fishes by the extraordinary development of the anterior interspinal bones and by their dorsal expansion into a more or less perfect shield, which in the Chinese *Amphisile* has been compared, not without reason, to the carapace of the turtles.

The Hemibranchian group is not particularly rich in forms. It contains only a score of known and described species. Some of them are so like each other that their right to specific rank must still be regarded as rather dubious; others, again, are so different that a comparatively great number of genera have been established. According to GILL the group contains 14 genera, distributed among 6 families. Most of the families live in the tropical seas; the Scandinavian fauna possesses only one.

FAM. GASTEROSTEIDÆ.

The anterior vertebræ of normal structure. Ventral fins with one spinous and one or two soft rays. In front of the soft-rayed (second) dorsal fin 3—15 free spinous rays (not united by a fin-membrane); in front of the anal fin one spinous ray. Suborbital ring united to the preoperculum, but without rigid connexion. Teeth on the intermaxillary bones and in the lower jaw; palate and tongue unarmed. No scales proper. Base of the caudal fin narrow, but depressed. Branchiostegal rays 3 on each side. Air-bladder simple. Pseudobranchiæ more or less well-developed; pyloric appendages wanting or rudimentary.

Within this family, which was founded by GÜNTHER[a] and originally ranged by him at the head of the system of the Teleosts, are collected the *Hemibranchii* in the exterior of which the ordinary piscine form is most typically persistent. Still these fishes show tendencies of transition to the carapaced Trumpet-fishes and also to the elongated Flute-mouths. An expression of this may be found in the proposed generic division of the family. One species, our common Three-spined Stickleback, with its well-developed dorsal plates and shorter form of body, especially of the snout, has been employed as the type of a distinct genus, the true Stickleback genus (*Gasterosteus*), while another species, the Fifteen-spined Stickleback, with its more elongated form and, in particular, its longer snout, is the single representative of a second genus, *Spinachia* or *Gastræa*. The latter genus is approximated to the Flute-mouths not only by the form of the body, but also by the structure of the pelvic apparatus, which in the Fifteen-spined Stickleback is broken up into its two halves, which merely meet each other by means of foliate processes in the median line of the belly.

All these fishes are of small size, but have long been famous both for their beauty and for the high degree of instinct that guides them in the propagation of their species. In spite of their insignificant size they are not destitute of importance. The gregarious habits of some species collect them in such enormous masses that they may easily be applied to industrial purposes. On the other hand, they are destructive enough, for their fatness is gained to a great extent at the expense of the fry and eggs of other fishes.

The range of the family embraces the northern parts of both hemispheres. Some of these fishes occur both in fresh water and in the sea or, at least, in brackish water; but the first genus we shall here describe, is exclusively marine.

[a] *Cat. Brit. Mus., Fish.*, vol. I, p. 1.

Genus GASTRÆA[a].

Body elongated (greatest depth less than $^1/_2$ the length of the head), in the abdominal region pentagonal and only slightly deeper than broad: the forepart (in front of the anal spine) shorter than the hind part, including the caudal fin. Number of free spinous rays in front of the soft-rayed dorsal fin at least 13. Ventral fins inserted at the middle of the long pelvic bones, which lie at the lower lateral edges of the belly and are without any firm osseous connexion with each other. Jaw-teeth compressed.

As we have mentioned above, this genus contains only one species:

THE FIFTEEN-SPINED STICKLEBACK (SW. TANGSPIGGEN).

GASTRÆA SPINACHIA.

Plate XXVIII, fig. 5.

Distance between the ventral spines and the anal spine less than $^3/_5$ of the length of the head or than $^2/_5$ of the distance between the former spines and the tip of the snout, which distance is more than 72 % of that between the anal spine and the tip of the snout. Free dorsal spines of uniform size, except the hindmost, which is also the largest. Branchiostegal membranes united underneath into a broad, free dermal fold across the isthmus.

R. br. 3; *D.* XIV[b]—XV 6[c]—7; *A.* I 5—7; *V.* I 2; *P.* 9—10[d]; *C.* $x+1+10+1+x$; *L. lat.* 40; *Vert.* 40—42.

Syn. *Aculeatus vel Pungitius marinus longus*, SCHONEV., *Ichth. Slesv. Hols.*, p. 10; *Aculeatus marinus major*, ID., ibid., tab. IV, fig. 3; *Gasterosteus* aculeis in dorso quindecim, ART., *Ichth. Gen.*, p. 52; *Syn.*, p. 81; *Centriscus*, A. 1, (aliis *Spinachia*) KLEIN, *Hist. Pisc.*, Miss. IV, p. 48; STRÖM, *Sondm. Beskr.*, part. 1, p. 316.

Gasterosteus Spinachia, LIN., *Syst. Nat.*, ed. X, tom. I, p. 296; *Fn. Suec.*, ed. II, p. 119; BL., *Fisch. Deutschl.*, part. II, p. 84, tab. LIII, fig. 1; RETZ., *Fn. Suec. Lin.*, p. 339; CUV., VAL., *Hist. Nat. Poiss.*, vol. IV, p. 509; EKSTR., Vet. Akad. Handl. 1831, p. 305; NILSS., *Prodr. Ichth. Scand.*, p. 87; EKSTR., v. WR., *Skand. Fisk.*, ed. 1, p. 21, tab. IV, fig. 3; SUNDEV., Stockh. L. Hush. Sällsk. Handl., H. VI (1855), p. 79; NILSS., *Skand. Fn., Fisk.*, p. 112; LINDSTR., Gotl. L. Hush. Sällsk. Arsber. 1866, p. 15 (sep.); GTHR, *Cat. Brit. Mus., Fish.*, vol. I, p. 7; SAUV. (*Gastræa*) Nouv. Archiv. Mus. Par., tom. X (1874), p. 36; BNCKE (*Gasterosteus*), *Fisch., Fischer., Fischz. W., O. Preuss.*, p. 76; *Handb. Fischz., Fischer.* (M. v. D. BORNE), p. 99; DAY, *Fish. Gt. Brit., Irel.*, vol. I, p. 246, tab. LXVIII, fig. 5; MELA, *Vert. Fenn.*, p. 280, tab. IX.

Spinachia vulgaris, FLMNG, *Brit. Anim.*, p. 219; KR., *Danm. Fiske*, vol. I, p. 193; MGRN, *Finl. Fiskf.* (disp. Helsingf. 1863), p. 16; COLL., Forh. Vid. Selsk. Christ. 1874, Tillaegsh., p. 14; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 5; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 171; HANSEN, *Zool. Dan., Fiske*, p. 31, tab. V, fig. 4; MÖB., HCKE, *Fisch. Osts.*, p. 64; STORM, N. Vid. Selsk. Skr. (Trondhj.) 1883, p. 15; LILLJ., *Sv., Norg. Fn., Fisk.*, vol. I, p. 370.

Spinachia Linnæi, MALM, *Gbgs, Boh. Fn.*, p. 373.

Obs. The name of *Spinachia* or, as KLEIN writes it, *Spinochia* is, according to CUVIER and VALENCIENNES, a Latinized form, dating from the Middle Ages, of the French *epinoche*.

The Fifteen-spined Stickleback is distinguished from its relatives by the elongated form of the body, with the greatest depth, at the base of the ventral fins, about $10^1/_2$—$8^1/_2$ % of the length. From the head to the vent the body is pentagonal, then quadrangular, but more and more depressed behind, until at the base of the caudal fin it suddenly becomes laterally compressed. The length of the body may rise, at least in the females, to $18^1/_2$ cm., but is usually between 13 and 15 cm.

The elongated head measures between $^1/_4$ and $^1/_5$[e] of the length of the body, and in old specimens the

[a] In order to enable us without tautology to retain the Linnaean specific name of *spinachia*, we here adopt the generic name proposed by SAUVAGE in 1874, a Latinized form of CUVIER'S *Les Gastrés*, in spite of the fact that, even in the first edition of his *Règne Animal* (1817), the latter author adopted *Spinachia* as the name of the subgenus which FLEMING (*British Animals*, 1828) raised to a generic rank.

[b] Sometimes 13, according to HEINCKE, sometimes 17, according to DAY.

[c] Sometimes 5, according to LILLJEBORG.

[d] Sometimes 11, according to KROYER.

[e] 25·6—21·5 % of the length of the body, according to our measurements of specimens between 53 and 172 mm. long.

length of the snout is exactly equal to the distance between the hind margin of the eye and that of the operculum. This elongation of the snout is, however, a character of growth, for in fry 21 mm. long the length of the snout is about 60 % of the post-orbital length of the head, in young specimens between 50 and 75 mm. long about 90 % thereof. The elongation is produced, as we have mentioned above, by the growth in a forward direction of the ethmoidal region and the palatine parts as well as of the preoperculum and interoperculum. At the same time the quadrate bone with the articular knob for the lower jaw moves forward, and the cleft of the mouth, which up to the present has been comparatively larger and almost horizontal, becomes relatively smaller and rather more ascending. With this elongation is also connected the relative diminution of the eyes; in a specimen 21 mm. long their longitudinal diameter is equal to the length of the snout, in specimens 25 mm. long about $^3/_4$, in specimens 50 mm. long about $^2/_3$, and in a female 172 mm. long only slightly more than $^1/_3$ of the same length.

The head is quadrangular, tapering in a forward direction, with perpendicular sides and only slightly convex occiput. The snout is depressed and blunt, with the upper profile slightly concave. The eyes are round, and their superior margin lies on a level with the flat or somewhat hollow forehead, or rises a very little above the latter, the breadth of which, at the anterior margin of the eyes, is equal to their diameter. The small, round nostrils, only one on each side, lie half-way along the snout. The edges of the mouth are furnished with fleshy lips, lobate on the sides of the upper jaw; the lower jaw projects beyond the upper, which may, however, be protruded by means of the long nasal processes of the intermaxillary bones. The length of the lower jaw is about $^1/_2$ that of the snout. When the mouth is closed, the small maxillaries, the length of which is about $^1/_2$ that of the intermaxillaries, drop under the projecting preorbital bones. The jaw-teeth are of equal size, chisel-shaped, and most of them notched at the margin; they are set in front in several (3 or 4) fairly regular rows, behind in a single row. The pharyngeal teeth are pointed, and above they form on each side an almond-shaped card, obliquely divided into an anterior, smaller patch and a posterior, larger one. The gill-rakers are setiform, 10 or 11 in number on the first branchial arch. The pseudobranchiæ lie high, on each side within the articulation of the hyomandibular bone; each of them is made up of five, digitiform lamellæ, set in a transverse row. The palatine fold of the upper jaw is fairly large, the corresponding dermal fold in the lower jaw less developed. The external bones of the head are granulated and striated. The operculum is triangular, with the hind inferior side somewhat convex, the upper side somewhat concave. The suboperculum has a short, anterior branch in a vertical direction and a longer, posterior one, broader below, tapering behind, and curved like a sabre; the latter forms the whole opercular margin along the lower posterior side of the true operculum. The preoperculum forms a right angle, with the anterior, horizontal arm, which is coasted by the subjacent interoperculum, considerably elongated, as we have mentioned above. The two posterior suborbital bones are attached to the upper (inner) margin of this arm, the posterior firmly, the anterior very loosely, thus forming a cuirass for the cheeks, but only under the eyes. The hind part of the cheek (between the eye and the vertical arm of the preoperculum) and the space between the long preorbital (first suborbital) bone and the anterior part of the horizontal arm of the preoperculum (a strip along the side of the snout, behind the corner of the mouth) are covered by the glossy skin alone. The gill-openings extend above the operculum for a distance measuring about $^1/_3$ of its length. Underneath the branchiostegal membranes are united into a broad, free fold, the hind margin of which coincides with the anterior end of the interclavicles.

The form of the trunk is determined principally by the granulated plates that follow the dorsal margin, the lateral line, and the ventral margins. The dorsal margin is occupied by the plates that have been developed in the skin on the tops of the interspinal bones. Nearest to the occiput there lie two flat plates, one behind the other, followed by a row of concave plates, generally 15 in number, each of which is furnished with a free spinous ray with a small, triangular membrane behind it. Next follow seven plates, which support the true, soft-rayed dorsal fin. On the dorsal margin of the tail this row is continued by fastigiated and carinated plates, growing more and more flattened, and finally smoothed out and indistinct. The ventral edges are formed in the forepart of the body by the interclavicles, which are comparatively small in this species, and which by their arcuate union in front together form an elongated horse-shoe, equal in length to the space between 9 of the free spinous rays on the back. Within each arm of this horse-shoe projects a small portion of the anterior extremity of one of the pelvic bones. The two pelvic bones are also elongated and narrow in this species, their length being about equal, in adult specimens, to the space between 10 or even 11 of the free dorsal rays. They are thin and almost flat, the inner surface alone being slightly hollowed into a broad channel; and they are strengthened along the middle by two ridges, an outer and strong one and an inner and weaker, which is interrupted at the middle. Above, towards the side of the body, their thin margin is only slightly broadened at the middle, and they do not send out any special branch in this direction. Inwards, on the other hand, at the lower ventral edge, at the middle of their length and a little further back, they send out a flat and thin process, somewhat wider towards the tip, which meets the corresponding process of the pelvic bone from the other side of the body, though without entering into any firm osseous connexion with it. The pelvic bones extend very nearly to a line with the vent; and here this angular structure of the ventral edges ends, to be replaced at the base of the anal fin and on the under surface of the tail by a row of plates analogous to that we have just seen on the dorsal side. The plates of the lateral line, about 40 in number, fastigiated and carinated, with the carinæ partly covering each other, form a straight row from the temporal region above the gill-cover out along the lateral edges of the compressed tail, though here they grow thin and indistinct.

The first free spinous ray on the back is set above the hind part of the gill-cover, at a distance from the tip of the snout measuring between $21\frac{1}{2}$ and 22 % (generally decreasing with age) of the length of the body. The last (hindmost) of these spinous rays lies exactly opposite the vent, and the distance between it and the tip of the snout varies individually between 45 and 46 % (exceptionally 43 %) of the length of the body. Thus, during youth, the space occupied by these spinous rays is, as a rule, somewhat less, in old specimens somewhat greater, than the distance between the first ray and the tip of the snout. The length of the rays is somewhat greater than the distance between them; and their articulations lie a little to one side and in a zigzag, so that, when they are depressed, the tip of each ray falls beside the base of the next ray behind it, in the groove formed by the above-mentioned concave plates[a]. Just behind the last spinous ray rises the true dorsal fin, triangular, with rounded apex, the first ray being somewhat shorter than the second, but equal in length to the third, the other rays decreasing in length gradually, but sharply. Sometimes both the first and the second rays are simple, but in most cases all the rays are more or less deeply branched. The last ray is united throughout its length by the fin-membrane to the dorsal edge. When erected, the rays are recurved, the anterior (as well as the posterior) side of the triangle being thus convex. The length of the base of the fin is about $\frac{1}{2}$ (varying between 56 and 47 %) of that of the head. Just in front of the anal fin we find a free spinous ray[b], equal in size to the last spinous ray on the dorsal edge, but situated further back, vertically below the first or even the second ray of the true dorsal fin. Thus, the anal fin being almost exactly similar to the dorsal in form, structure, and size, the termination of the former lies somewhat further back than that of the latter. The form of the caudal fin reminds us, to a certain extent, of a combination of the anal fin with the true dorsal, in which combination each of these fins would correspond to a half of the caudal fin, which is fan-shaped when expanded. In this species, as in all the Scandinavian Sticklebacks, this fin contains 12 rays, excluding a few (generally 2 or 3) small supporting rays at each margin), among which the 10 middle ones are branched for about half their length, but the outermost simple. The middle rays of the caudal fin are always somewhat, though sometimes only slightly, shorter than the longest rays of the dorsal fin, and measure about 8[c] or 9 % of the length of the body.

The pectoral fins are of the form and structure common to all the Sticklebacks. As a rule they consist

[a] When the number of these rays is less than usual, it is generally the 14th that is wanting, as KRØYER has remarked, the distance between the last ray and the last but one being thus greater than that between the other pairs. The interspinal plate of the absent ray is also wanting. In such specimens we have also found the third spinous ray considerably reduced, and its interspinal plate proportionately smaller than the others. In some cases HEINCKE found only 13 free spinous rays.

[b] In our figure this ray has unfortunately been overlooked.

[c] Sometimes 7.

of 10[a] simple rays of fairly uniform length, though the middle ones are somewhat longer than the outer, the tip of the fins, when they are folded, being thus evenly, but sharply rounded. When expanded these fins are fan-shaped. Their base is almost perpendicular, and by the great expansion of the shoulder-blade and the coracoid bone is removed farther than usual from the clavicle, leaving an even patch, covered with glossy skin, in front of it. The length of the pectoral fins is generally about equal to the base of the soft-rayed dorsal or the anal fin, and is usually somewhat greater in the males than in the females, varying between about 10 and 12 % of the length of the body.

The ventral fins lie a little behind the middle of the pelvic bones and a little behind the end of the first third[b] of the body. They are made up of one spinous ray, which is distinctly longer than (sometimes nearly twice as long as) any of the other spinous rays, and behind this ray they have a triangular fin-membrane, set obliquely inwards and backwards, and containing in its posterior (inner) part two small, soft rays, the last of which is in most cases difficult to detect. Like all the other spinous rays, that of the ventral fins is also granulated throughout the greater part of its length, with smooth tip; but in this species all the spinous rays are without lateral spines and denticles.

The only external difference that we have been able to discover between the sexes of this species, is that pointed out by LILLJEBORG, namely that the pectoral fins are generally longer in the males than in the females; and even this is faint. This uniformity is highly remarkable, for in our other Sticklebacks the difference between the sexes is striking enough, even in the external form.

The peritoneum is white with a silvery lustre, but dotted with black, which is often the predominant colour on the dorsal side of the abdominal cavity. The intestinal canal is simple and short. Just behind the diaphragm the œsophagus, which is lined with longitudinal folds, passes into the stomach, the inside of which is reticulate, and which extends scarcely half-way along the abdominal cavity, to about a line with the hind extremity of the interclavicles, where it is bounded from the intestine by a strong and muscular contraction. The inside of the intestine is thickly lined with villi, arranged in oblique, transverse series. In a straight direction, and with a breadth almost equal to that of the stomach, but growing narrower behind, the intestine extends almost to the end of the abdominal cavity, where it bends in a sharp curve obliquely upwards and forwards, soon to return in a curve no less sharp backwards and downwards to the vent. The only trace of pyloric appendages that we have been able to discover, is an extremely short process, directed back towards the stomach, on the intestine just behind the pylorus.

The liver lies in the form of an undivided mass below and along the sides of the œsophagus and stomach, with a blunt point in a downward and forward direction towards the union of the interclavicles. On the left side it has a short lateral lobe, which does not extend further back than the main lobe; but the lobe on the right side is longer, and follows the intestine for about half of its anterior, straight part, or a little further. At the end of the middle lobe, under the termination of the stomach, a little to the right, lies the gall-bladder, and on the left side, above the end of the stomach, the spleen. The air-bladder is situated in the posterior part of the abdominal cavity, and its anterior extremity lies above the end of the stomach.

The ovaries and testes are paired and saccate. The former at least, with their comparatively large and few eggs — KRÖYER estimated their maximum number at 300 — occupy the greater part of the abdominal cavity during the spawning-season.

In coloration the Fifteen-spined Stickleback is one of our most beautiful fishes, though under the influence of mental agitation, of terror for example, it often suddenly loses its beauty and brightness of colour, and does not regain them for a long time. The upper part of the body is olive green, shading into brown, the lower yellowish with white, silvery belly. The sides are, as it were, transparent, showing glimpses of the spinous processes of the vertebræ in the form of dark, transverse, parallel streaks. Below the lateral line, on a ground of lustrous silver, lies a row of large, crescent-shaped and oval, olive green spots, which grow smaller behind and finally disappear on the tail. A dark brown band runs along the side of the head from the corner of the mouth to the base of the pectoral fin.

[a] Sometimes 9; exceptionally 11.

[b] The distance between the ventral spine and the tip of the snout varies in different individuals between about 34 and 37 % of the length of the body.

The pectoral fins are yellow with a brassy lustre. The true dorsal and the anal fins are grayish brown with yellow rays in front; behind the membrane is transparent. The caudal fin is olive-green, with transparent outer margin and yellowish brown rays. The iris is gray, above darker with black margin, below whitish yellow; the pupil is surrounded by a narrow, orange ring.

The geographical range of the Fifteen-spined Stickleback is known to extend from North Cape along the west coast of Europe to the Bay of Biscay. In Iceland and America it is unknown. The most westerly parts of its range are the Faroe Islands and Ireland. It penetrates into the Baltic as far as the south coast of Finland. Off Hogland, in the Gulf of Finland, it is common, according to MELA; in the island-belt of Stockholm it is rare. Being distinctly a marine fish, never entering fresh water, it is commoner on the west coast of Sweden than on the east. It is also common on the coast of Norway, off the Orkney and Shetland Islands, and southward at least to the coast of Brittany; but in the Bay of Biscay it is rare.

The Fifteen-spined Stickleback is a shore-fish and lives among the seaweed, ascending into half-a-fathom of water and even up to high-water mark. "Its favourite haunts," says MALM, "are such spots as possess a sandy bottom, studded with large or small stones covered with *Fucaceæ* and interspersed with groves of *Zostera*. Among these it gracefully threads its way by short stages, now hither and now thither." It is not very active nor very timid; but when frightened it darts forward with the speed of an arrow. In contradistinction to the other Sticklebacks it leads a more solitary life, or at least does not assemble in so dense or large shoals. It is tenacious of life[a] and a greedy eater. Its food consists principally of small crustaceans (especially of the genera *Mysis* and *Idothea*) and worms; but it is also accused of preying upon the roe and fry of other fishes. COUCH[b] once saw a Fifteen-spined Stickleback seize and partly devour a young Eel 3 inches long, though it was at last compelled to disgorge its victim.

During the spawning-season, which occurs in spring and summer, the Fifteen-spined Stickleback makes its way to shallow water, within a harbour or in some little inlet sheltered from the waves, often between the tide-marks. Here it builds a nest for its eggs and young. This is constructed either on the bottom or, perhaps more frequently, floating in the water, under a pendent tuft of seaweed or some other object — COUCH found one of these dwellings between the loose twists of the end of a rope[c]. When the nest hangs free, it is usually pear-shaped and of the size of one's fist. BUCKLAND[d] gives the following description of the nursery of the Fifteen-spined Stickleback: "The main body of the nest is formed of very soft weed — in fact, as soft as sponge — and, strange to say, as though for the sake of ornament, our little architect has placed at the point where the nest is thickest a bit of brilliant blood-red weed. Nay, more, it appears as though the builder of the nest, fearing the risk of discovery, had worked in great broad portions of brown ribbon weed, which should act, firstly, as a covering, or band, to keep the whole structure together; and, secondly, to serve the purposes of concealment. So beautifully, indeed, is this nest constructed for the concealment of the eggs, that unless the naturalist to whom the nest was sent had been previously aware what the structure meant, he might easily have been pardoned if he had not seen the eggs at all. After a careful dissection of the outer coatings of the nest, the eggs themselves came into view. These eggs are round little bodies about the size and colour of mustard seed. They are in bunches like grapes, and we try whether they are to be separated from the bunch with ease. Another marvel: the body of eggs are all sewed into a compact mass by a very thin, delicate fibre, which in the sun glistens like a cobweb or the very finest floss silk. The filaments which hold the eggs are worked through, over and round them, so as to form a complete network." Threads of the same sort also serve to hold the walls of the nest together, and are secreted by the fish in the form of a glutinous substance that hardens in the water.

MALM has described (l. c.) his observations of the spawning of the Fifteen-spined Stickleback on the 3rd of August, 1854, off Kristineberg (Gullmar Fjord).

[a] KRÖYER, however, found it less tenacious of life than the true Sticklebacks.

[b] *Hist. Fish. Brit. Isl.*, vol. I, p. 183.

[c] l. c., pl. XXXVIII.

[d] *Nat. Hist. Brit. Fish.*, p. 250. For further information on this head see HANCOCK, Ann. Mag. Nat. Hist., 2nd ser., vol. X (1852), p. 246.

"It was a female[a], greenish in colour, that was busy near the landing-stage, in about 7 or 8 dm. of water, building a dwelling, or a kind of nest, for the eggs soon to be deposited. In a round hollow, about $2^1/_2$ cm. deep and 15 cm. in diameter, in the sandy bottom, she placed, several times an hour, small fragments of dead plants, which she found during her wanderings in the neighbourhood and carried in her mouth to the spot. Now and then she worked herself into the heap thus collected, turning quickly round and round, and emerged on the other side of the pile. In this manner she carded the building-materials with the stiff and sharp rays of her fins, and at the same time oiled them with the slime secreted by her own body, thus forming an elastic tube, in which she finally deposited her eggs. The male in his more bluish dress kept guard, swimming round and round the spot, and now and then rewarded by a friendly greeting from the female, while the enemies of the roe, the shrimps and shore-crabs etc., were repulsed by the powerful onslaughts of the brave sentinel, as soon as they ventured to approach his post. The female was often compelled to come to the rescue, but the fish were always victorious. But if another male of the same species came up, he was at once joined by his host in some friendly sport, which ended in a regular game of *tig* among the stones and seaweed several yards from the spot. But as soon as the host saw that he had led astray his uninvited guest, whom he had evidently enticed from the spot by this stratagem, he returned at full speed, to resume at the next moment the defence of his home and family. They paid no attention to fishes of other species, such as Gobies etc." From this observation MALM concludes that the Fifteen-spined Stickleback lives in pairs, at least during the spawning-season, and is not polygamous like the other Sticklebacks; while it would also seem to be peculiar to this species that the female should build the nest and take part in its defence. Other observers, however, are of opinion that here too the male is the actual builder, but that the nest is guarded both by the male and the female. The parents continue their vigilant care of the eggs and the new-hatched young for at least three or four weeks. Enemies are repulsed; if the nest is damaged, they repair it; if they are driven away, they soon return. If the nest be built between the tide-marks, they must, of course, leave it to its fate during the ebb; but the moisture retained by the walls of the nest suffices to keep the eggs or young alive until the tide rises again.

Of the growth of the fry we learn from the collections of the Royal Museum that during the expedition of the gunboat *Gunhild*, on the 25th of July, 1878, a young specimen $31^1/_2$ mm. long was taken at a depth of four fathoms on a stony and weedy bottom, in the south of the Sound between Malmö and Falsterbo. It belonged, no doubt, to the fry of the same year. On the Irish coast THOMPSON[b] found young specimens 19 mm. long in June and others, 25 mm. long, in July. Through Professor LINDSTRÖM the Royal Museum has acquired some young specimens between 57 and 71 mm. in length and taken on the coast of Gothland in August, 1852. These last specimens, however, can hardly have been less than a year old.

The solitary life of the Fifteen-spined Stickleback, which prevents it from ever being caught in any quantity, deprives it of all special importance to man in an economical respect. It is taken only by accident among other fishes in small-meshed nets or the seine; and it is utilised only in the manufacture of oil and as manure.

(EKSTRÖM, SMITT.)

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[a] As the nest was afterwards destroyed by accident and the fish were frightened away, MALM was prevented from ascertaining by closer examination whether this specimen was really a female, and her companion a male.

[b] *Nat. Hist. Irel.*, vol. IV, p. 90.

GENUS GASTEROSTEUS[a].

Body mackerel-like, compressed (greatest depth more than half the length of the head), without other carinæ than the lateral edges of the belly and the elevation of the lateral line on the hind part of the tail; forepart of the body (in front of the anal spine) longer than the hind part, including the caudal fin. Number of free spinous rays in front of the soft-rayed dorsal fin less than 13. Ventral fins inserted at the outer, front corner of the pelvic bones, which coalesce with each other in the median line of the belly into a triangular ventral plate, tapering behind. Jaw-teeth conical.

The genus of the Sticklebacks contains the most widely-spread of all the Scandinavian fishes. There is hardly a single brook in which we fail to see these small and lively creatures swimming merrily about, often within narrow limits which the heat of summer reduces more and more each minute. For economical purposes they generally possess far too little importance to interest the practical fisherman, who usually knows them merely by name. The zoologist cannot content himself with so slight an acquaintance. To him a knowledge of the Stickleback is quite as important as of its far larger and far more useful fellow, the Salmon. Both are equally small fractions in the great series of natural forms which it is his task to investigate, and both are equally interesting, equally advantageous subjects of study. When we add to this the wonderful instinct of the Sticklebacks, which guides them to an architectural skill exceptional among fishes, we have sufficient grounds for bestowing on them more than usual attention.

To the systematist they are also of absorbing interest, for the course of development may be traced with especial distinctness in their differences of form and changes of growth. Their relation to the preceding genus has been expressed in a masterly way by Dr. HEINCKE[b], in an elucidation of the significance of the variations affecting the dorsal spines in the Three-spined Stickleback. With this object he had examined about 10,000 specimens of the species in question.

The Three-spined Stickleback is generally furnished — and this is one of its most important characters — with 3 free spinous rays at the dorsal edge in front of the soft-rayed dorsal fin. It had long been known, however, that the number of these spinous rays might be increased to 4[c]; and a variety of this kind, with the four spinous rays comparatively short, had been described by CUVIER and VALENCIENNES[d] as a distinct Italian species, *Gasterosteus tetracanthus*. HEINCKE found about 1 percent of the Three-spined Sticklebacks that he examined, furnished with four spines; and of this number he examined 61 specimens in order to locate the supernumerary ray. Each of the spinous rays is attached to and articulated, in a singular manner which we shall describe more fully below, with one of the interspinal plates on the back. These plates are as a rule (fig. 157 and fig. 158, *B*) 6 in number and arranged

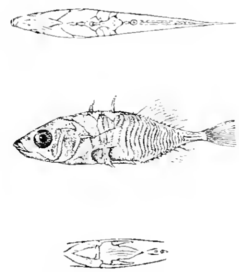

Fig. 158. *Gasterosteus aculeatus, gymnurus.* Natural size. From Italy. After HEINCKE.

in a row: 2 small ones just behind the head, 2 larger ones, each with a spinous ray, the posterior usually the larger, 1 smaller plate with no spinous ray, and lastly 1 supporting the hindmost spinous ray. The largest two of these plates, however, are evidently due to the coalescence of at least 2 plates respectively. In fig. 159 we see the anterior one broken up into two parts, and in fig. 160 the posterior of them shows the same division. The anterior also rests on the upper

[a] The generic name is derived from ARTEDI, *Genera Piscium*, p. 52.
[b] Öfvers. Vet. Akad. Förh. 1889, p. 395.
[c] CUV., VAL., *Hist. Nat. Poiss.*, vol. IV, p. 491.
[d] l. c., p. 499.

spinous processes of two vertebræ, the posterior on those of four. Thus we have as a rule to deal with 8 interspinal plates at the dorsal edge in front of the soft-rayed dorsal fin. In one single case, however, HEINCKE could trace 9 of these interspinal plates, the last two each with a distinct, well-developed spinous ray, and the third, counting from behind, with a rudimentary spinous ray "in the form of a rigid spine."

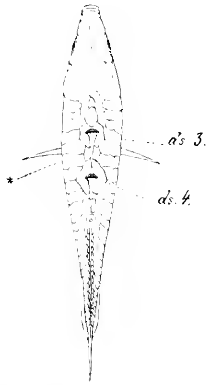

Fig. 159. *Gasterosteus aculeatus, trachurus.* Natural size. From the Frisches Haff, off Königsberg. — * the posterior, detached part of the third dorsal plate (*ds. 3*). After HEINCKE.

The Three-spined Stickleback has thus shown at least traces of as many as 5 free spinous rays at the dorsal edge.

If we now observe the arrangement of these 5 spinous rays, we shall find that each one of the 9 dorsal plates, with the exception of the first, may be furnished with a spinous ray, though not simultaneously. In order to express the differences that occur in this respect, we shall denote each of the interspinal plates by an Arabic figure (1—9), the plates which in each case must be regarded as double, by brackets (⏞), the three ordinary spinous rays by the Roman numerals I—III, the most usual supernumerary ray by IV, and the rudimentary and supernumerary ray that has only once been observed, by V. The cases (varieties) observed by HEINCKE are then as follows:

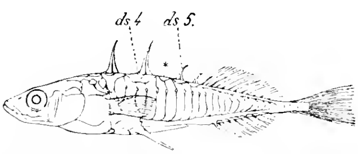

Fig. 160. *Gasterosteus aculeatus, trachurus, tetracanthus,* with the supernumerary spinous ray set on the penultimate dorsal plate. Natural size. From Kiel Bay. — * the posterior, detached part of the fourth dorsal plate (*ds. 4*). After HEINCKE.

A: in Three-spined Sticklebacks with 3 free spinous rays at the dorsal edge.

a: with the regular number (6) of interspinal plates, the forms most typical in this respect (figs. 157 and 158).

$$\overset{0}{1} - \overset{0}{2} - \overbrace{3 - 4}^{\text{I}} - \overbrace{5 - 6}^{\text{II}} - \overset{0}{0} - \overset{0}{8} - \overset{\text{III}}{9}$$

b: with 7 interspinal plates (the 3rd and 4th detached from each other, fig. 159).

$$\overset{0}{1} \quad \overset{0}{2} - \overset{\text{I}}{3} \quad \overset{0}{4} - \overbrace{5 - 6}^{\text{II}} \quad \overset{0}{0} \quad \overset{0}{8} - \overset{\text{III}}{9}$$

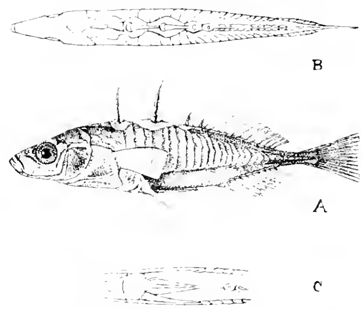

Fig. 161. *Gasterosteus aculeatus, trachurus, tetracanthus,* with the supernumerary spinous ray set on the penultimate dorsal plate. Natural size. From Eckernförde Bay. After HEINCKE.

B: in Three-spined Sticklebacks with 4 free spinous rays at the dorsal edge.

c: with a supernumerary spinous ray on the penultimate interspinal plate, otherwise as in variety *a*. 36 specimens out of 61 showed this arrangement (fig. 161).

$$\overset{0}{1} - \overset{0}{2} - \overbrace{3 - 4}^{\text{I}} - \overbrace{5 - 6}^{\text{II}} - \overset{0}{0} \quad \overset{\text{IV}}{8} - \overset{\text{III}}{9}$$

d: similar to *c*, but with the 5th and 6th plates detached from each other (fig. 160). 16 specimens out of 61.

$$\overset{0}{1} - \overset{0}{2} - \overbrace{3 - 4}^{\text{I}} - \overset{\text{II}}{5} - \overset{0}{6} - \overset{0}{0} - \overset{\text{IV}}{8} - \overset{\text{III}}{9}$$

e: with a supernumerary spinous ray on the 6th plate and with this plate detached from the 5th. 4 specimens out of 61.

$$\overset{0}{1} - \overset{0}{2} - \overbrace{3 - 4}^{\text{I}} - \overset{\text{II}}{5} - \overset{\text{IV}}{6} - \overset{0}{0} - \overset{0}{8} - \overset{\text{III}}{9}$$

f: with only 5 interspinal plates, otherwise similar to *c*. 2 specimens out of 61.

$$\overset{0}{0} - \overset{0}{2} \quad \overbrace{3 - 4}^{\text{I}} - \overbrace{5 - 6}^{\text{II}} - \overset{0}{0} - \overset{\text{IV}}{8} - \overset{\text{III}}{9}$$

g: with only 6 interspinal plates, otherwise as in *d*. 1 specimen out of 61.

$$\overset{0}{0} - \overset{0}{2} - \overbrace{3 - 4}^{\text{I}} \quad \overset{\text{II}}{5} - \overset{0}{6} - \overset{0}{0} - \overset{\text{IV}}{8} \quad \overset{\text{III}}{9}$$

h: with a supernumerary spinous ray on the 4th interspinal plate, which is detached from the 3rd, the latter, on the other hand, being confluent with the 2nd (fig. 162). 1 specimen in 61.

$$\begin{array}{ccccccccc} 0 & \multicolumn{2}{c}{\mathrm{I}} & \mathrm{IV} & \multicolumn{2}{c}{\mathrm{II}} & 0 & 0 & \mathrm{III} \\ 1 - & \multicolumn{2}{c}{\overbrace{2 - 3}} & - 4 - & \multicolumn{2}{c}{\overbrace{5 - 6}} & - 0 - & 8 - & 9 \end{array}$$

b: with a supernumerary spinous ray on the 2nd interspinal plate, otherwise similar to *a*. 1 specimen in 61.

$$\begin{array}{ccccccccc} 0 & \mathrm{IV} & \multicolumn{2}{c}{\mathrm{I}} & \multicolumn{2}{c}{\mathrm{II}} & 0 & 0 & \mathrm{III} \\ 1 & 2 & \multicolumn{2}{c}{\overbrace{3 \quad 4}} & \multicolumn{2}{c}{- \overbrace{5 - 6}} & - 0 - & 8 - & 9 \end{array}$$

C: in one Three-spined Stickleback with a rudiment of a fifth spinous ray and with eight interspinal plates.

$$\begin{array}{ccccccccc} 0 & 0 & \multicolumn{2}{c}{\mathrm{I}} & \mathrm{II} & 0 & \mathrm{V} & \mathrm{IV} & \mathrm{III} \\ 1 - & 2 - & \multicolumn{2}{c}{\overbrace{3 - 4}} & - 5 - & 6 - & 7 & 8 - & 9 \end{array}$$

Now, as at least 7 of the interspinal plates — though only 3—5 at once — may be furnished in the Three-spined Stickleback with true spinous rays, and as 7—12 free spinous rays occur at the dorsal margin

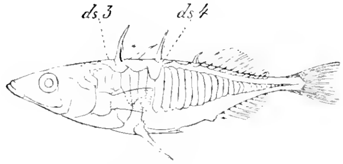

Fig. 162. *Gasterosteus aculeatus, trachurus, tetracanthus* (*spinulosus*) with the supernumerary spinous ray ( ) set on the posterior, detached part of the third dorsal plate. Natural size. From the Frisches Haff, off Königsberg. After HEINCKE.

of the Ten-spined Stickleback, while in the Fifteen-spined Stickleback the limits of the variation in this respect are 13 and 16, the series, with decreasing numbers, is complete from the last species to that first mentioned. HEINCKE assumes that the development has taken this direction, with constantly sinking numbers. Thus, where more than 3 free spinous rays occur at the dorsal edge of the Three-spined Stickleback, we have a retrogression to an older stage of development, through which the species has already passed. The Fifteen-spined Stickleback, according to this theory, represents the earliest stage of the development of the whole family, whose descent should thus be traced from fishes of the Fistularioid family.

The alterations of development, however, lead us to a different conclusion, namely that the Ten-spined Stickleback stands nearest the probable origin of the family. We have already seen that the elongated form which is the chief characteristic of the genus *Gastræa* — though we meet with it in the youngest forms of all the Sticklebacks — especially in the character that suggests a transition to the Flute-mouths, namely the elongation of the snout, is a character of age, a character which develops during growth from a juvenile stage with the typical form of the species perfect in other respects, but with the length of the snout only slightly greater than in the true Sticklebacks. Even during the later (older) stages of growth this general rule holds good, for the length of the snout shows increase, e. g. in proportion to the postorbital length of the head (see the following table), both in the Fifteen-spined Stickleback and the true Sticklebacks, but is least in the Ten-spined species. Another relation, in which the changes of development also follow the same direction in all the three species now under consideration, gives the same result. If we endeavour to formulate an expression for the position of the soft-rayed dorsal and the anal fins with respect to each other, we find that, as a general rule, the anal spine lies somewhat behind the perpendicular from the beginning of the former fin — in the Ten-spined Stickleback alone it may exceptionally lie somewhat in front of this line — and that the percentages for the distance between the former fin and the tip of the snout compared with that between the anal spine and the same point, run in all three species in inverse proportion from the earlier stages of growth to the later. The highest percentages, which are thus expressions of the lowest stages of development, occur in the Ten-spined Stickleback (see the following table). But this is not all. In the relations in which the Fifteen-spined Stickleback shows a deviating direction of development, it stands nearest to the Ten-spined Stickleback. For example, if we compare the length of the soft-rayed dorsal fin with that of the head, we find that this fin is considerably longer in the true Sticklebacks than in *Gastræa*, and longest in the Three-spined Stickleback. The percentage for this relation also increases, as a general rule, during the growth of the Sticklebacks, but decreases with age in *Gastræa* (see the following table).

Average in:	*Gastræa spinachia.*		*Gasterosteus pungitius.*		*Gasterosteus aculeatus*	
Length of the body expressed in millimetres	61.9	132.2	41.2	56.3	55.8	69.7
" " " snout in % of the postorbital length of the head	96.1	96.3	51.2	56.8	73.6	71.8
Distance between the soft-rayed dorsal fin and the tip of the snout in % of the distance between the anal spine and the same point	97.2	95.4	99.9	97.8	90.7	86.1
Length of the base of the soft-rayed dorsal fin in % of the length of the head	52.6	49.1	84.1	88.1	86.2	95.7

Thus both the Fifteen-spined and the Three-spined Sticklebacks stand nearer to the Ten-spined Stickleback during youth than they do in later life. During growth they diverge from this species, each in a special direction. The first direction of development tends towards the Flute-mouths, the second, as we have mentioned above, towards the Trumpet-fishes.

This conclusion differs essentially, it is true, from that arrived at by HEINCKE, but agrees with the latter in the most important point, namely that the Three-spined Stickleback is descended from a species that was extremely closely allied to the Ten-spined Stickleback, unless indeed its ancestor be this very species. As evidence in favour of this HEINCKE cites *Gasterosteus Bussei*, the form described from Amur in 1887 by HERZENSTEIN and WARPACHOWSKI, with 9 free spinous rays at the dorsal margin (like the Ten-spined Stickleback), but with a complete row of scutes along the sides of the body (like the Three-spined Stickleback). A similar form had already been described in 1869, from DAVID's Chinese collections, by GUICHENOT[a] under the name of *Gasterosteus sinensis*, and in 1880, from DYBOWSKI's collections in the bays of Northern Japan, by STEINDACHNER[b] under the name of *Gasterosteus japonicus*. We have another intermediate form in *Gasterosteus (Eucalia) inconstans* from North America and Greenland, with the branchiostegal membranes inferiorly free, at least to some extent, from the isthmus (as in the Ten-spined Stickleback) and without lateral plates on the body, but with only five free spinous rays at the dorsal edge[c].

The range of the genus *Gasterosteus* embraces both fresh and salt water in the Arctic and Temperate Zones of the Northern Hemisphere, both in the Old World and the New; but the number of the species is probably no more than five, two of which belong to the Scandinavian fauna.

THE THREE-SPINED STICKLEBACK (SW. SIORSPIGGEN).

GASTEROSTEUS ACULEATUS.

Plate XXVIII, figs. 1 (♀) and 2 (♂).

Three (exceptionally four) free spinous rays at the dorsal margin. Branchiostegal membranes inferiorly united to the isthmus throughout its length.

R. br. 3; *D.* III—IV 10—12[d]; *A.* I 8—10; *P.* 10[e]—11; *V.* I 1; *C.* $x+1+10+1+x$; *L. lat.* 3—34; *Vert.* 31—32[f].

Syn. *Gasterosteus* aculeis in dorso tribus, ART., *Gen. Pisc.*, p. 52; *Syn. Pisc.*, p. 80; *Spec. Pisc.*, p. 96; LIN., *Fn. Suec.*, ed. 1, p. 103; WESTBECK, Vet.-Akad. Handl. 1753, p. 261; STRÖM, *Sondm. Beskr.*, vol. 1, p. 315; ÖDMANN, Vet.-Akad. Handl. 1782, p. 167.

Gasterosteus aculeatus, LIN., *Syst. Nat.*, ed. X, tom. 1, p. 295; FABR., *Fn. Groenl.*, p. 169; RETZ., *Fn., Suec. Lin.*, p. 338; PALL. (*Gasteracanthus*) *Zoogr. Ross. Asiat.*, tom. III, p. 229; CUV. (*Gasterosteus*), *Régn. Anim.*, ed. 1, tom. II, p. 320; EKSTR., Vet.-Akad. Handl. 1831, p. 296; NILSS., *Prodr. Ichth. Scand.*, p. 85; JENYNS, *Man. Brit. Vert. Anim.*, p. 348 (+*G. spinulosus*, p. 350); EKSTR., V. WR., *Skand. Fisk.*, ed. 1, p. 17, tab. 4, fig. 1, *a* et *b*; KR., *Danm. Fiske*, vol. 1, pp. 169 et 590; LILLJ., Vet.-Akad. Handl. 1850, p. 309; HANCOCK, Ann. Mag. Nat. Hist., ser. 2, vol. X, p. 241; SUND., Stockh. L. Hush. Sällsk. Handl., H. 6 (1855) pp. 79, 85, 176; NILSS., *Skand. Fn., Fisk.*, p. 103; THOMPS., *Nat. Hist. Irel.*, vol. IV, p. 82; HECK., KN., *Susswasserf. Österr. Mon.*, p. 38 (+*G. brachycentrus*, p. 41); SIEB, *Susswasserf. Mitteleur.*, p. 66; MGRN, *Finl. Fisk.-Fn.* (Disp. Helsingf.) p. 14; LINDSTR., Gotl. L. Hush. Sallsk. Arsber. 1866, p. 14 (sep.); CANESTRINI, *Fn. D'Ital.*, pt. III, *Pesci*, p. 25; COLL., Forh. Vid. Selsk. Christ. 1874, Tillaegsh., p. 11; ibid. 1879, p. 2; N. Mag. Naturv. Christ., Bd. 29 (1884) p. 48. MALM, *Gbgs. Boh. Fn.*, p. 371; SEIDL., *Fn. Balt.*, p. 128; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 4; FEDDERS., ibid., p. 73; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 73; ID., *Handb. Fischer., Fischz.* (M. V. D. BORNE), p. 98; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 163; MELA, *Vert. Fenn.*, p. 277, tab. IX; DAY, *Fish. Gt. Brit., Irel.*, vol. 1, p. 238, tab. LXVIII, figg. 1—3; AL. AGASS., Proc. Amer. Acad. Arts, Scienc., vol. XVII (1882), p. 288, tab. IX; HANSEN, *Zool. Dan., Fiske*, p. 27, tab. V, figg. 1 et 2;

[a] Nouv. Arch. Mus. d'Hist. Nat. Paris, tome V, p. 204, pl. 12, fig. 4.
[b] Stzber. Akad. Wiss. Wien Math. Naturw. Cl., Bd. LXXXII, I, p. 264, taf. III, fig. 2.
[c] Cf. JORDAN and GILBERT, Bull. U. S. Nat. Mus., No. 16, p. 394.
[d] Sometimes 8, according to KROYER.
,, 14, ,, ,, LILLJEBORG.
[e] ,, 9, ,, ,, KROYER.
[f] Exceptionally 30, sometimes 33, according to FATIO.

STORM. N. Vid. Selsk. Skr., Trondhj. 1883, p. 15; MÖB., HCKE. *Fisch. Osts.*, p. 66; LILLJ., *Sv., Norg. Fisk.*, vol. I, p. 343; MÖB., *Nature*, vol. XXXIX, No. 998 (Dec. 13, 1888) HCKL, Öfvers. Vet.-Akad. Förh. 1889, p. 395.

Gasterosteus biaculeatus, SHAW (ex. PENN.) *Gen. Zool.*, vol. IV, p. 608.

Gasterosteus trachurus + *G. gymnurus* (*leiurus*) + *G. argyropomus* + *G. brachycentrus* + *G. tetracanthus* + *G. noveboracensis* + *G. niger*, CUV., *Règn. Anim.*, ed. 2, tom. II, p. 170; + *G. semiarmatus* + *G. semiloricatus*, CUV., VAL., *Hist. Nat. Poiss.*, vol. IV, pp. 493 et 494; *G. loricatus* + *G. dimidiatus*, REINH., D. Vid. Selsk. Math. Naturv. Afh., VII (1838), pp. 114 et 119; *G. aculeatus* + *neustrianus* + *semiloricatus* + *semiarmatus* + *leiurus* + *Bailloni* + *argentatissimus* + *elegans*. BLANCH., *Poiss. d. eaux douces Fr.*, pp. 213—236; *G. aculeatus* + *ponticus* + *noveboracensis* + *suppositus* + *obolarius* (?) + *loricatus* + *niger* + *serratus* + *neustrianus* + *semiarmatus* + *semiloricatus* + *teraunus* + *leiurus* + *Bailloni* + *algeriensis* + *plebeius* + *inopinatus* + *argentatissimus* + *elegans* + *islandicus* + *biaculeatus* + *microcephalus* + *argyropomus* + *brachycentrus* + *tetracanthus* + *spinulosus*, SAUV., *Nouv. Arch. Mus.*, tom. X, pp. 9—25; *G. microcephalus* + *biaculeatus* + *atkinsii* (ex BEAN) + *aculeatus*, JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 395.

Obs. The great number of nominal species that have been established, according to the above list of synonyms, in the endeavour to elucidate the inconstancy of form among Three-spined Sticklebacks, is merely a significant token of the lengths to which this inconstancy may run in a species that sometimes occurs in enormous multitudes, is found in far distant localities both in salt water and in fresh, and both in form and colour shows marked sexual distinctions.

The Three-spined Stickleback attains a length of at least about 9 cm. Our largest specimen is a female from Greenland which measures rather more than 91 mm. from the tip of the snout to the end of the middle rays of the caudal fin, or 93 mm. from the tip of the lower jaw to the end of the outer caudal rays[a]. The form of the body reminds us strongly of the Horse-Mackerel, being fusiform with strong lateral compression. The body is deepest across the pelvis at the articulation of the ventral spines, where the depth is about $^1/_5$ of the length of the body, varying individually between $18^1/_2$ and $22^1/_2$ % thereof. The thickness at the same spot is about half the depth, varying individually between 44 and 57 % thereof. Except during the spawning-season, when the organs of generation become tumid and render the body more terete, the thickness is almost uniform from the eyes back to the strongly compressed base of the caudal fin, the sides being flat throughout the forepart of the body, but with sharp carinæ on their posterior parts, except in the variety *gymnurus*, which is without caudal plates, and in which the sides of the tail are also flat. The dorsal profile between the head and the soft-rayed dorsal fin and the ventral profile between the head and the anal fin are usually comparatively straight or only slightly convex, while the upper and lower contours of the head in front and of the tail behind are more sharply convergent. Sometimes, however, especially in the females, which generally show a deeper form of body, the entire upper and lower profiles of the body run in unbroken curves. The external form is also affected to a considerable extent by the more or less advanced development of the covering of plates, this being the origin of most of the numerous different names by which the species has been known.

The whole covering of plate-armour shows fairly great individual variations both in extent and in strength. In its strongest form it consists of comparatively thick osseous growths in the skin, externally resembling Ganoid scales, granulated and striated by grooves and ridges, the latter rough with small granules. But, as HEINCKE has remarked, both the thickness and the roughness may be reduced, to the greatest extent, as a rule, in the Three-spined Sticklebacks that inhabit brackish or fresh[b] water, or belong to more southern regions. Still forms with extremely reduced plate-armour also occur in the Arctic regions, as for instance in Greenland, where the *Sofia* Expedition of 1883 took a number of small specimens of the *gymnurus* form in a lake near Ritenbenk (North Greenland). These specimens, like the Italian *argyropomus*, have only three plates on each side of the body, namely the three that adjoin the ascending lateral disk of the pelvic bones.

The plate-armour of the back we have already examined for the most part, and we need only add that here, as in the Fifteen-spined Stickleback, the soft-rayed dorsal fin rests on a row of interneural plates (here about 13, i. e. — excluding the plate of the last spinous ray — one for each ray and one more behind the fin). This statement also applies to the anal fin, which generally has 11 interhaemal plates at the base, the first supporting the spinous ray and the last two usually

[a] Thus almost exactly equal to the largest specimen in Copenhagen Museum, according to HANSEN (*Zool. Dan.*, l. c.). According to PALLAS it attains a greater size. His *Gasteracanthus cataphractus* from Kamchatka seems to be simply the typical Three-spined Stickleback, but is stated to attain a length of 122 mm. (*longitudine pollicum sesquiquinque*). Cf. also TILESIUS, Mém. Acad. Petersb., tom. III (1809—10), p. 226.

[b] Already remarked by KRØYER (l. c., p. 180).

without rays. The ventral margin in front of the anal fin forms a more or less distinct break for the vent; and in front of the vent, at a greater or less distance therefrom, lie the pelvic bones so characteristic of the Sticklebacks, or rather their covering bones. Here we see the so-called pelvic bones (*propelvis*) distinctly situated as osseous growths in the skin, in an homologous series with the interhaemal plates mentioned above; while in the other Teleosts the pelvic bones, in their position and often in their form as well, have proved quite as distinctly homologous with the interhaemal bones (spines) themselves. This difference is accompanied by another: in the Sticklebacks the ventral fins are attached to the middle (in *Gastræa*) or to the anterior part (in *Gasterosteus*[a]) of the so-called pelvic bones, while in the other Teleosts they articulate with the hind extremity of these bones.

In the Three-spined Stickleback, as in the following species, the pelvic bones, with their inner margins united by a suture in the median line of the belly, form a compact, triangular plate, pointed behind, which at the anterior part of each of its sides sends out a foliate disk up the sides of the belly. In the Three-spined Stickleback this disk generally meets three of the lateral plates of the body on each side, thus forming a complete pelvic girdle, belonging to the dermoskeleton. The anterior margin of the pelvic plate is straight or only slightly concave[b]. The two anterior corners touch the interclavicles already mentioned, which in the Three-spined Stickleback are comparatively broad — their breadth at the middle about equal to the distance between them[c] — and so long that the pelvic bones lie entirely behind the insertions of the pectoral fins.

In the typical Three-spined Stickleback the sides of the body are almost entirely covered by a corslet formed by a row of plates belonging to the lateral line, the only naked parts being the belly itself, up to a level with the bottom of the insertions of the pectoral fins, a narrow strip along the soft-rayed dorsal and the anal fins, and the patch in front of each of the pectoral fins. Among these lateral plates the middle ones, below or just in front of the last spinous ray on the back, are the largest (deepest). Forward and backward the plates diminish in size; but on the last eight or nine (on the peduncle of the tail) we find a raised, median carina, following the longitudinal direction of the body, and perceptible, though not very distinct, to the twelfth plate, counting from behind. This median carina renders the breadth (thickness) of the body no less along the greater part of the tail than it is in front; but just in front of the caudal fin the breadth decreases more or less rapidly. The lateral line, which pierces these plates, runs from the temporal region parallel to and near the back. The sixth plate, counting from in front, is the most constant in position, and unites the 4th dorsal plate to the top of the ascending disk of the pelvic bones, with which disk the 5th and 7th lateral plates are also contiguous in most cases. These three lateral plates (5—7) are also the most persistent, while the others may be reduced, attenuated, and obliterated, as we have described above. The first to disappear are the plates that lie on the posterior part of the ventral sides and the anterior part of the sides of the tail, between the seventh plate (from in front) and the carinated caudal plates; — a form of this description from Norway has been named *hemigymnus* by COLLETT. Later the fish loses both the foremost plates (in front of the fifth) and the hindmost, carinated caudal plates, and the peduncle of the tail undergoes more and more lateral compression (*gymnurus*). At the same time the silvery lustre of the body generally disappears, and the back develops more or less distinct, dark spots or transverse bands, suggesting a retrogression to the juvenile characters.

The head is laterally compressed; the cheeks are parallel; but the snout is attenuated in front even on the sides. The upper and lower profiles of the head meet at fairly equal angles (the upper sloping as much as the lower rises), with the exception of a break formed by the articulation of the lower jaw. This break is

[a] In the North American *Apeltes quadracus* the pelvic bones are separated from each other behind, as in the Fifteen-spined Stickleback; the anterior part of these bones (in front of the ventral spines) is short, broad, and continuous, as in the Three-spined Stickleback, but without any ascending disk at the lateral margins. The interclavicles are so small that the anterior part of the pelvic bones lies below the insertion of the pectoral fins, with the ventral spines just behind it.

[b] In the variety *islandicus* (according to SAUVAGE, l. c., p. 21, pl. 1, fig. 8, *a*), as in the above-mentioned *gymnurus* form from Greenland, the pelvic plate is both narrow and deeply incised at the anterior margin, just as in the Ten-spined Stickleback.

[c] In some specimens of the above-mentioned *gymnurus* form from Greenland, however, the interclavicles are as narrow and as widely separated at the middle of their length as in the Ten-spined Stickleback.

most distinct in lean specimens, hardly perceptible in fat and fleshy ones. Thus in the former the lower jaw rises somewhat more rapidly in a forward direction, and projects beyond the true tip of the snout. Sometimes too, especially in lean specimens, the said break renders the inferior profile of the head behind it almost horizontal. The length of the head is greater in the males than in the females, and varies individually between $23\frac{1}{2}$ and 28 % of that of the body[a]. The eyes are round, and their superior margin lies almost exactly in the same plane as the interorbital space, which is flat or very slightly convex and in front narrows regularly, but only slightly; the line from the tip of the snout to the upper angle of the pectoral fin touches the lower margin of the pupil. The diameter of the eyes is equal to the breadth of the interorbital space[b] and in the fry, as usual, considerably greater than (sometimes $1\frac{1}{2}$ times) the length of the snout, in old specimens equal to this length or at least $\frac{4}{5}$ thereof. The simple, round nostrils, only one on each side, lie at the upper edges of the convex snout, about half as far from the eyes as from the tip of the snout. The length of the snout is in young specimens about $\frac{1}{2}$ (or less), in old specimens (more than $\frac{1}{2}$ dm. long) as much as $\frac{3}{4}$, sometimes $\frac{2}{3}$, of the postorbital length of the head, which length measures in young specimens about $\frac{3}{5}$ (62 or 63 %), in old about $\frac{2}{5}$ (40—48 %) of the total length of the head, or in the former (though not during the earliest stages) as much as $\frac{1}{2}$ (50—46 %) in the latter only about $\frac{1}{3}$ (37—32 %) of the distance between the first spinous dorsal ray and the tip of the snout. The cleft of the mouth ascends obliquely and is rather small, the length of the upper jaw being equal to the diameter of the eyes or even less than it. Lips are not wanting; but they are not so tumid as in the Fifteen-spined Stickleback. Here too, the upper jaw is capable of protrusion by means of the fairly long nasal processes of the intermaxillary bones, which processes extend, when drawn back, up to the groove in the upper surface of the snout, a little behind the line of union between the two nostrils. The length of the lower jaw is about equal to that of the snout, in young specimens considerably greater than the latter. The maxillary bones are narrow, only slightly widened at the hind extremity, and curved downwards, but about equal in length to the intermaxillaries. When the mouth is closed, they are scarcely covered by the suborbital bones. Among the latter three bones the middle one is the smallest, and the hindmost, which is somewhat larger than the foremost (the preorbital bone), more or less completely fills the angle of the preoperculum, with its lower margin touching the horizontal branch of the last-mentioned bone, and sometimes with the inferior part of its hind margin also touching the front of the vertical branch of the same, while a triangular process, sharply narrowing upwards, unites this hindmost suborbital bone to the posterior frontal bone. Thus, the preorbital bone, which forms the outer margin of the nasal cavity, being also united to the anterior frontal bone, the orbit is completely closed; and the naked patches on the cheeks, covered only by a glossy skin, have the same position as in the preceding species, though the anterior patch, behind the corner of the mouth, is much shorter. The jaw-teeth are of uniform size, set in front in several rows, behind in one or two, of uniform thickness, cylindrical, more or less blunt at the tip, and straight or only slightly curved. The pharyngeal teeth are of similar form, but somewhat larger and in general more pointed. The gill-rakers are pectinated, largest in the outer row on the front of the first branchial arch, where they are about 16 in number, in the other rows small and scattered. The palatal folds within the jaws are well-developed both above and below. The tongue is more developed than in the preceding species, moderately fleshy, and broad (blunt at the tip). The structure of the opercular apparatus is the same as in the Fifteen-spined Stickleback, only that the anterior, horizontal branch of the preoperculum and the interoperculum are shorter, and that the ascending process of the suboperculum between the operculum and the vertical branch of the preoperculum is larger. In form the operculum resembles a semicircle set on end and superiorly truncated at the end of the first third of its length or even a little earlier. The gill-openings are smaller than those of either the preceding species or the following one, the branchiostegal membranes coalescing underneath with the isthmus throughout its length, back to the anterior extremity of the interclavicles, and thus being separated from each other. In the typical Three-spined Stickleback (the *trachurus* form) all the external bones of the head, as

[a] A comparison between 4 males and 8 females gives the result that in the males the length of the head is more, in the females less, than 27 % of the length of the body.

[b] In young specimens and in the *gymnurus* form the breadth of the forehead is comparatively less.

well as the other plates and bones that appear at the surface of the body, are rough with grooves alternating with granulated ridges, corresponding to the radiating grooves and striæ in the structure of an ordinary scale. This marking is most handsome and most regular on the surface of the operculum, where it radiates from the articulation (the upper anterior corner) of the bone, with the grooves, in their even and handsome curves, and the almost smooth ridges terminating at the hind inferior margin thereof. In the *gymnurus* form, where the ossified dermal growths are generally more or less reduced, the external bones of the head may also be covered to a great extent by the skin, thus losing their Ganoid appearance.

Of the structure of the fins we know already how the spinous dorsal rays vary in number and position. The ordinary place of the first spinous ray lies at about the end of the first third of the length of the body, of the second spinous ray at the end of its second fifth, and of the last spinous ray a little behind the middle of the body. The most usual supernumerary ray lies a little in front of the middle of the body. On this head we must remark, however, that in later life the first spinous ray is generally removed distinctly in a forward direction, its average distance from the tip of the snout thus sinking from 32·8 to 30·8 % of the length of the body while this length increases, on an average, from 55·8 to 69·7 mm. The spinous rays are of a more or less broad, triangular form, with concave or nearly straight sides, and with the front convex and the back concave. The front is rough and lacunose, like the above named parts of the dermoskeleton; the lateral margins are spiniferous for a greater or less distance from the base out towards the subulate tip. The roughness and the spines partially disappear, however, under the same conditions as the plate-armour of the body, in the *gymnurus* forms. These spinous rays also vary considerably in length. As a rule the second is the longest, though the first may sometimes equal it in length; the maximum length we have found in the latter case, is $42\frac{1}{2}$ % of the distance between the first spinous ray and the tip of the snout, while the minimum lengths (in percent of the same distance) have proved to be 16 in the case of the first ray, 17 in that of the second. The length of the last spinous ray varies between $7\frac{1}{2}$ and 17 % of the said distance; and this ray generally forms a sharp, almost geniculate curve. When erected, these spinous rays stand straight up; when depressed, they lie in a straight line with each other, the tip of each ray sometimes (when the length of the rays is so great) resting on the base of the ray behind it. The interspinal plates on which the rays are set, are furnished with a groove in which the latter are partly received when depressed. These spinous rays, as well as the others (those of the anal and ventral fins), are articulated in such a manner that they can be locked fast by the fish at any angle whatever — though generally and at most in an upright position — and cannot be depressed by force, unless they are simultaneously lifted a little way. This result is attained by the presence at the middle of the base of each spinous ray, in addition to its true articulation — a *trochlea* articulation between each lateral half of the base of the ray and a transverse hollow in the interspinal plate — of a deep fissure (articular cavity), into which is fitted a disk-like, circular process of the interspinal plate. The position of the former articulation is a little eccentric relatively to this disk, and still more so relatively to the articular pivots of the spinous ray, which bound the said fissure, and which are more elliptical in outline. Thus, when the spinous ray is erected, these pivots with their elliptical friction-surfaces fall into the circular articular cavity on each side of the central disk of the interspinal plate. The lower lever of each pivot attains a greater size than the radius of the disk and of the said articular cavities. Any attempt to bend the spinous ray results merely in a pressure partly of the pivots against the walls of the articular cavities, partly of the bottom of the middle fissure of the spinous ray against the top of the disk. As soon as the spinous ray is lifted, however, and the said lever thus shortened, the pressure ceases, and the ray falls. Each of the spinous rays has a small, triangular fin-membrane behind it. By means of this membrane the last spinous ray is united to the base of the first ray of the soft-rayed dorsal fin, which in this species begins distinctly in front of the perpendicular from the vent. This fin is of an elongated triangular form, sloping evenly backwards from the first rays, and finally passing almost imperceptibly into the dorsal margin of the peduncle of the tail. Its length (base) is about equal to the length of the head in old specimens, in young ones less than the same[a]; and its height (longest ray) is

[a] The specimens we have received from Archangel, are marked in this respect, as in several others, by the persistency of the juvenile characters.

about $^2/_5$ of its length. All its rays are branched at the tip. The peduncle of the tail (the space between the dorsal and caudal fins) is twice or three times as long as deep. The anal fin begins perceptibly behind the perpendicular from the beginning of the soft-rayed dorsal fin, but ends almost exactly opposite the termination of the latter. The distance between it and the tip of the snout is generally greater in the females than in the males, the length of the head in all the females we have examined, being less than 43 % of this distance, in the males more than 44 % thereof. The soft-rayed anal fin is preceded by a spinous ray, which is usually exactly similar to the last spinous ray on the back and joined in the same way to the fin. The length (base) of the soft-rayed anal fin varies between 14 and 17 % of the length of the body, and measures as a rule about $^2/_3$, exceptionally $^3/_4$[a], of the length of the soft-rayed dorsal fin. It is otherwise similar to the latter in structure and form. The ventral fins contain two rays, the spinous ray and one shorter, soft ray at the hind margin of the fin-membrane. The spinous ray is always larger and stronger than any of the spinous rays on the back, but otherwise similar to the latter and varying under the same conditions as they. Thus, its length may vary between more than half (54 or 55 %) and about one-third (sometimes 29 %) of the distance between the first spinous dorsal ray and the tip of the snout. The position of the spinous ventral ray is subject to the following rules: in the males the distance between it and the beginning of the anal fin is usually perceptibly less than half of that between it and the tip of the snout (exceptionally equal to half of the latter), in the females, on the other hand, usually considerably greater (60—68 % of the distance between the ray and the tip of the snout), though the young females come nearer the males in this respect, or are even similar to them. The same distinction of age and sex may also be observed in the relation to the length of the head: in old females the distance between the spinous ventral ray and the anal fin may be even greater than the length of the head, in younger females (though more than 5 cm. long) we have found it to be only $^1/_5$ of this length, and in the males we have never found it to be more than $^3/_4$ thereof. The structure and position of the pectoral fins are the same as in the preceding species, with the same thin-skinned, glossy patch in front of their vertical insertion; but their tips are more sharply truncate. Their length varies between about 13 and 17 % of that of the body, measuring in the males, according to our measurements, more than 72 % (73—90 %) of the distance between the spinous ventral ray and the beginning of the anal fin, in the females less than 72 % (71—47 %) of the same distance. The caudal fin is straight or slightly forked at the hind margin. In all our specimens the 10[b] middle rays are branched, the others simple. The length of the fin at the middle is about equal to the postorbital length ot the head.

The internal organs are similar to those of the Fifteen-spined Stickleback. The peritoneum is silvery, but punctated with brown. The air-bladder is comparatively large, coasts the whole dorsal side of the abdominal cavity forward to a line with the first spinous ray on the back, and sends out, according to KRÖYER, "from its under surface a canal to the middle of the upper surface of the stomach." This canal (pneumatic duct) finally shrinks, however, into a ligament.

"The most remarkable characteristic of the Three-spined Stickleback," writes EKSTRÖM, "lies in its variations of colour. In winter the body is of a pure silvery white, with the upper part of the head and the back blue. In summer the top of the head and the whole of the back down to the lateral line are blackish gray. When the spawning-season sets in, the fish exhibits a surprising play of colours. The back first becomes brownish, developing darker, transverse bands, and the silvery white sides show a dash of brassy yellow. This applies in particular to the females. The males at the same time acquire a red spot, which begins under the head at the meeting of the branchiostegal membranes, and which expands rapidly, the reddish tinge usually extending throughout the lower part of the fish, from the tip of the lower jaw to the vent. The extent of this red colour varies in different individuals. In some cases it rises up the sides a little above the lateral line; in others the whole body is red, except the highest part of the back, which is then reddish brown, and the forehead, which is always of a deep bluish-green colour. The iris is of a handsome green. We have represented a male in this attire in Plate XXVIII, fig. 2, and fig. 1 in the same plate is a reproduction of a female in her winter dress."

[a] In exceptional cases also only 62 %.

[b] KRÖYER found only the 8 middle rays branched.

The geographical range of the Three-spined Stickleback embraces the whole of Europe, with the exception of the Danube[a], and extends south to the fresh water of Algiers; but the species has never been found in the Mediterranean itself, though it occurs in the Black Sea. In the north of Asia (Siberia) it is common. Both this species and the next one were found on Behring Island by the Vega Expedition. In North America the Three-spined Stickleback lives at least as far south as Southern California and New York. In Greenland and Iceland it has long been known. In Spitzbergen, on the other hand, it has not been met with. The Three-spined Stickleback is thus a Boreal-arctic species; and as we have remarked above, it occurs in its most typical form, with most developed armour, chiefly in the sea, while the strength of the plate-armour and of the spines is generally reduced in brackish and still more in fresh water.

Throughout Scandinavia the Three-spined Stickleback is found not only in all the lakes, large and small, streams, and brooks, but also in both island-belts, the Eastern and the Western. It is often met with in collections of water so small and so isolated that it appears difficult, if not impossible, to explain the manner in which it has been conveyed thither, or the sources from which it derives its support. It is fondest of calm water, and in summer frequents shallow spots close in shore, especially where the sunshine has free play. Here it leads a merry life, and one may often see it leap several centimetres out of the water; while at other times it keeps still at the same spot, as though there were nothing in the world to disturb it. But in a moment it is all life and spirit, and darts off a few paces with the speed of an arrow. In stormy weather it is tossed on the waves, and has thus been cast even into a boat. Towards autumn it retires to deeper spots on the shores of channels, estuaries, or larger inlets. In late autumn and at the beginning of winter, however, it roams about in large companies, which in many parts of our eastern archipelago yield rich harvest to the fisherman. When the cold is most severe, it probably lies packed in large shoals at the bottom, at least in the island-belt; for when, as sometimes happens, it is taken in the seine at this time of year, it is caught in great numbers. Sociability is also a characteristic trait of the Three-spined Stickleback; solitary specimens are seldom met with, and it generally lives collected in large or small companies.

The Three-spined Stickleback devours with avidity worms, insects, larvae, small mollusks, and small fry. Though of insignificant size it is a greedy and bold fish-of-prey, and furiously attacks fishes which are even larger than itself. It sometimes does damage by no means to be despised; and in their internecine battles it happens often enough that a Stickleback rips up the belly of his antagonist with one of his ventral spines.

The spawning-season of the Three-spined Stickleback, which period is attended by several remarkable phenomena, occurs about the end of June or even earlier. Even in May both the male and the female begin to change colour in the manner above described. This is the prelude of the spawning, which begins as soon as the fish have acquired the proper colour. The shoals which now ascend to shallow, weedy shores in order to spawn, distribute themselves in such a manner that the males and females are separated. Each of the males, which seem to be much fewer than the females, chooses a certain spot, at some distance from his neighbours, where he exercises undisputed authority. Here he builds the nest to which he entices one female after another to lay her eggs. During this period the males are violently jealous of each other, and a slight action on the part of one of them is often all that is required to goad his fellow to madness and provoke a duel. These combats are waged as follows: the two rivals rush with the speed of arrows against each other, deal a powerful side-stroke with their sharp ventral spines, and hasten with undiminished speed each back to his own domain. After a few onsets the superiority of the stronger combatant is demonstrated, his territory is extended, and he signalises his triumph by a splendour of colours, while the vanquished lays aside his brilliant dress as though overcome with shame. While the males disport themselves in these chivalrous tournaments, or rather fight for their nests, the females swim about in long troops of greater or less strength outside the battle-ground, and now and then a male selects his temporary mate from the company. The female that heads the troop, swims forward with rapid darts, followed by the others, suddenly stops, and assumes a vertical position, with head turned towards the bottom. The others assemble round her and range themselves in the same manner, as densely packed as possible.

[a] "Der Stichling fehlt dem Donaubecken im engeren Sinne." HECKL., KN., *Süsswasserf. Oesterr.*, p. 41.

When she has thus collected the troop around her, she suddenly deals a blow that scatters the whole crowd in an instant. This sport is often repeated, but the rapidity with which they disperse, renders it impossible to observe whether it is always the same female that takes the lead, or whether they change places. These operations are continued, as long as the sun is high

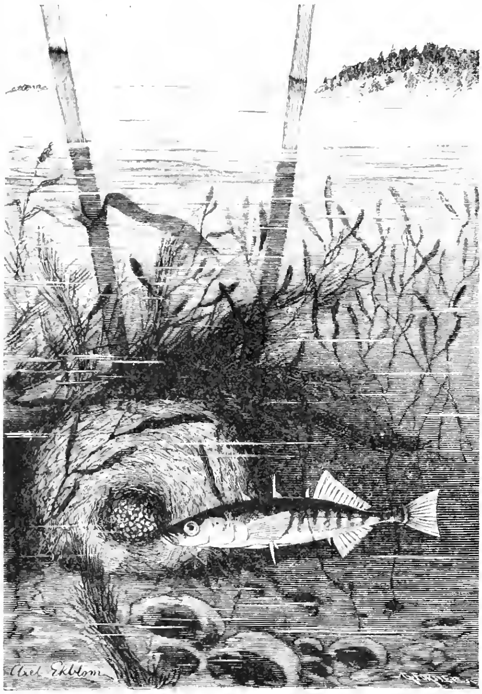

Fig. 163. Male of *Gasterosteus aculeatus* in front of its nest Natural size.

in the heavens, for 4—6 days, according to the weather. It seems more than probable that during these evolutions the females lose some roe, which adheres to water-plants, and that this is fertilized by the males that, perhaps only for the time being, have not built any nest for the eggs. BENECKE has also ascertained that under certain circumstances, as for example when he finds a suitable crevice or secluded nook among the water-plants, the male does not build any nest properly so called. Thus we have to deal with two methods of spawning, the free spawning, in which the eggs are developed where they fall, among the water-plants, and the more connubial method, in which the eggs are developed in a nest built by the male. But in any case the nest-building is one of the most interesting parts of the life of the Three-spined Stickleback, and one which many have been in a position to observe (fig. 163).

The earliest account we possess of the nest-building of the Sticklebacks is nearly two hundred years old. In 1721 the English writer RICHARD BRADLEY tells us[a] that one Sergeant HALL had seen a Stickleback build a nest, and had secured the latter in order to present it to BRADLEY, who gives a figure of it and says that he "supposes it was rather composed to lay the spawn in, than for a lodgment for the fish itself." Since that date several naturalists have watched the building operations of the male Three-spined Stickleback in its native haunts; but the most accurate observations of its habits have been made in aquaria, where the Three-spined Stickleback constructs its dwelling in the same way as when at liberty. BREHM has described its method of building in his work on *The Life of Animals*[b] as follows:

"WARRINGTON[c], COSTE[d], and EVERS have observed their captive specimens at work. During the spawning-season, as we have mentioned, the male wears a dress of the most gorgeous colours, and he displays his enhanced activity and vivacity in other ways as well. As soon as he has decided on a certain spot at the bottom, he first drags together some roots and other parts of several aquatic plants. These pieces may be larger than himself, and are often fetched from considerable distances. With great pains he tears off comparatively large bits even from living plants, tests their weight by letting them fall to the bottom, and employs in his work only those that sink quickly, rejecting all that prove too light. The building-materials are thus carefully selected, piled, and still further adjusted, until the little architect finds them arranged according to his wishes. To attach the nest to the bottom he employs sand or small pebbles[e].

[a] *A Philosophical Account of the Works of Nature*, p. 61, pl. VIII, fig. II. It may be questioned, however, whether this nest belonged to the Three spined Stickleback or to the following species.

[b] *Thierleben*. 2:te Aufl., 3:te Abth., 2:te Bd., p. 88.

[c] Ann., Mag. Nat. Hist. 2nd ser., vol. X, p. 276.

[d] Mém. Sav. Etrang. Inst. Fr., tome X (1848), p. 575.

[e] The Three-spined Stickleback may also build its nest above the bottom and among the branches of the water-plants, though this method of building seems to be more characteristic of the next species.

The tubular chamber is constructed, and the form and durability of the whole nest attained, by the Stickleback swimming slowly over the parts already in position, and at the same time gluing them together and cementing them. EVERS distinctly observed how the builder, when he had added new layers, shook his fins, raised his head, bent his body upwards, and slid his belly over the structure, emitting at the same time a drop of a viscid substance, which could be clearly distinguished in the water, and the effects of which might immediately be perceived in the now cemented building-materials[a]. At times he shook the building and then pressed it together again; at times he kept swimming over it. With his fins, which he kept in continual and rapid motion, he produced a current, and thus washed away from the nest the pieces that were too light and the loose stalks, which he then took up again and tried to fit in more durably. It took about four hours to procure the various building-materials; but at the expiration of this time the outlines of the nest were ready. Its completion, the removal of the parts that are too light, the arrangement of the separate stalks, the plaiting of their ends, and the addition of the sand to weigh them down, require several days. While the Stickleback is building his nest, he thinks only of his work and endeavours merely to provide against any interruption in its progress or hindrance to its completion. He labours indefatigably and watches with suspicion every creature that approaches the nest with or without evil intentions, whether it be another Stickleback, a newt, a water-beetle, or a larva. A water-scorpion (*Nepa*) in one of EVERS' aquaria was seized by the cautious builder thirty times or more, and carried in his mouth over to the opposite side of the aquarium.

The size of the nest varies pretty considerably, depending both on its situation and on the materials of which it is composed. As a rule it seems to be of the size of one's fist. It is generally ellipsoidal and entirely closed above, but furnished at the ends with an entrance and an exit. At first only the entrance is visible, but subsequently, exactly opposite it, we discover the exit. When the Stickleback has finished his building-operations, he endeavours to attract a female to the nest. WARRINGTON says that a completed nest excites the attention of the female; but COSTE asserts that the male sallies forth to guide her thither, and that he ushers her into the nest with a shower of caresses. The last statement, however, is also accepted by WARRINGTON. The male distinctly shows his delight at the arrival of the female, swims round her in all directions, enters the nest, sweeps it out, returns in a moment, and tries to drive the female in by thrusting at her from behind with his snout. If she will not obey of her own accord, he also employs his spines, or at least his caudal fin, to overcome her reluctance; but in case of need another female is fetched. If the male succeeds in persuading a female to enter the nest, she lays a few eggs within it, according to COSTE only two or three, and then bores a hole through the wall of the nest on the side opposite to the entrance, and departs. The second opening in the nest does not exist until it is formed in this manner. The current that now flows through the openings, is of benefit to the eggs. On the following day the male sets out again in quest of a new female, whom he compels by kindness or force to lay eggs, and repeats this process until a sufficient number of ova is procured. During or immediately after the laying of the spawn he enters the nest, rubs his side against that of the female, and then glides over the eggs in order to fertilize them.

From this hour his zeal and watchfulness are redoubled. He has to guard and defend the eggs against every aggressor. Every Stickleback that approaches is furiously attacked and put to flight, whether it be a male or a female, for both are equally dangerous enemies of the eggs, and the latter is perhaps even more greedy of the ova or the new-hatched fry than the former. Until the young have emerged from the eggs, the male shows his care in other ways as well. With his mouth he repairs every damage to the nest, and often stations himself in front of or within the chamber, keeping his pectoral fins in vibration and thus renewing the water in the nest, as though he knew that the eggs require fresh oxygen.

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[a] MÖBIUS (*Nature*, vol. XXXIX, No. 998, Dec. 13, 1888, p. 168) saw the male Stickleback keep spinning round the nest new threads, which originated from the urinary bladder. The chemical reactions showed that these threads consist of mucin, which is secreted, however, not by the urinary bladder, but by the kidneys. The section of a kidney, treated with osmic acid and coloured with hematoxylin, showed that only a few of the cells lining the *tubuli uriniferi* partake in the development of the mucin, while most of them do not undergo any change of this description. After the end of the spawning season, no mucinous cells can be found in the kidneys, which are now less tumid.

At last the time for the ripening of the eggs approaches, and new troubles come. He has now to protect and defend the helpless young. In WARRINGTON'S aquarium a female laid her eggs at night on the 8th of May, and on the very next day the mother was driven away by the male. The latter continued his guardianship until the 18th of the same month, and then began suddenly to destroy the nest, leaving only a few stalks at the foundation. All the mud and sand that covered the eggs was removed in his mouth, and a space about 8 centimetres in diameter carefully cleared. Astonished at such conduct on the part of the nest's protector, WARRINGTON took a magnifying glass to ascertain the cause, and discovered the new-hatched fry. Henceforth the male Stickleback never ceased swimming in every direction over the cleared space, redoubling his vigilance, and driving away every other fish that came too near. As the young gained in size and strength, they seemed anxious to leave the nest, but the father intercepted them time after time, carefully taking the truants in his mouth, and returning them to their quarters. Not until they were strong enough to swim with ease, did the father's watchful care gradually begin to slacken, but at last, when they were quite capable of procuring their own food, he left them entirely to shift for themselves."

When the spawning is over, the handsome colours of the fish gradually disappear, and its normal temperament returns.

From the great numbers in which this species occurs, especially during certain years, we might suppose it to be very prolific; but this is not the case. The female has no more than 110—150 eggs in both ovaries; and as the restricted number of the males leads us to assume that not all the eggs are fertilized, the fecundity of the species cannot be set very high. In spite of this, as we have already mentioned, in certain years enormous shoals of Three-spined Sticklebacks are met with. Several reasons have been suggested to explain this fact. The most probable explanation of these cases in general is CUVIER'S, that the years in which these large shoals appear have been more than usually favourable to the process of reproduction; but SUNDEVALL explains a portion of these variations by the fact that, during the years in which the Herring-fry are plentiful in the outer part of the island-belt, the Stickleback retires thither and is comparatively scarce nearer to the mainland; while the largest catches of Sticklebacks on the coast of the mainland seem to be made during periods when the opposite is the case.

The Three-spined Stickleback, which is surpassed in voracity by few predatory fishes, becomes very fat, and is probably rapid of growth, soon attaining its full size. But the statement of certain authors, that it does not live more than 3 years, seems to require corroboration.

This fish is hardly used at all as human food — though in England, together with Herring-fry, it often tempts consumers under the name of Whitebait. STELLER and TILESIUS state that the Stickleback which occurs on the coast of Kamchatka, is delicious when boiled and an excellent ingredient in soup. Still, even the Kamchatkans themselves reject it for their own use, but keep it to feed their dogs in winter. The single specimens which in Scandinavia are caught at almost every haul of the seine for other fish, are generally thrown among the offal and used as food for swine. Predatory fishes and seafowl, however, eagerly devour the Stickleback, and it is the principal food of the Garpike.

When the Three-spined Stickleback is taken in quantities, which happens only in certain years, it is boiled down into oil, a manufacture to which so early a writer as WESTBECK (1753) directed the attention of his countrymen. A barrel ($4^1/_2$ bushels) of fresh Sticklebacks yields more than one gallon of clear oil. The foot or sediment that settles at the bottom of the cauldron is an excellent manure, two barrels (9 bushels) of this sediment, mixed with a sufficient quantity of water, being reckoned equal to 10 lasts[a] of dung.

The only method of fishing employed exclusively for this fish is simple enough. The fishery commences at the beginning of November — some fishermen state that the Stickleback does not come in before the ground has been covered with snow — and continues until the inlets and channels have begun to freeze. Towards evening, when it has been observed that the Sticklebacks are collected in a shoal, the presence of which is betrayed at sunset in calm weather by the surface of the water being rippled as if by fine rain or a shower of sand, two fishermen repair to the spot in a boat. In the bow of the boat is erected a kind of fire-pan (fig. 164), on which dry wood is laid and kindled. When the boat has reached that side of the shoal towards

[a] Sw. *parlass* = a load drawn by two horses.

which the heads of the fish are turned, one of the two fishermen keeps the boat still by means of a stake, which is thrust into the bottom, while his companion scoops the fish out of the water into the boat with a fine hand-net (fig. 165). In this way several boat-loads may be taken in a night. In December, 1887 a correspondent writes from the island-belt of Östergothland: "The violent storms of this autumn have driven into our creeks and bays a multitude of "*pigg*" or *spigg* (Sticklebacks), for which a fishery has now been carried on for some time. The Sticklebacks must have fed extraordinarily well this year, for they are so fat that 2½ gallons of oil may easily be extracted from a barrel of fish. The owners of the stretches of shore where the Sticklebacks swim in shoals, esteem themselves especially fortunate, for the Stickleback-fishery takes the palm of all the fisheries among our islands. On the strip of shore belonging to a small crofter, for example, the value of the catch has proved to be 600 crowns (£33), and on the coast-line of a farm 2,000 crowns (£110). The shoals press on without a pause to their destination, so that the fisherman may keep seining the whole day at the same place, and the catch in spite of this be quite as great in the last draught as it was in the first".[a]

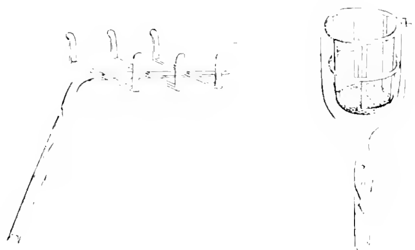


Fig. 164. Different kinds of fire-pans used in fishing by torchlight.

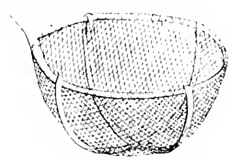


Fig. 165. Stickleback-net.

In his annual report for 1869 Baron G. C. Cederström, the pisciculturist, describes the singular behaviour of the Sticklebacks during this fishery as follows: "In autumn the Sticklebacks generally repair towards evening to the shallow water near the shores, where they keep still, resting on the bottom as though the spinous rays of the ventral fins now served as feet. In the morning they again return to somewhat deeper water. It is highly interesting to watch the effect of the torch-light on them, while they are at rest. When the light approaches them, they generally remain quite still at first for a few moments, apparently unconcerned; but suddenly a fish starts up, casts itself to one side, and joins some comrade disturbed in the same manner, or takes its place in an army already formed and advancing in the immediate neighbourhood, an army which like a long, moving wall roves along the bottom, at first, as a rule, in a circle round the light. Gradually the advancing wall increases in height, length, and breadth, while it circles hither and thither, as if to collect more and more stragglers, in curves of greater or less extent, until at last, when the army appears to be sufficiently strong, it suddenly dashes up and assembles beneath the light. Here the crush that now follows is tremendous, and the movements of the fish culminate in a strange confusion, exactly as though they intended with their immense numbers to overpower and vanquish the fire. In spite of the hand-nets now plied, they still rush on, undaunted as before. When their numbers are so few that the fisherman does not think it worth while to use the net there any longer, he moves to another spot between 50 and 200 yards off, or sometimes even nearer his former station; and here the same occurrences are repeated."

The Stickleback bears different names in different parts of Sweden. On account of its spinous fin-rays it is called *pigg*, *spigg*, and *stagg*, in Scania *hornstagg*, in the eastern archipelago *skotspigg*[b], *horntagg*, and *hornfisk*. On account of its bright and tin-like colour it is known in winter as *tennfisk*, *tennfisk med spjut* (Speared Tinfish) etc. In Gothland, according to Lindström, it is coupled with the following species under the name of *baingyl* or *bainkyl*[c].

(Ekström, Smitt.)

[a] See the *Dagens Nyheter* for the 15th of December, 1887.

[b] Qvod nomen "paullo urbanius" quam vulgare *Skitspigg*: Retzius.

[c] So called because it thrives in small collections of water (*bain* = bone, *gyl* = pool). Tr.

THE TEN-SPINED STICKLEBACK OR TINKER (SW. SMASPIGGEN).

GASTEROSTEUS PUNGITIUS.

Plate XXVIII, figs. 3 and 4.

Free spinous rays on the back usually 9 (7[a]—12). Branchiostegal membranes united underneath into a fold posteriorly free from the isthmus.

R. br. 3; *D.* 7[a]—12/10—12; *A.* 1/8—10; *P.* 9—10; *V.* $\frac{1}{1}$; *C.* $x+1+10+1+x$; *Vert.* 32—33.

Syn. *Gasterosteus* aculeis in dorso decem, ART., *Ichth., Gen.*, p. 52; *Syn.* p. 80; *Spec.*, p. 97; LIN., *Fn. Suec.*, ed. I, p. 104.

Gasterosteus Pungitius, LIN., *Syst. Nat.*, ed. X, tom. I, p. 296; *Fn. Suec.*, ed. II, p. 119; RETZ., *Fn. Suec. Lin.*, p. 338; PALL. (*Gasteracanthus*), *Zoogr. Ross. Asiat.*, tom. III, p. 228; CUV., VAL. (*Gasterosteus*), *Hist. Nat. Poiss.*, vol. IV, p. 506; EKSTR., Vet. Akad. Handl. 1831, p. 302; NILSS., *Prodr. Ichth. Scand.*, p. 86; EKSTR., *Skand Fisk.*, ed. I, p. 20, v. WRIGHT, tab. IV, fig. 2; KR., *Danm. Fiske*, vol. I, pp. 188 et 593; SUNDEV., Stockh. L. Hush. Sällsk. Handl., H. 6 (1855), p. 79; NILSS., *Skand. Fn., Fisk.* p. 110; THOMPS., *Nat. Hist. Irel.*, vol. IV, p. 89; GTHR, *Cat. Brit. Mus., Fish.*, vol. I, p. 6; SIEB., *Susssw. Mitteleur.*, p. 72; MGRN, *Finl. Fisk-Fn.* (disp. Helsingf.), p. 15; LINDSTR., Gotl. Läns Hush. Sällsk. Arsber. 1866, p. 15 (sep.); COLL., Forh. Vid. Selsk. Christ. 1874. Tillægsh., p. 13; ibid. 1879, No. 1, p. 4; N. Mag. Naturv. Christ., Bd. 29 (1884), p. 49; DAY, Journ. Linn. Soc. Lond., vol. XIII (1876), Zool., p. 110; MALM, *Gbgs. Boh. Fn.*, p. 373; SEIDL., *Fn. Balt.*, p. 128; WINTH., Nat. Tidskr. Kbhvn, ser. 3, vol. XII, p. 4; FEDDERS., ibid., p. 74; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 169; DAY, *Fish. Gt. Brit., Irel.*, vol. I, p. 244, tab. LXVIII, fig. 4; MELA, *Vert. Fenn.*, p. 279, tab. IX; FATIO, *Fn. Vert. Suisse*, vol. IV, part. I, p. 98; HANSEN, *Zool. Dan., Fiske*, p. 30, tab. V, fig. 3; STORM, Norsk. Vid. Selsk. Skr., Trondhj., 1883, p. 15; MOR., HECK. *Fisch. Osts.*, p. 65; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 393; LILLJ., *Sv., Norg. Fisk.*, vol. I, p. 363.

Gasterosteus occidentalis, CUV., VAL., l. c., p. 509. *Gast. dekayi* + *G. nebulosus*, AG., *Lake Superior*, pp. 310 et 311. *Gast. concinnus*, RICH., *Fn. Bor. Amer.*, p. 57. *Gast. mainensis*, STORER, Bost. Journ. Nat. Hist., vol. I, p. 464. *Gasterosteus pungitius* + *G. burgundianus* + *G. lævis* (ex CUVIER, *Règn. Anim.*, ed. 2, tom. II, p. 170) + *G. lotharingus* + *G. breviceps*, BLANCH., *Poiss. d. eaux douces Fr.*, pp. 238, cett.; *Gasterostea pungitia* + *G. burgundiana* + *G. occidentalis* + *G. dekayi* + *G. blanchardi* + *G. mainensis* + *G. lævis* + *G. lotharinga* + *G. breviceps* + *G. concinna* + *G. globiceps*, SAUVAGE, Nouv. Arch. Mus. d'Hist. Nat. Par., tom X, pp. 29, cett.

Obs. As appears from this list of synonyms, it has also been proposed to base a number of independent species on the variations of the Ten-spined Stickleback. The lack of constancy is, however, just as great here as in the preceding species; and to judge by our present knowledge of the forms, only the East Asiatic variety (*Gasterosteus sinensis*, GUICHENOT, see above), with its fully-plated lateral line and its large, comparatively few spinous rays on the back, which are equal in length to the diameter of the eyes or still longer, deserves to be especially distinguished as an intermediate form between this species and the Three-spined Stickleback.

The Ten-spined Stickleback is the smallest fresh-water fish of Europe. Its ordinary length when full-grown is about 5 or 6 cm. LILLJEBORG, however, speaks of specimens 81 mm. long from the moats of Upsala Castle. In form it is usually shallower (more elongated) and more terete than the preceding species, the depth of the body at the insertions of the ventral fins being on an average[b] about 18 % of its length (as compared with 20 % in the preceding species), and the breadth straight across the upward lateral processes of the pelvic bones on an average 58—62 % of the said depth (as compared with 52—51 % in the preceding species). But in this respect no constant difference can be traced, and the largest specimens of the Ten-spined Stickleback as a rule come nearer and nearer the Three-spined species.

The Ten-spined Stickleback is generally without any external trace of plate-armour on the sides of the body; but in most cases the lateral line is raised on the sides of the tail in the form of a carina, rendering the breadth of the peduncle of the tail considerably greater than its depth, and now and then showing plate-like ossifications in the skin. But quite as frequently this carina is really membranous, and sometimes hardly a trace of it is visible, the base of the caudal fin thus acquiring a terete appearance. Especially in the southern parts of the geographical range of the Ten-spined Stickleback this last form seems to be the commonest one, and it has been described by CUVIER under the name of *Gasterosteus lævis*. The plates at the dorsal margin and along the base of the anal fin are hidden in the skin; but the former are more concave on the upper surface than in the preceding species, thus forming a groove both deeper and broader, into which the spinous dorsal rays may be depressed. In number these spinous rays vary within the limits given above —

[a] Abnormal specimens with only 2 or 4 free spinous rays on the back are mentioned by DAY (l. c.).

[b] In our specimens, which are between 38 and 60 mm. in length.

sometimes even the greater number of them may be wanting. They do not stand at right angles to the back, but lean alternately towards the sides. They are also set, not in a straight line, but in a zigzag (∴∴∴). They are subulate in form, somewhat curved but only slightly widened at the base, with sharp points and smooth edges. In size they are fairly equal, though the hindmost ray is generally somewhat larger than the others[a] and equal in length to the spinous ray in front of the anal fin. All of these spinous rays are usually shorter than the diameter of the eyes; but the anal spine may sometimes equal this diameter in length. Each of them has a small, triangular fin-membrane behind it. In this species too, the ventral spines are the largest, their length varying between $^2/_5$ and $^1/_4$ of the distance between the first dorsal spine and the tip of the snout. At the outer margins, at least in full-grown specimens, they are usually granulated or even spiny with osseous tubercles arranged in several rows. Their articulations are constructed in the same manner as in the preceding species.

The pelvic bones are narrower than in the Three-spined Stickleback, and the sinus in their anterior margin is deeper but narrower. Their upright lateral processes are somewhat broader and more obliquely cut at the top. The interclavicles are also narrower than in the preceding species, but of about the same length, the pelvic bones lying entirely behind the perpendicular from the insertion of the pectoral fins.

The head as well as, in most cases, the whole body is more elongated (shallower) than in the Three-spined Stickleback; but its relative length is about the same, being on an average about $^1/_4$ of that of the body. Its structure is also the same as in the Three-spined Stickleback, with the exception of the character that lies in the above-mentioned arrangement of the branchiostegal membranes.

The soft-rayed dorsal and the anal fins are also of a low, triangular form. The first ray in each of them is simple but distinctly articulated. They are fairly analogous in position, the beginning of the dorsal fin never lying in front of the perpendicular from the hind part of the vent. The base of the soft-rayed dorsal fin is always perceptibly shorter than the head, but varies between 20 and $24^1/_2$ % of the length of the body. The length of the base of the anal fin varies between about 16 and $19^1/_2$ % of that of the body.

The hind margin of the caudal fin is straight, sometimes slightly forked or even convex, an indication of the transition to *Gastræa*. Its length at the middle is always perceptibly less than the postorbital length of the head. The pectoral fins are similar to those of the Three-spined Stickleback both in form and relative size.

The internal organs resemble those of the Three-spined Stickleback; but the air-bladder is somewhat narrower. KRØYER found some instances to corroborate CUVIER'S observation to the effect that the intestine runs from the stomach straight to the vent, instead of previously forming a circular coil, as it generally does both in this species and in the two preceding ones.

The relation between this species and the Three-spined Stickleback is of especial interest when we consider the external differences of growth and sex, which show that the Ten-spined Stickleback represents partly the earlier (lower) stages of development and partly the male characters. The following table of averages contains the changes of growth most important in this respect, together with the sexual differences especially conspicuous in the Ten-spined Stickleback.

Average in	10 specimens of *Gasterosteus pungitus*	14 specimens of *Gasterosteus aculeatus*	8 specimens of *Gastræa spinachia*	Obs.
Length of the body expressed in millimetres	48.7	62.7	107.0	—
Longitudinal diameter of the eyes in % of the length of the snout	102.3	91.8	42.7	juv. [illegible] sen.
Postorbital length of the head in % of its total length	49.8	43.2	45.8	juv. > sen.
Length of the base of the anal fin in % of the distance between the anal spine and the tip of the snout	33.0	24.7	23.[illegible]	juv. [illegible] sen.
» » » head in % of the distance between the first dorsal spine and the tip of the snout	93.6	79.0	100.2	juv. [illegible] sen.
» » » » » » » » » » » » anal » » » » » » » » »	45.0	41.0	49.8	[illegible]
Postorbital length of the head in % of the distance between the first dorsal spine and the tip of the snout	46.4	34.[illegible]	43.0	[illegible]
Distance between the ventral spines and the anal spine in % of the length of the head	79.[illegible]	89.3	41.[illegible]	[illegible]
» » » » » » » » » » » » » » distance between the ventral spines and the tip of the snout	55.2	58.6	30.6	[illegible]
» » » » » » » » » » » » » » » » » anal spine » » » » » » » »	35.0	36.0	22.0	[illegible]

[a] EKSTRÖM (Vet. Akad. Handl., l. c.), however, found the second ray longest and the hindmost shortest.

In the first three relations the development has advanced in the same direction from *pungitius* both to *aculeatus* and to *spinachia* — in each case, except the second, furthest in the last species —, but in the fourth *spinachia* has retained the most primitive character of the Sticklebacks. In the last five relations *spinachia* is the nearer to *pungitius*, and stands in each case, except the sixth, on the opposite side to *aculeatus*. The direction of development is fixed in *aculeatus* by the female, in *spinachia* by the male characters.

The coloration of this species is quite as varied as that of the preceding one, and is affected by the different seasons of the year, the different moods of the fish, and the different bottoms and lights of the water in which the fish lives. Here too, we find darker (Plate XXVIII, fig. 4) and lighter forms. In winter the upper part of the head and the back are of a bluish drab, and the sides silvery white, with extremely fine, dark dots. In summer, on the other hand, the head and the upper part of the whole body are of a marked olive-green. The lower part of the body is now light green, with a dash of brassy yellow, which shades more into red under the head and at the bases of the pectoral fins. The whole body is thickly strewn with distinct, black dots. It is this dress which is depicted in Plate XXVIII, fig. 3, painted from a large specimen, a female taken in the neighbourhood of Haparanda in June, 1832. During the spawning-season the males are black on the sides of the belly.

The Ten-spined Stickleback has the same geographical range as the Three-spined species, but in Europe does not penetrate so far south. MOREAU sets the southern limit for the range of the Ten-spined Stickleback in France at lat. 45° N. According to FATIO this species is wanting in Switzerland. HECKEL and KNER do not include it among the fishes of the Austrian Empire. It is also unknown in Italy (CANESTRINI, GIGLIOLI); but it occurs in the Black Sea, according to PALLAS, and NORDMANN[a] says that it is found in several streams in the south of Russia. On the other hand, its occurrence in Greenland and Iceland is uncertain. Neither REINHARDT nor LÜTKEN includes it in their lists of the fishes of Greenland, though HANSEN says that it lives there; and FABER had never seen it in Iceland. RICHARDSON'S *concinnus* belonged, however, to the extreme north of North America (Saskatchewan and Great Bear Lake) and, PALLAS knew the species from Siberia and the Sea of Okhotsk. The Vega Expedition found it together with small Three-spined Sticklebacks, as we have mentioned, on Behring Island. BEAN[b] assigns it to Alaska; and it was already known to CUVIER from Newfoundland (*occidentalis*).

In Scandinavia the Ten-spined Stickleback is common from the extreme north to the southernmost provinces, both in most of the Swedish lakes and streams and on the Baltic coast. In Norway, according to COLLETT, its occurrence is only sporadic and confined to fresh and brackish water.

The habits of this species are essentially the same as those of the preceding one. It prefers clear, running water. It is sociable, and therefore lives collected in large shoals during the greater part of the year. It also joins company with the Three-spined Stickleback, when the latter sets out on its autumn wanderings. In temperament it seems to be very sluggish, but can move with great rapidity. Its food consists of worms, insects, fish-roe, and bits of grass, which it devours with avidity. We often find this little fish, like its congener, very fat.

The spawning-season generally occurs in June and July — according to BENECKE even in April — when the fish makes its way to small brooks and rills, where during the spawning we find it packed in multitudes. Males and females are promiscuously assembled, and try to crowd as near to the grassy bank as possible. The roe is orange and, in comparison with the size of the fish, coarse, the eggs being about 1 mm. in diameter. It is deposited either on the grass or in a nest, for here as in the preceding species the male builds a shelter for the eggs until the exclusion of the fry[c]. As long as the spawning lasts, and as long as the male has to defend the eggs, the fish is not at all timid, and suffers itself to be taken in the hand.

The Ten-spined Stickleback, which in different localities bears different names, e. g. *benunge*, *skinälling* etc., is utilised in the same way as the Three-spined species. It is said to yield a finer oil. It is taken chiefly in November, when it collects in shoals together with the Three-spined Stickleback.

(EKSTRÖM, SMITT.)

[a] DEMIDOFF'S Travels, tom. III, p. 382.
[b] *Cat. Collect. Fish. U. S. Nat. Mus.*, Gt. Intern. Fisher. Exhib. London 1883, p. 19.
[c] See RANSOM, Ann., Mag. Nat. Hist., ser. 3, vol. XVI, p. 449.

PHYSOCLYSTI LOPHOBRANCHII[a].

Physoclysts with tufted branchial laminæ.

This single character is enough to divide from the rest of the Physoclysts a series extremely remarkable in many respects, which contains two families, and of which our Pipefishes and the Sea-horses of warmer regions are well-known types.

The gills of the Teleosts generally consist, as is well known, of a great number of branchial laminæ — on the first branchial arch of a Cod 3 dm. long, for example, we can count about 100 pairs — which are arranged in a double row on the outside (the convex side) of each branchial arch, like the teeth of a comb but in pairs, each lamina alternating with (obliquely opposite) the other lamina of the pair, though they are united to each other for a greater or less distance from the base. Each of these laminæ (fig. 166) is furnished on each side (above and below) with numerous, transversely-set lamellæ — in the Cod we can count as many as 1,000, but in other Teleosts they are much fewer, in the Gudgeon (*Gobio fluviatilis*) for example, only 50 or 60 — which are honeycombed by the capillary network of the respiratory vessels with a view to the oxygenation of the blood and its transmission from the branchial arteries to the branchial veins. In the Lophobranchs the number of the branchial laminæ is considerably reduced, in a Pipefish, for example, being only 5—8 pairs on each arch, the minimum number on the foremost and hindmost of the four branchial arches, the maximum on the two middle arches. But to compensate for this the comparatively few branchial lamellæ are considerably enlarged, being visible even to the naked eye, or at least with the help of a weak magnifying-glass. They are largest at the middle of each lamina, their size decreasing regularly towards the base and the tip thereof; and the lamina itself is curved, not unlike a peacock's feather. "By means of this arrangement," says RETZIUS, "the branchial laminæ (fig. 167) acquire an appearance something like that of bunches of peacocks' feathers, set alternately and touching each other with the convex part of their curves. When we see the two rows of these bunches from without (fig. 168), the figure also reminds us somewhat of the foliation of *Salvinia*."

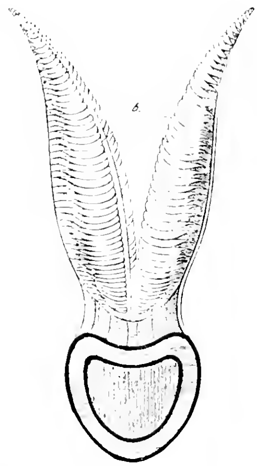


Fig. 166. A pair of branchial laminæ attached to a section of a branchial arch in the Cod. *b*, the lamellæ. Magnified and schematized. After TH. WILLIAMS.

Fig. 167. A pair of branchial laminæ attached to a section of a branchial arch in *Syngnathus*. Magnified. After A. RETZIUS.

Fig. 168. A branchial arch with its alternating laminæ and their lamellæ in *Syngnathus*. Magnified. After A. RETZIUS.

[a] L'ordre des *Lophobranches*, CUV., Regne Anim., ed. 1, tom. II, p. 155.

This character is accompanied, however, by several other peculiarities, most of which call to mind the Hemibranchs. The body is scaleless, but in general completely covered with Ganoid-like plates, though these may sometimes be thin and coated with skin, so that they become indistinct. They are arranged in longitudinal and transverse rows. The number of the transverse rows is usually equal to that of the vertebræ, to the processes of which they are more or less closely united; and in consequence they generally form distinct segmental rings round the body. In most of the Lophobranchs and especially in the Pipefishes the body is highly elongated, like that of the Eels or the Flutemouths, and the snout is produced as in the latter forms. The branchial arches are incomplete, consisting in each case of a single cartilaginous bone; the epibranchial and upper pharyngeal bones, as well as the hypobranchial bones, are wanting. The interclavicles are present, but are not externally visible.

The organs of motion are feeble and the musculature as a whole is not much developed; but in the motory muscles of the fins ROLLETT[a] has been enabled to observe a fact that seems calculated to possess the greatest importance for the explanation of the structure and function of the striated muscles. Each of these muscles consists, as is well known, of a number of small fibres, corresponding to large cells, each with its envelope, a thin membrane, and its contents. Within the thin membrane, the *sarcolemma*, that confines the muscular fibre, we find two essentially distinct substances, the first, which has been named by KÜHNE *rhabdia*, the staff-substance, divided into a number of cubical, parallelopipoid, virgulate, or lamellar parts, arranged beside each other in longitudinal or transverse rows, but in general at very minute intervals, which are filled by the second substance, the *sarcoplasma*, a kind of protoplasm with nuclei distributed among it. The great muscles of the body in the tiny Sea-horse are also of this structure; but ROLLETT has pointed out a remarkable difference in the relative proportions of these two substances in the muscles that set the fin-rays in vibration. Here, where the movements are too rapid for the eye to follow them, the sarcoplasm preponderates greatly over the *rhabdia*. Up to the present time science has not fully succeeded in elucidating the significance and co-operation of the two substances in the contraction of the muscles. But, as only the sarcoplasm together with the sarcolemma comes in immediate contact with the end apparatus of the fibrillæ of the motory nerves, we may at least conjecture both that the physiological significance of the two substances is different, and that the operation of the nervous power varies according to the different quantity and distribution of the two substances in a muscular fibre. ROLLETT'S observation of the Sea-horse—together with several other observations, e. g. of the wing-muscles in insects—entitle us at least to the assumption that extremely rapid muscular motion may be promoted by the more advanced development of the sarcoplasm.

The Lophobranchs are characterized, it is true, by a considerable reduction of the true organs of motion; but one genus, *Solenostomus* from the Indian Ocean and Australia, the type of a distinct family, is fully equipped in this respect, in particular with a high anterior dorsal fin, a large caudal fin, and both long and broad ventral fins. All the other genera, which together form the family *Syngnathidæ*, are destitute both of the first dorsal fin and of the ventral fins; the anal, caudal, and finally even the pectoral fins are reduced in most of them, and entirely disappear in some forms. When the caudal fin has disappeared, the tail becomes a prehensile organ, more or less developed, which fishes of this description, e. g. the well-known Sea-horses, curl round the branches of seaweeds or round other suitable objects, in order to hold themselves fast.

All these fishes are feeble creatures, which depend for their protection chiefly on their resemblance to the surrounding objects. Our small Pipefishes closely resemble the thread-algæ (*ulvæ*) to which they often attach themselves, and several Sea-horses develop foliate growths sometimes of the most fantastic shapes, by means of which they acquire a deceptive likeness to the seaweed. They must seek their food among the weakest minute animals, for their toothless mouth is most like a sucking tube (cf. above, pp. 263 and 264, on the internal folds of the mouth in the Gobies).

In the method of their reproduction all the Lophobranchs of which we have any information on this head, show the peculiarity that they carry the impregnated eggs and, until they can help themselves, the

[a] *Ueber die Flossenmuskeln des Seepferdchens (Hippocampus antiquorum) und über Muskelstructur im Allgemeinen*, Arch. Mikr. Anat. XXXII (1888), p. 233.

excluded embryos on their ventral side. In the great majority of cases it is the males that have to perform this duty, just as the males of the Pycnogonoid family carry the lumps of eggs on their feet. But in *Solenostomus* the ventral fins of the female coalesce longitudinally with the ventral side so as to form a sac, in which the fertilized eggs are stored and developed.

Of the two families of this series there occurs in the Scandinavian fauna only the

Fam. SYNGNATHIDÆ.

The greater part of the margin of the branchiostegal membrane united to the body, leaving only at the top, above and just behind the end of the operculum, a small, fissure-like gill-opening on each side.

This family, as defined[a] by KAUP[b], includes the great majority of the Lophobranchs, with about 150 species, distributed among 15 genera. All the Syngnathoids that occur in the Scandinavian Fauna, belong to GÜNTHER'S[c] subfamily *Syngnathinæ*, which is distinguished from the Sea-horses (*Hippocampinæ*) — with their descending (prone) head, elevated occiput, and more or less tumid body — by an evenly elongated form of body, with the head prolonged in the same direction as the trunk and with the latter only slightly thicker than the caudal part. In the *Syngnathinæ*, too, the tail is never so developed into a prehensile organ as in the *Hippocampinæ*.

The above-mentioned rings formed by the plate-armour of the body are composed (fig. 169) on the

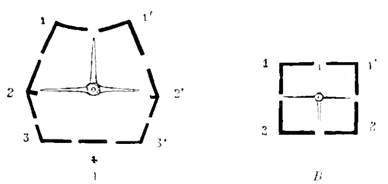


Fig. 169. Schematic transverse section of a *Syngnathus*. Magnified. After MOREAU. *A*, transverse section of the trunk; 1—1', 2—2', and 3—3' the paired plates; 4, the ventral plate. *B*, transverse section of the tail.

trunk (in front of the vent) of 7, 8, or 9, and on the tail (behind the vent) of 6 or 4 plates, so arranged that the former make up 3 or, at the end of the trunk, 4 pairs and an unpaired ventral plate, which disappears behind the vent, while either the uppermost or the lowest pair disappears either behind the end of the dorsal fin or even behind the vent. As the paired plates are bent at greater or less angles, longitudinal carinæ are formed on the sides of the body, three on each side of the trunk or even to the termination of the dorsal fin, and two on each side of the tail, where its section is quadrangular. But in many cases the said angularity is slight or absent, while the skin that covers the plates grows comparatively thick, rendering the body smoother, the plates and carinæ more indistinct or even imperceptible.

As in the rest of the Lophobranchs and a great proportion of the Hemibranchs, the snout is elongated and bears at the tip the gape, which is almost vertical when closed, with the ascending under-jaw forming the extreme margin of the head in front. In the Deep-nosed Pipefish (*Syngnathus typhle*) the elongation of the snout is produced in the following manner. The ethmovomerine part is elongated like a staff, and coasted below by the long and narrow parasphenoid bone, while the frontal bones extend forward above in the form of long and narrow covering-bones over about half of the said elongation. The hyomandibular bone is an oblong, quadrangular but irregular, vertically set disk, which is united at a right angle below with the abnormally developed *os symplecticum*, which is directed forward, extends below the eyes, and sends out a branch obliquely upward towards the lateral ethmoid (prefrontal) bone, while a second, still longer, horizontal branch meets a process in a backward direction from the quadrate bone. This horizontal branch of the *symplecticum* is partly naked (without covering bones) externally, but is covered behind and below, throughout the greater portion of its extent, by the preoperculum. The vertical (posterior) branch of the preoperculum lies

[a] The family *Syngnathidæ* as established by BONAPARTE (*Cat. Metod. Pesc. Eur.*, 1846, p. 89) was differently defined, so as to exclude the Sea-horses.

[b] *Cat. Lophobr. Fish. Brit. Mus.* (1856), p. 5.

[c] *Cat. Brit. Mus., Fish.*, vol. VIII, p. 153.

outside the hyomandibular bone and is united above to the inferior margin of the suborbital bones. The obliquely ascending branch of the *symplecticum*, on the other hand, is separated by a space, occupied by the masticatory muscles, from the two posterior suborbital bones, which bound the orbit below, but is united to the hind superior corner of the anterior suborbital (the preorbital) bone, where the latter meets the lateral ethmoid bone. The foremost suborbital bone forms the greater part of the side of the snout, being united in front as a covering bone to the ento-(meso-)pterygoideum and the quadrate bone, but leaving behind the latter an opening in the middle for about a third of the depth of the snout; the middle suborbital bone is united below to the *symplecticum*; the hindmost suborbital bone both to the *symplecticum* and, behind, to the preoperculum. We refer to the opercular apparatus a narrow, lancet-shaped, thin bone which lies along the inside of the horizontal, forward branches of the preoperculum and the *symplecticum* and the horizontal, backward branch of the quadrate bone. This lancet-shaped bone is united by ligaments behind to the upper part of the ceratohyoid bone and in front to the angular part of the lower jaw. The latter union clearly shows that the bone must be an interoperculum[a], corresponding most nearly in form and position to the interoperculum in *Tetrodon* for example, though here it has passed within the *symplecticum* and become united behind to the upper part of the outside of the ceratohyoideum, instead of retaining its union to the suboperculum[b], which is here reduced to an extremely thin disk within the lower margin of the operculum.

The lower jaw is remarkable for its extraordinary depth behind and its sharply curved and toothless dental part. The maxillary bones are comparatively well-developed and their hind (lower) extremity is expanded; but the toothless intermaxillaries are small, styliform, and without nasal processes. The palatine bones are shorter than the maxillaries and of fairly uniform breadth. At the anterior angle of the union of each palatine bone to the top of the ascending branch of the quadrate bone we find the narrow pterygoid bone, which is bent at an obtuse angle, and behind the said union, close to the ridge of the snout, the entopterygoid bone, which is united in the same manner to the quadrate bone.

The tongue is wanting, and the glossohyoid bone can hardly be discerned; but the urohyoid bone is comparatively long. When the last bone is drawn back, the anterior (lower) end of the ceratohyoid bone with the tip of the whole branchial apparatus is forced downwards[c], the cavity of the mouth being thus widened and filled with a fresh supply of water. In this manner the Lophobranchs pump in their food together with the water needed for their respiration. The method in which the transverse dermal folds (*vela*) just behind the jaws assist to this end, has already been touched upon. The gill-rakers are small, denticulate, and pectinately arranged along both margins of the inside of the branchial arches. Their function, the prevention of food and foreign substances from penetrating into the gill-cavities when the fish swallows, has already been pointed out by RETZIUS[d].

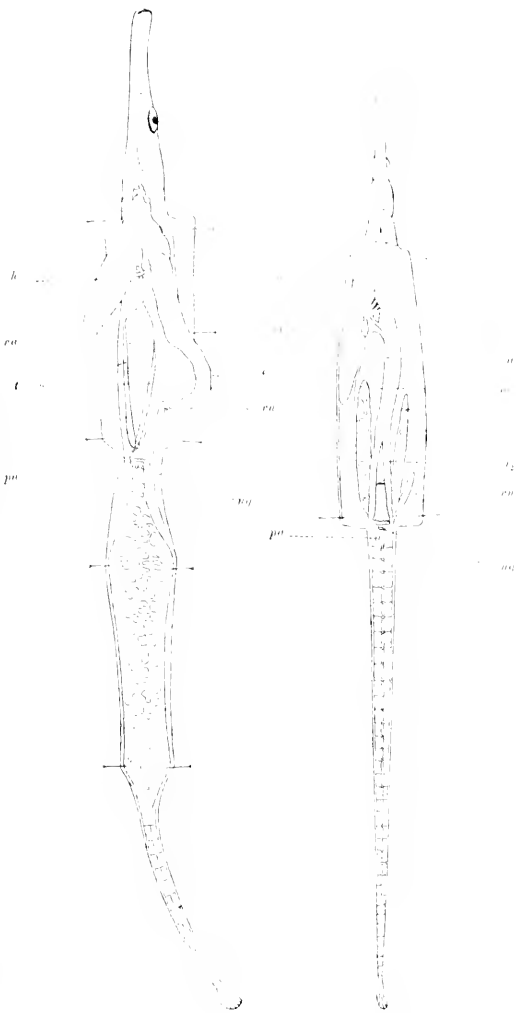
The intestinal canal (fig. 170) is simple in all the Lophobranchs, but shortest in the *Syngnathinæ*. In the *Hippocampinæ* (the Sea-horses) the intestine forms at least a few curves, but in the *Syngnathinæ* it is straight or nearly so, thus rendering the whole digestive canal, from the pharynx to the vent, equal in length to or only slightly longer than the abdominal cavity. The lines of demarcation between the œsophagus, the stomach, and the intestine are only internal, and consist merely in the difference of the mucous membrane, while the beginning of the last division is marked as usual by the mouth of the gall-duct. But the small intestine is divided from the rectum by an annular valve. No pyloric appendages can be traced. The mesenterium is wanting or only partly developed, in front and behind, to bind the stomach and intestine to the dorsal wall of the abdominal cavity. Both the ovaries and the testes are paired, simple, and elongated. Their discharging ducts are short and distinct down to their

[a] J. PLAYFAIR MCMURRICH (*On the Osteology and Development of Syngnathus Peckianus* Quart. Journ. Micr. Sc., n. ser., No. XCII (Oct. 1883), p. 623), assumes that this bone is a metapterygoid.

[b] See, however, below, on the ligamentous connexions between *os epihyale*, the interoperculum, and the angular part of the lower jaw in *Silurus*.

[c] See for example our figure of *Syngnathus acus*. The entire figure (*A*) shows the ceratohyoid bones depressed to a pointed protuberance on the throat just behind the perpendicular from the eye; and in the lower figure (the anterior part of the ventral side of the body, *B*) the urohyoid bone extends back from the ceratohyoid bones and between the opercula.

[d] *Anatomisk undersokning ofver nagra delar af Syngnathus Acus och Ophidion*, Vet. Akad. Handl. 1833, p. 146.



A B

Fig. 170. Anatomy of *Syngnathus typhle*. After A. RETZIUS.

A: Male, with the abdominal wall opened and folded outwards and the marsupium, in which appear the cavities left by the eggs, distended.

h, liver; *ra*, air-bladder, with the anterior, thin-walled part pointed and obliquely divided from the posterior; *t*, testes; *pa*, anal fin; *vu*, urinary bladder; *i*, intestine, opened for a short distance at the vent; *ug*, urogenital aperture, behind (below) the vent, which is opened.

B: Female, with the abdominal wall opened and folded outwards.

h, liver; *vf*, gall-bladder; *pa*, anal fin; i_1, intestine, at the mouth of the gall-duct coming from the right side (in the figure the left); i_2, posterior part of the intestine, opened in order to show the valve that divides the intestine from the rectum, which is also opened as well as the vent; *ov*, ovaries; *vu*, urinary bladder; *ug*, urogenital aperture.

opening just behind the vent. The urinary bladder is long and narrow, lies on the left side, and coasts the left sexual organ. The air-bladder is large and coasts the upper wall of the abdominal cavity for at least one-half or two-thirds of the length of the latter.

The ribs are wanting. Among the other peculiarities of the skeleton the structure of the shoulder-girdle is especially remarkable. The posttemporal bone (fig. 171, *pt*) coalesces with the mastoid bone (*epoticum*) of the skull and is covered in a Ganoid fashion by a plate-like layer, pointed behind. The supraclavicular bones are wanting; but the clavicle (*cl*) is all the larger. This bone is **T**-shaped, with the upper (horizontal) bar united to the transverse processes of the first two vertebræ. The first transverse process is directed backwards, and so long that all the anterior upper branch of the clavicle may be contiguous with it; while the second of these processes, which is comparatively short, and only slightly expanded at the top, adjoins the angle between the horizontal and vertical branches of the clavicle. The outside of the clavicle is covered by the three plates on each side of the body which form the first (foremost) ring; and in *Syngnathus acus* the inner prong of the vertical shaft, which is forked at the bottom, in the **T**-form of the clavicle, is supported on the first abdominal plate belonging to the same ring. This plate is wanting in *Syngnathus typhle*, where the support is therefore given by the lower lateral plate. Only the anterior margin, however, of the middle lateral plate in this ring is united to the middle of the shaft in the **T**-form of the clavicle, the rest of this plate lying as a covering over the muscular mass of the pectoral fin, in the middle of which mass we find the extremely thin scapulo-coracoid disk (*sc*) together with the four basal bones (fig. 171, *bas*) of the pectoral fin. This disk is not divided here into its ordinary component parts (the shoulder-blade and the coracoid bone), and is extended between the hind part of the upper (horizontal) branch of the clavicle and the inner prong of the vertical shaft of the clavicle, without touching this bone at any other point. At this lower end of the clavicle, however, within the lower end of the scapulo-coracoid disk and above the inner side of the first two abdominal plates in *Syngnathus acus*, lies one interclavicle (*icl*), which meets both the clavicle and the said disk (fig. 171, *sc*). Neither in *Syngnathus acus* nor in *S. typhle* have we succeeded in finding more than one such interclavicle, though according to PARKER the former species possesses two.

The skeleton is otherwise extremely simple and only slightly ossified, with the vertebræ elongated and their processes straight and of uniform breadth, or slightly broader at the top; but in the vertebræ above which the dorsal fin is attached, the upper spinous processes are divided sagitally (in the longitudinal direction of the body) into three or four divergent branches. Distinct hæmal arches appear only at the beginning of the caudal region, where a few may be found.

By far the greater number of the *Syngnathinæ* are marine fishes: they are met with everywhere, where seaweeds cover the bottom. Out at sea they accompany the tufts of sargasso-weed, or drift about at the surface with the current and the waves. Some of them, however, also live in brackish water, and a few species occur in fresh water alone. The species that occur in Scandinavia may be distinguished as follows:

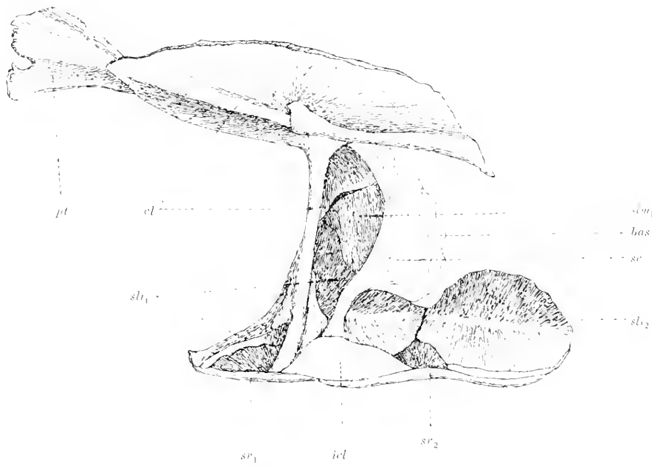


Fig. 171. Right scapular arch of *Syngnathus acus*, seen from within, 7 times the natural side. Principally after PARKER.
pt, posttemporal bone; *cl*, clavicle; *sli_1*, lower lateral plate in the first ring (*scutum laterale inferius annuli primi*); *sli_2*, lower lateral plate in the second ring; *sr_1*, ventral plate in the first ring; *sr_2*, ventral plate in the second ring; *icl*, interclavicle; *slm_1*, middle lateral plate in the first ring; *bas*, basal bones of the pectoral fin; *sc*, scapular disk.

A: The adult fishes without pectoral fins. The males carry the impregnated eggs in a layer of mucus on the ventral side of the trunk.
- *a:* Beginning of the dorsal fin far in front of the perpendicular from the vent, its distance from the tip of the snout being at most about $^4/_5$ (less than 85 %) of the distance between the vent and the same point ...... *Nerophis æquoreus.*
- *b:* Distance between the dorsal fin and the tip of the snout at least $^9/_{10}$ of that between the vent and the latter.
  - *aa:* Length of the trunk and head (distance between the vent and the tip of the snout) more than 45 % of the length of the body .... *Nerophis ophidion.*
  - *bb:* Distance between the vent and the tip of the snout less than 35 % of the length of the body ... ... *Nerophis lumbriciformis.*

B: The adult fishes furnished with pectoral fins. The males[a] carry the impregnated eggs in a canaliculate sac on the ventral side of the tail.
- *a:* Length of the head more than 15 % of that of the body ...... *Syngnathus typhle.*
- *b:* Length of the head less than 14 % of that of the body.
  - *aa:* Length of the head greater than that of the base of the dorsal fin ... ... *Syngnathus acus.*
  - *bb:* Length of the head less than that of the base of the dorsal fin... ... ... *Syngnathus rostellatus.*

[a] In our Scandinavian species.

Ever since FRIES[a] pointed out the remarkable fact that the larvae of *Nerophis lumbriciformis* are furnished with fully developed and actively employed pectoral fins, it has been evident that the former of the two above groups, into which we have after FRIES divided the Scandinavian *Syngnathinae*, has been developed by a retrogressive metamorphosis from forms agreeing more closely with the better equipped types. The *Needle-fishes* (*Syngnathi Ophidii* in FRIES) are also distinguished by a considerably smaller head, in adult fishes less than $^1/_{10}$ of the length of the body, and a smoother body, without or at least with only indistinct longitudinal carinae. It is also a rule among the Lophobranchs that the larvae and the young fishes have sharper carinae or even spines on the plates of the body, where the older fishes show fainter traces thereof. Thus the Needle-fishes, in this respect too, represent older (more advanced) stages of development. This cannot prevent them, however, from being regarded as less fully equipped even in respect to the covering of the body. An exotic genus within this group, *Protocampus*, which otherwise comes fairly near *Nerophis*, also retains the larval vertical fin even in the case of full-grown specimens, at the dorsal edge both in front of and behind the true dorsal fin, and at the ventral edge of the trunk. Again, the manner in which the male Needle-fishes carry their eggs, must surely be regarded as more primitive than the corresponding arrangement in the rest of the *Syngnathi*. We therefore begin our description with the forms which FRIES called *Tangsnällor* (*Syngnathi Marsupiales*).

GENUS **SYNGNATHUS**[b].

The adult fishes furnished with pectoral, caudal, dorsal, and anal fins. The uppermost row of plates on each side of the trunk terminates posteriorly at the end of the dorsal fin or just in front of this point. Vent situated in the anterior half of the body. The males carry the impregnated eggs in a canaliculate sac underneath the tail.

Some fifty species, known and defined with greater or less certainty, are contained within this genus, which is spread over all the seas of the Tropical and Temperate Zones, and is represented even in some of the rivers and lakes of the Tropics.

The upper marginal carina on each side of the tail runs forward in this genus below the posterior part of the upper lateral carina of the body, on each side of the dorsal fin, either to meet the middle lateral carina of the trunk or to disappear above its termination. The egg-sac of the males is formed in this genus in the following manner. The anterior part of the lower marginal carina of the tail grows obliquely downwards on each side for a greater or less part of its length, and along the under surface of the free margin develops a dermal fold, a continuation of the anal mucous membrane. These dermal folds on each side of the body converge towards each other, but without coalescing, their free margins being closely approximated to each other, but leaving a slit, which the fish can widen or firmly close at pleasure. "When the spawning-season approaches," says EKSTROM of *Syngnathus typhle*, "the foliate lids (dermal folds) that close the marsupium of the male, become swollen, and the marsupium is gradually filled with a white, clear, and thick mucus, which serves as a bed for the eggs, and decreases in quantity as the young grow, until, by the time they are large enough to swim and make independent progress though the water, little or none of it remains. One day in the month of July I was present at the hauling of a seine in the island-belt, and secured a male of this species that had fully developed young in the marsupium. I at once constructed a dam with stones from the beach, and the fish was set in the pool soon after it had been taken from the seine. After it had swum to and fro for a while, it opened the marsupium by a downward movement of the tail, whereupon the young crept out one after another and swam under and on both sides of the male, but always kept close to its body at a little distance from the marsupium. As soon as I tried to capture the male, it made a sudden movement, at the same time bending the body in an arch upwards, and the young at once crept into the marsupium, the lids of which were then shut. The same experiment was re-

[a] *Metamorphos, anmärkt hos Lilla Hafsnålen*, Vet. Akad. Handl. 1837, p. 59.

[b] ARTEDI, *Ichthyol.*, *Gen. Pisc.*, p. 1. In his works, however, this genus represented the whole of the modern series *Lophobranchii*. In ARISTOTLE the genus was called βελόνη, a name which ATHENÆUS subsequently transferred to the modern *Rhamphistoma*. GAZA translated βελόνη by *acus*, which was the most general name of the genus during the Middle Ages; but BELON called it *Typhle* or *Typhline*.

peated several times, but both the male and the fry invariably behaved in the same manner.

As the genus is defined in the above diagnosis, it contains six of KAUP'S[a] and DUMERIL'S[b] genera, two of which, *Siphonostoma* and *Syngnathus*, are retained by GÜNTHER[c]. The distinction between these two genera is stated to consist in the character that in *Siphonostoma* the lower covering plates of the shoulder-girdle (the lowest pair of lateral plates in the first ring) are only loosely joined to each other at the middle of the belly; while in *Syngnathus* they are firmly coalescent, and their juncture is usually covered by the first ventral plate, which is always wanting in *Siphonostoma*, this genus thus having an oblong, rhomboidal patch, covered only with skin and without plate, at the middle of the belly just behind the shoulder-girdle. The difference is of little importance, at least in the Scandinavian fauna, which contains only three of these species.

THE GREAT PIPEFISH (SW. STORA TÅNGSNÄLLAN[d]).

SYNGNATHUS ACUS

Fig. 172.

Snout comparatively narrow and shallow. Length of the head less than 14 % of that of the body and at most 24 % of that of the tail, which is more than twice the length of the trunk. Distance between the dorsal fin and the tip of the snout at most 39 % of the length of the body, and the length of its base less than $^1/_3$ of this distance and also less than the length of the head. Length of the marsupium of the male more than twice that of the head. Hind margin of the caudal fin rounded.

Fig. 172. *Syngnathus acus* from the Great Fishing-bank, S. W. of Bergen, where the depth was 100–150 fathoms, taken by Fisherman ANDERSSON of Bohuslän in 1874. *A*, $^1/_2$ of the natural size; *B*, the head seen from below, natural size.

R. br. 2; *D.* 38–42; *A.* 3–4; *P.* (10) 11–12 (13); *C.* (9) 10; *Vert.* 66; *Ann.* 62–66=(20–22)+*x*.

Syn. *Syngnathus* corpore medio heptagono, cauda pinnata, ART., *Ichthyol.*, *Spec. Pisc.*, p. 3, No. 3; LIN., *Fn. Suec.*, ed. I, p. 126, No. 336.

Syngnathus Acus (p. p.), LIN., *Syst. Nat.*, ed. X, tom. I, p. 337; ("Laminæ corporis trunci 20, caudæ 43"); BL., *Fisch. Deutschl.*, pt. III, p. 113, tab. XCI, fig. 2; FLMNG, *Brit. Anim.*, p. 175; JEN., *Man. Brit. Vert.*, p. 484, YARR., *Hist. Brit. Fish.*, ed 1, vol. II, p. 325; FR., Vet. Akad. Handl. 1837, p. 27; KR. (*Siphostoma*), *Danm. Fiske*, vol. III, 1, p. 692, SUND. (*Syngnathus*), Öfvers. Vet. Akad. Förh. 1852, p. 85; NILSS., *Skand. Fn.*, *Fisk.*, p. 684; KP., *Cat. Lophobr. Fish.*, *Brit. Mus.*, p. 41; GTHR (p. p.), *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 157; DÜM., *Hist. Nat. Poiss.* (Nouv. Suit. à Buff.), tom. II, p. 552; COLL. (p. p.), Vid. Selsk. Forh. Christ. 1874, Tillaegsh., p. 200; ibid. 1879, No. 1, p. 101; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 53; HCKE (p. p.), Arch. f. Naturg. 46 (1880), I, p. 332; MOR., *Hist. Nat. Poiss. Fr.*, tom. II, p. 42; DAY (p. p.), *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 259, tab. CXLIV, fig. 1; STORM, Vid. Selsk. Skr. Trondhj. 1883, p. 42; LILLJ., *Sv.*, *Norg. Fisk.*, vol. III, p. 454.

Syngnathus Typhle, BL., *Fisch. Deutschl.*, pt. III, p. 112, tab. XCI, fig. 1; MALM (p. p.), Öfvers. Vet. Akad. Förh. 1852, p. 84.

Obs. ARTEDI'S description (*Descr. Spec. Pisc.*, l. c.) leaves no room for doubt that he really distinguished between the two species

[a] *Cat. Lophobr. Fish.*, *Brit. Mus.* 1856.

[b] *Hist. Nat. Poiss.*, tome II (Nouv. Suites à Buffon, Paris 1870).

[c] *Cat. Brit. Mus.*, *Fish.*, vol. VIII, pp. 154 and 155.

[d] FRIES.

that according to his opinion had already been represented by RONDELET (*De Pisc.*, lib. VIII, cap. IIII, p. 229) in distinct figures, but combined in one chapter (as one species). The first of these figures evidently represents the species called *Typhle* in BELON (*Nat., Divers. Poiss.*, p. 446); the second (lower) figure should thus correspond to the species called by LINNÆUS *Syngnathus acus*, assuming that this species occurs in the Mediterranean, from which locality RONDELET had procured his fish[a]. After ARTEDI's observation "Numerus incisurarum seu crenarum transversarum, in hoc genere, omnino attendendus est", when we employ the Linnæan name, we must first be guided by the character which LINNÆUS gives, and which is drawn from the number of the rings on the body. Both FRIES (l. c.) and SUNDEVALL (l. c.) have adequately shown that LINNÆUS otherwise confounded these two species, and cannot be regarded as an authority on this question. As SUNDEVALL also points out, DONOVAN, in his description of *Syngn. typhle*, was the first after ARTEDI clearly to define the distinction between the two species, and the first to give to the name of *acus* the employment which has subsequently and rightly been observed by the English faunists.

The Great Pipefish attains a length of about half a metre (STORM). From Dynekil (Bohuslän) the Royal Museum has received through Mr. C. A. HANSSON specimens up to 442 mm. long. The elongated, whip-like body shows a distinct break, especially in adult specimens, at the boundary between the trunk and the tail; and the trunk is thickest, as usual, in the females. The greatest depth of the body, at the middle of the trunk, may sometimes rise to nearly 5 % of its length, but is usually only 3 or 4 % thereof, or in the females about $13\frac{1}{2}$—15 %, in the males about 11—12 % of the length of the trunk[b]. The greatest breadth is as a rule about $\frac{4}{5}$ of the greatest depth. At the beginning of the tail the depth of the body in old specimens is at most about 3 %, sometimes only $2\frac{1}{2}$ %[c] of its length, and from this point it decreases regularly to the shallow base of the caudal fin. The length of the trunk behind the gill-cover is about 28—26 % of that of the body; and the length of the tail, including the caudal fin, varies between about 59 and 61 % of that of the body.

The plate-armour is distributed in such a manner that 21 or 22, sometimes, in young specimens, 20 rings (including the ring of the shoulder-girdle) belong to the trunk, and 43—45 to the tail. Here, as in the other *Syngnathi*, these plates are striated with transverse ridges and grooves between them, starting from the middle carina, which is finely dentated. The uppermost plates, which meet at the middle of the back, are almost square and bent at a slightly obtuse angle, rendering the dorsal side flat or slightly concave. In the middle lateral row on the trunk the plates are more distinctly hexagonal or even octagonal, and bent at a very obtuse angle. In the lowest lateral row on the trunk the angle of curvature varies according to the greater or less distension of the belly, but the form of the plates is more like that of those in the middle lateral row. The middle ventral row also consists of hexagonal or octagonal plates. The two hindmost rings on the trunk are without ventral plate, its place being occupied by the anal region. On account of the form of the plates two rows of diamond-shaped patches, covered only with skin, are left on each side of the trunk and also on its ventral side; but on the back there is only one row of these rhombs, which generally extend across the whole dorsal plane, but sometimes, especially in front, are indistinct, the contiguous plates being perfectly rectangular. The middle lateral row of the trunk ends in the hindmost ring of this region, as a rule obliquely below the beginning of the row that forms behind the dorsal fin the upper lateral margin of the tail, and below the posterior part of the dorsal fin (behind the vent) a middle lateral row belonging to the tail. But sometimes the last-mentioned row wedges itself into the hindmost ring on the trunk, which ring may thus contain four plates on each side. The difference in this respect is, however, so irregular that we sometimes find the former to be the case on one side of the body, the latter on the other side. The four sides of the tail behind the dorsal fin are constructed in the same manner as the dorsal plane of the trunk; but the ventral side is broader than the dorsal, which is parallel to it, the difference being greatest in old specimens. The marsupium of the males extends under 24—26 rings.

The length of the head measures 12—$13\frac{1}{2}$ % of that of the body. At the occiput it is only slightly shallower than the beginning of the trunk and not very sharply marked off therefrom. Here as in the *Syngnathi* in general, the trunk is furnished at the

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[a] Whether the Atlantic *Syngnathus acus* also occurs in the Mediterranean, is not yet decided with certainty. MOREAU had no knowledge of it from this locality, and CANESTRINI (*Fauna D'Italia, Pesci*) does not include it among the fishes of Italy. On the other hand, MOREAU gives *Syngnathus ethon*, and CANESTRINI *Syngn. taenionotus*, which seem to stand in the same relation to the Mediterranean *Syngn. rubescens*, as *Syngn. rostellatus* to *Syngn. acus*.

[b] In young specimens about $1\frac{1}{2}$ dm. long the greatest depth of the body may be only about $2\frac{1}{2}$ % of its length and 10 % of the length of the trunk.

[c] In young specimens still less, sinking at least to $2\frac{1}{5}$ % of the length of the body.

extreme front of its dorsal plane with two unpaired plates, which have been called occipital, because their middle carina forms a continuation of the occipital carina. These plates also lie so far forward that the anterior one partly covers the crest of the occiput, and the small gill-openings lie beside the front part of the posterior plate. Thus the hind part of the head with the gill-openings lies to a great extent within the limits of the trunk. The anterior occipital plate is shorter than the posterior, sometimes only half as long. The true occipital carina is hardly as high as these so-called occipital plates; but still the occiput rises considerably from the forehead, which in its turn slopes forward towards the snout. The occiput is also convex, and the sides of the hind part of the head are considerably tumid, on account of the alveated form of the oval opercula. These bones are striated with smooth ridges, radiating upwards and downwards and leaving between them rows of small cavities in the surface; and an horizontal ridge, granulated by a row of small round tubercles and scarcely half as long as the operculum, runs back from the articulation of this bone. The occiput, the top of the head, and the temples are cavernous in the same manner, but with coarser and more irregular depressions. The snout, on the other hand, is smooth, with the exception of the bars (carinae) that follow its dorsal side. One of these bars, the dorsal carina of the snout, runs in a line with the occipital carina, which has terminated and been obliterated on the concave forehead. This bar is coasted on each side by another, an immediate continuation in a forward direction of the strongly elevated upper orbital margin, which is continued backwards in the same manner by a ridge that runs obliquely up towards the beginning of the anterior occipital plate. The orbital margin itself is also continued downwards and sharply defined in old specimens, in which the praefrontal bone also forms a prominent knob at the middle of the anterior orbital margin. All these ridges are granulated at the free margin, more or less distinctly and most so in old specimens, by a row of small round tubercles. In front of the said praefrontal protuberance, which is not very distinct in young specimens, lies a triangular depression, within which an obliquely longitudinal elevation of the skin bears a small round nostril at each end. When the mouth is closed, the snout is somewhat compressed from the sides, with the breadth gradually decreasing in front; but when the mouth is open, it is more terete and, when seen from above, of more uniform breadth. The tip of the snout is turned upwards, and rises perceptibly above the ascending tip of the lower jaw.

The length of the snout varies considerably in different individuals, but especially according to age. In young specimens, up to a length of 2 dm., it may be only slightly greater or even somewhat less than half the length of the head; but in older specimens it measures about 56—59 % thereof. The variation is as great, but reversed, in the case of its least depth, which we have found in young specimens to measure 20—18 % of its length, while the corresponding proportion in old specimens varies between about 15 and 13 %. As a rule the least depth of the snout is $^2/_3$ of the length of the lower jaw, which is about the same as the diameter of the eyes. The postorbital length of the head, occupied almost entirely by the gill-cover, measures about $^1/_3$ (31—34 %, exceptionally 36 %) of its entire length.

As we have mentioned above, the branchiostegal membranes are entirely coalescent, below and on the sides, with the front of the shoulder-girdle. The gill-openings, with their crescent-shaped lids, are small horizontal crevices, about half as long as the diameter of the eyes, and situated in a line with the latero-dorsal carinae of the trunk, which begin just behind them.

The only paired fins, the pectorals, occupy an obliquely vertical position about half-way up the body, and are of almost uniform breadth, with sharply rounded tip. Their rays are simple and unarticulated, somewhat widened at the tip, and usually 12, exceptionally 10—13, in number. The length of the longest (middle) rays is always less than the depth of the body at the beginning of the tail.

The dorsal fin begins on the last or the penultimate ring of the trunk, at a distance from the tip of the snout which we have never found to exceed 39 % (37—38$^1/_2$ %) of the length of the body, and which is greatest as a rule in the females. It is of almost uniform height, though it rises slightly in a backward direction for about three-fourths of its length and then sinks again. Its rays (usually 35—42, exceptionally 43—45), like those of the other fins, are simple and unarticulated; they are somewhat broader at the tip and compressed (flattened in the longitudinal direction of the body). It more or less entirely occupies 10 or 9 rings of plates, and the length of its base, which is always shorter than the head, measures 11 or 12 % of that of the body.

The anal fin lies just behind the vent, at a distance from the tip of the snout not exceeding 41 % (39—40$^1/_2$ %) of the length of the body. It is extremely small, resembling a thin and narrow dermal flap, a little expanded towards the tip, and consists of three (according to MOREAU four) rays, which do not attain a length of even half that of the longest rays of the dorsal fin. It is often so entirely enveloped by the marsupium of the males as to be invisible externally.

When expanded the caudal fin is fan-shaped, with rounded hind margin. As a rule it contains 10 rays, more seldom 9. Its length at the middle is about 3 % (2·8—3·2 %) of that of the body, or at most about $^1/_4$ (26—22 %, least in old specimens) of that of the head.

The coloration is reddish or yellowish brown, with about 12 or 13 broad, dark brown, transverse spots across the hind part of the head, the back, and the tail. These spots are intersected, however, by longitudinal, oblong, smaller spots of the ground-colour. The sides of the snout are also marked in a similar manner. The ventral side is yellow or red. The lower part of the gill-cover gleams with a silvery lustre. The caudal fin is dark brown. The anal and pectoral fins are transparent, but the edges of the rays are dark brown. The dorsal fin resembles the last-mentioned fins, but has several transverse spots arranged in rows on the rays.

The geographical range of the Great Pipefish extends along the whole west coast of Europe south of the neighbourhood of Trondhjem, and according to GÜNTHER the British Museum has also received specimens through Sir A. SMITH from the Cape of Good Hope. On the English coast the species is very common. It seems hardly probable that it occurs in the Mediterranean, as KRØYER has already remarked. It rather appears to be represented there by one or perhaps two very nearly allied species, *Syngnathus rubescens* and *S. tenuirostris*. In the west of the Atlantic it is unknown. KRØYER states that it occurs in the Cattegat; and according to WINTHER he received two young specimens from the northern entrance of the Sound, off Hornbæk. In Christiania Fjord it is comparatively plentiful, according to COLLETT; and the Royal Museum has received through Mr. C. A. HANSSON several specimens, between 270 and 442 mm. in length, from Dynekil and Strömstad Fjord. Thus it cannot be considered rare on the north coast of Bohuslän; but further south it has never been met with on the Swedish coast.

The Great Pipefish generally lives, like other Lophobranchs, among the seaweed in comparatively shallow water, even between the tide-marks. But now and then we meet with the *Syngnathi*, and with this species among others, at the surface, even far out at sea, where they show a high degree of activity in their movements, especially at night. During the Atlantic expedition of the corvette *Josephine* in 1869 I stood many a night in the bows, and watched the wriggling motion, in lines of phosphorescent light through the dark waves, of *Syngnathus pelagicus*, a species which comes very near the Great Pipefish, but is distinguished from it in several respects, for example by a comparatively larger head and shorter tail and by the much shorter marsupium of the males. THOMPSON also tells us of the Great Pipefish[a]: "A friend who has frequently watched the movements of pipefishes in Belfast Bay describes them as skimming along the surface of the water, in the summer evenings especially, like a slate thrown horizontally. — He has seen them skipping for 20 or 30 yards at a time, and also springing a foot high into the air." The specimen which is represented in our figure, was taken by a fisherman from Bohuslän, ANDERSSON by name, on "the Great Fishing-bank S.W. of Bergen in 100—150 fathoms of water;" but we have no information whether it was taken at the bottom, or perhaps found at the surface. In its daily life, according to KRØYER, the Great Pipefish "swims slowly, with singular, stiff, angular, and as it were contorted movements." At these times, here as in the Lophobranchs in general, it is the vibrating dorsal fin that is the real instrument of locomotion, the pectoral fins, which move in the same manner, seeming rather to steer the course of the fish. The fish lies in every possible position, with the head turned downwards or upwards or forwards at will, as it glides on in quest of its food[b], which seems to consist principally of crustaceans[c], usually of minute size, though "not unfrequently," says COUCH, "shrimps of comparatively no small size are swallowed; and there have been found in the stomach some so large as to raise our wonder how they

[a] *Nat. Hist. Irel.*, vol. IV, p. 239.
[b] Cf. COUCH, *Hist. Fish. Brit. Isl.*, vol. IV, p. 353.
[c] Cf. OLSSON, *Iakt. fisk. föda*, Lunds Univ. Arsskr., VIII (1871), p. 10.

could have been made to pass between the jaws and through the gullet, this depending, of course, on the distensive powers of the snout.

The spawning-season occurs in spring and summer. COUCH found a male with eggs in the marsupium in April. On the 7th of May, 1869, at the west entrance of the Channel (Lat. 47° 14' N., Long. 9° 9' W.), the Josephine Expedition took several young specimens of this species, swimming freely about at the surface. These specimens were between 10 and 21 mm. long, of light colour and transparent, but already marked with transverse spots. In the smallest of them the whole of the embryonic vertical fin was still persistent. The largest ones had fully developed fins, except the anal, of which not a trace was yet visible; and their plates, as is usual in the fry, were tipped with spines. We found the number of rings in front of the dorsal fin to be 19. MALM saw in the possession of Mr. G. KOLTHOFF a male 140 mm. long, with almost fully developed embryos, that had been taken in the neighbourhood of Skaftö (Gullmar Fjord) on the 1st of August, 1877. In two males which were taken in Strömstad Fjord by Mr. C. A. HANSSON in September and October, 1888, the marsupium is quite empty.

It was in this species that JOHN WALCOTT first discovered, either in 1784 or 1785 according to YARRELL, that it is really the male who carries the impregnated eggs during their further development, and not the female, as had previously been supposed ever since the time of ARISTOTLE. WALCOTT's observation was first published, however, by YARRELL in 1836, or five years after EKSTRÖM had published his account of the Deep-nosed Pipefish (*Syngnathus typhle*).

THE LESSER PIPEFISH (SW. LILLA TÅNGSNÄLLAN[a]).

SYNGNATHUS ROSTELLATUS.

Plate XXVIII, figs. 6—8.

Snout terete and shallow. Length of the head less than 13 % of that of the body and at most 20 % of that of the tail, which is more than twice that of the trunk. Distance between the dorsal fin and the tip of the snout at most 37 % of the length of the body, and the length of the base of this fin more than $^1/_3$ of this distance and also greater than the length of the head. Length of the marsupium of the males more than twice the length of the head. Hind margin of the caudal fin rounded.

D. 33—39; *A.* 3[b]; *P.* 9—11; *C.* (9) 10; *Ann.* 52—56 (15—17) + *x*.

Syn. *Syngnathus pelagicus*, DONOVAN, *Brit. Fish.*, tab. LVIII (nec OSBECK).

Syngnathus typhle, MALM (p. p.), Öfvers. Vet. Akad. Förh. 1852, p. 84.

Syngnathus rostellatus, NILSS., *Skand. Fn., Fisk.*, p. 687; SCHLEG., *Dier. Nederl., Vissch.*, p. 179, tab. 17, fig. 2; LTKN, Vid. Meddel. Naturh. For. Kbhvn 1865, p. 222; MALM, *Gbgs. Boh. Fn.*, p. 595; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 53; PETERSEN, Vid. Meddel. Naturh. For. Kbhvn 1884, p. 159; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 459.

Syngnathus acus (p. p.), GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 157; COLL., Forh. Vid. Selsk. Christ. 1874, Tillægsh., p. 200; ibid. 1879, No. 1, p. 101; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 259, tab. CXLIV, fig. 2.

Syngnathus Dumerilii, DÜM., *Hist. Nat. Poiss.* (Nouv. Suit. à Buff.), tom. II, p. 556; MOR., *Hist. Nat. Poiss. Fr.*, tom. II, p. 49.

Obs. As appears from the title of Plate XXVIII we originally held the same opinion as GÜNTHER and DAY, that this little Pipefish was merely a juvenile form, singular in certain respects, of the preceding species. The collections made by HEDENBORG in the Bosphorus for the Royal Museum show, however, that *Syngnathus rostellatus* is certainly distinct from the Mediterranean species with which it has been identified by GÜNTHER (*Syngn. bucculentus*, RATHKE; *S. brevirostris*, HEMPR. and EHRENB.). The latter species has a shorter snout and longer postorbital region etc., the length of the snout in all HEDENBORG's specimens being less than 47 % of that of the head, the postorbital length of the head equal to or at least more than $^4/_5$ of the length of the snout, and the least depth of the snout $^1/_4$—$^1/_3$ of its length, while the depth of the body at the beginning of the tail is more than $^1/_5$ (22—26 %) of the length of the base of the dorsal fin. These two species cannot, therefore, be ranged as mutually complementary forms of transition to *Syngnathus acus*. Furthermore, in 1842 the Royal Museum received through Mr. PONTIN, Member of the Swedish Medical Council, a thing previously unknown, to the best of our knowledge, namely a young specimen 155 mm. long of the Atlantic *Syngn. acus*, taken "by a Dutch captain, probably in the North Sea." This specimen has 64 (20 + 44) rings on the body;

[a] MALM, l. c.

[b] Sometimes 4, according to LILLJEBORG and NILSSON.

the length of the head is somewhat more than 13 % (13·2 %) of that of the body, the length of the base of the dorsal fin less than $\frac{1}{3}$ (31·6 %) of the distance between this fin and the tip of the snout or only 88 % of the length of the head, and the temporal carinæ — which in *Syngnathus rostellatus* are never more than rudimentary — are distinct, starting backwards from the supraorbital margins. Thus, as we know the true juvenile form of the Great Pipefish, we are compelled to retain the Lesser Pipefish as a distinct species, however nearly these two species are allied.

The Lesser Pipefish attains a length of 16 cm.[a] The form of its body so closely resembles that of young specimens of the preceding species that in this respect it is difficult to state any constant distinction between them; but the plate-armour confirms the rule already formulated by Artedi, that within this genus we must look for characteristic differences, first of all, in the number of rings on the body. The Lesser Pipefish has only 15—17 rings on the trunk and 37—40 on the tail, or at most 57 in all, thus at least 6 less than the minimum number in the preceding species. The middle lateral carina of the trunk is usually coherent in this species with the upper lateral edge of the tail. It is stated, however, that this character may also be found in the preceding species, at least in young specimens thereof; and on the other hand, the two carinæ may be separated in this species in the same manner as in the preceding one — see the largest of the specimens figured in Plate XXVIII (fig. 8, *a*; twice the natural size in fig. 8, *b*). The marsupium of the males occupies the first 23—26 rings of the tail.

The length of the head measures about $10\frac{1}{2}$—$12\frac{1}{2}$ % of that of the body, and its structure is otherwise the same as in the preceding species; but behind the eyes, on the top and on the temples in front of the small occipital carina, it is evenly convex, without the carinæ which in the Great Pipefish run back on each side from the upper orbital margin, or with only a rudiment of a similar carina immediately behind each orbit.

The pectoral fins are comparatively larger than in the Great Pipefish, and are inserted lower down the sides. The length of their longest rays is greater than the depth of the body at the beginning of the tail.

The dorsal fin is supported on 10 or 11 plates, but sometimes partly occupies as many as 13. It begins at a distance from the tip of the snout that measures 34—36[b] % of the length of the body; and the length of its base is about 15—$12\frac{1}{3}$ % of the same length, though, so far as we have been able to ascertain, the variations are so restricted that it is always greater than the length of the head. Its upper margin is more regularly curved than in the Great Pipefish, with the longest rays nearer the middle.

The anal fin is of insignificant size; but the caudal fin is comparatively larger than in the preceding species, its length being at least $3\frac{1}{2}$ % of that of the body and 38—31 % of that of the head.

The three figures which are given in Plate XXVIII, represent three individuals, one female (fig. 8), a young male with undeveloped marsupium (fig. 7), and a specimen of the fry (fig. 6). These specimens were taken at the beginning of July, 1887 in Koster Fjord (Northern Bohuslän) at the surface, where the depth of water was about 100 fathoms. They were forwarded alive by Mr. C. A. Hansson to the Royal Museum, where they lived a few days longer. Their coloration was above greenish, shading into brown; but the dorsal side itself was lighter, shading into gray. The lower part of the sides and the belly were silvery, the former with a golden lustre in the male. The darkest colour thus appeared like a longitudinal band from the sides of the snout, across the eyes, on the postorbital part of the head, and on the sides of the body just below the uppermost lateral carina. But behind the dorsal fin, at the transition to the tail, it was broken off short, and the lateral band of the tail overlapped it below. The caudal fin was brownish violet. The other fins were transparent. The iris was golden. No traces of transverse bands appeared on the body; but that this is not a constant character of the species, seems more than probable, and is easily explained, with the knowledge we possess of the generic power of changing colour. In some of the specimens belonging to the Royal Museum, which have lain in spirits for more than forty years, transverse bands of a darker colour appear between the rings on the trunk, and in the males the strips between the marsupial plates are in some cases lighter, in others darker. According to Nilsson too, "the coloration is above dark gray or brown with darker transverse bands, below yellowish white; the caudal fin with transverse streaks of brown."

The Lesser Pipefish is fairly common in Bohuslän, according to Malm the commonest species of the genus

[a] According to Collett. The largest specimen in the Royal Museum is a male 155 mm. long.

[b] Moreau's measurements of a female *Syngnathus Dumerilii*, which is probably identical in species with *S. rostellatus*, shew, however, that this percentage may rise to 37.

except the Deep-nosed form. It was forwarded by v. DÜBEN to the Royal Museum in 1845 from Bergen. Baron GYLLENSTIERNA found it in Skelder Bay off Kullen, and handed over his specimens to NILSSON, who was the first to describe this species. In the Sound it has been met with by several Danish zoologists, among others by LÜTKEN off Hveen. HANSEN has taken it in the Cattegat off Læsö. It goes southward in the Atlantic to the Bay of Biscay, according to MOREAU, but is rare on the French coast.

The habits of the Lesser Pipefish probably resemble in the most essential respects those of its larger congener; but its comparatively larger fins are suggestive of a more active life, and its insignificant size must compel it to seek its food among the most minute marine animals. Its spawning-season occurs in spring and summer; from May to the middle of June MALM found eggs and young in the marsupium of the males.

In order finally to express, with the greatest brevity, the difference of form between this species and its nearest two relatives in the Atlantic region, we give below the most important proportions in this respect of three specimens of equal size, a male of *S. rostellatus* from Bohuslän, a female of *S. acus* from the North Sea, and a male of *S. pelagicus* from the Sargasso Sea (Lat. 32° N., Long. 43° W.), all three 155 mm. long from the tip of the snout to the hind margin of the caudal fin.

	Syngnathus		
	rostellatus.	*acus*	*pelagicus.*
Number of rings on the trunk	16	20	17
,, ,, ,, ,, ,, tail	40	41	32
Length of the head in % of that of the body	10.0	13.2	13.9
Distance between the dorsal fin and the tip of the snout in % of the length of the body	34.6	36.8	38.7
,, ,, ,, anal ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,,	35.5	39.0	43.2
Length of the trunk behind the gill-covers in % of the length of the tail	40.0	42.3	51.7
,, ,, ,, base of the dorsal fin in % of the distance between the dorsal fin and the tip of the snout	35.4	31.6	33.3
,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, vent ,, ,, ,, ,, ,, ,, ,,	34.5	29.7	29.8
,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, ,, length of the head	121.8	87.8	93.0
,, ,, ,, middle rays of the caudal fin in % of the length of the head	31.1	24.4	27.9

THE DEEP-NOSED PIPEFISH (SW. KANTNÅLEN OR TÅNGSNÅLLAN).

SYNGNATHUS TYPHLE.

Plate XXIX, fig. 1.

Snout laterally compressed and comparatively deep. Length of the head more than 15 % of that of the body and at least $^1/_4$ of that of the tail, which in the males is generally more, in the females less, than twice the length of the trunk behind the gill-covers. Distance between the dorsal fin and the tip of the snout at least $39^1/_2$ % of the length of the body, and the length of the base of this fin less than $^1/_3$ but more than $^1/_4$ of this distance, and also less than the length of the head. Hind margin of the caudal fin more or less obtusely pointed.

R. br. 2; *D.* 35—38[a]; *A.* 3; *P.* 13—15; *C.* (8) 10; *Vert.* 55: *Ann.* 52—57 = (17—19) + *x*.

Syn. *Syngnathus* corpore medio heptagono, cauda pinnata, ART., *Ichthyol.*, *Spec. Pisc.*, p. 2; LIN., *Fn. Suec.*, ed. 1. p. 126, No. 335.

Syngnathus Typhle, LIN. (p. p.), *Syst. nat.*, ed. X, tom. 1, p. 336 (Laminæ corporis trunci 18, caudæ 36): DONOVAN, *Brit. Fish.*, tab. LVI: FLMNG., *Brit. Anim.*, p. 175: JEN., *Man. Brit. Vert.*, p. 485; YARR., *Hist. Brit. Fish.*, ed. 1, vol. II, p. 332: FR., Vet.-Akad. Handl. 1837, p. 28, tab. III, fig. 2: BONAP. (*Siphostoma*, ex RAF.), *Cat. Met. Pesc. Europ.*, p. 89; KR., *Danm. Fiske*, vol. 3, p. 673; NILSS (*Syngnathus*), *Skand. Fn.*, *Fisk.*, p. 689; SUNDEV., Stkhlms L. Hush. Sällsk. Handl., H. VI, pp. 83 et 165: MGRN (*Siphostoma*), *Finl. Fiskfn.* (disp. Helsingf.), p. 69; LINDSTR. (*Syngnathus*), Gotl. L. Hush. Sällsk. Årsb. 1866, p. 24 (sep.); GTHR (*Siphonostoma*), *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 154: COLL., Forh. Vid. Selsk. Christ. 1874, Tillægsh., p. 199, ibid. 1879, No. 1, p. 100; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 52; BNCKE (*Syngnathus*), *Fisch.*, *Fischer.*, *Fischz. O. W. Preuss.*, p. 189; HCKE (*Siphonostoma*), Arch.

[a] 34—40, according to MOREAU.
[b] 38—46, ,, ,, DAY.

f. Naturg., Jahrg. 46, Bd. I (1880), p. 321; Mor., *Hist. Nat. Poiss. Fr.*, tom. II, p. 55; Mela, *Vert. Fenn.*, p. 360, tab. X; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 257, tab. CXLIV, fig. 3; Mör., Heke (*Siphonostomum*), *Fisch. Osts.*, p. 102; Coll. (*Syngnathus*), N. Mag. Naturv. Christ., Bd. 29 (1884), p. 113; Lill. (*Siphonostoma*), *Sverg., Norg. Fisk.*, vol. III, p. 139.

Syngnathus acus, Ekstr., Vet. Akad. Handl. 1831, p. 271, tab. II, figg. 1 et 2; Schagerstr., Physiogr. Sällsk. Tidskr., p. 314; Malm (*Siphonostoma*), *Gbgs. Boh. Fn.*, p. 592.

The Deep-nosed Pipefish attains a length of 33 cm., according to Yarrell. The largest Scandinavian specimen in the possession of the Royal Museum is a female 27 cm. long (from Norway, through Marklin): and according to Ekström the size of the species never exceeds $22^1/_4$ cm. in the island-belt of Södermanland. In form of body it is much the same as the Great Pipefish, the only difference being that it generally has a longer trunk and shorter tail. It thus represents in general the sexual characters that distinguish the females. As a rule too, the depth of the body is somewhat less; at the beginning of the tail it seldom (and only in the males and young specimens) exceeds $2^1/_2$ % of the length of the body[a].

The plates of the body essentially correspond in form and arrangement to those of the two preceding species. As we have mentioned above, however, the foremost inferior plates, the lowest covering-plates of the shoulder-girdle, are more loosely attached to each other at the middle of the ventral side[b], and the first ventral plate is nearly always wanting[c]. The first of the ventral plates that are present (corresponding to the second in the Great Pipefish), is also, as a rule, considerably reduced, so that a longitudinal, narrow strip, covered only with skin, is left behind the juncture on the ventral side of the plates belonging to the shoulder-girdle. Thus, as the last (and sometimes the penultimate) ring on the trunk is also without ventral plate, here as in the Great Pipefish, we find only 17 (sometimes only 16) ventral plates, while the number of plates in the lower lateral row of the trunk is usually 18. In the cases where the last-mentioned number is 19, there are only 18 ventral plates; when it is 17, we find, as a rule, only 16 of the latter. The so-called occipital plates are only slightly raised, and the anterior one is still smaller than in the Great Pipefish. The middle lateral carina of the trunk (the middle lateral row of plates) as a rule forms a regular continuation of the carina curving downward in front from the upper lateral margin of the tail, and in this respect the Deep-nosed Pipefish thus represents the early stages of the two preceding forms. But it is not unusual to find between the said carinæ the same break here as in the Great Pipefish, the middle lateral carina of the trunk ending in the last ring of the trunk (see, for example, Plate XXIX, fig. 4), and the corresponding lateral carina of the tail beginning obliquely above this point, in the first caudal ring. We have never found the last-mentioned carina intrude within the last ring of the trunk. The marsupium of the males extends, when fully developed, along 24 caudal rings, and attains a length more than double that of the head.

The length of the head, as a rule greatest in young specimens, measures about 18—15 % of that of the body[d]. The contour of the postorbital part of the head passes evenly into that of the forepart of the trunk. The occipital carina is not very prominent on the flat occiput, which slopes evenly and gradually in front into the slightly concave forehead, but is sharply marked off from the steeply sloping temples, this sharp break being formed on each side by the temporal carina running back from the upper orbital margin. The superior profile of the forehead and snout is also even, and the orbital margin rises hardly perceptibly above it. The præfrontal knob is elongated in an horizontal direction. The carinæ of the snout are the same as in the Great Pipefish. The distinguishing character of the head of this species lies in the deep and strongly compressed form of the snout, when the mouth is closed, and also in the fact that at the ascending tip of the snout the lower jaw projects almost as far as the upper. When the mouth is wide open, the snout assumes the terete shape of a straight, cylindrical tube, only a little distended in front.

The length of the snout measures as a rule 60—63 % of that of the head: but in young specimens (between 6 and 7 cm. long) and exceptionally in adult ones this percentage may sink to 57 or even to 56.

[a] 2·8 is the highest percentage we have found in this relation, and this in a male 247 mm. long.

[b] Now and then these plates are so loosely joined that they are not even contiguous, being united merely by the skin.

[c] It is present, however, in one of our largest specimens, from Norway.

[d] According to A. H. Malm (*Om den brednabbade kantnålens utveckling och fortplantning*, disp. Lund 1874, p. 4) the length of the head varies in the fry (12—43 mm. long) between about $^1/_6$ and $^1/_5$ of that of the body.

Its least depth, just behind the upward curve of the tip, is as a rule about $^1/_5$, but sometimes no more than 15 % of its length. The length of the lower jaw, which is as a rule about $^1/_4$ (varying, however, in different individuals between 30 and 21 %) of that of the snout, measures in adult specimens, at least after they have attained a size of 12 cm., distinctly more (generally $^1/_3$ more) than the diameter of the eyes[a], but in young specimens (6 or 7 cm. long) is about equal to this diameter[b]. The eyes are also comparatively smaller than in the Great Pipefish. In young specimens (6 or 7 cm. long) their diameter is about $^1/_4$ or even 28 % of the length of the snout, but with increasing age this percentage sinks to about 15 or even 14. In the said young specimens the postorbital length of the head measures about 38—36 % of its entire length, or about $^2/_3$ (at least 64 %) of the length of the snout; but in older specimens this proportion sinks to about 30 or 29 % of the length of the head, or 50—46 % of that of the snout.

The gill-openings are comparatively somewhat larger than in the Great Pipefish, their length being about $^2/_3$ of the diameter of the eyes; but they are otherwise of the same form and position.

The pectoral fins are of the same obtuse shape as in the Great Pipefish, or even broader, and generally contain a greater number of rays.

The dorsal fin is longer and lower than in the Great Pipefish, in the former respect coming nearer the Lesser Pipefish. It is also set comparatively further back, this being due to the shortness of the tail. Here, however, we find a distinct sexual difference in the Deep-nosed Pipefish: in the females the trunk is comparatively longer than in the males, and the dorsal and anal fins are consequently situated further back. The two preceding species represent in this respect that direction of development which has been fixed by the preponderant influence of the male characters. In the Deep-nosed Pipefish the distance between the dorsal fin and the tip of the snout, to the best of our knowledge, is never less than $39^1/_2$ % of the length of the body, in the males hardly more than 42 %, in the females about 44 %, and in young specimens sometimes 47 %. It generally begins on the last ring of the trunk (the anal ring), sometimes on the penultimate one. The base of the fin ($12—13^1/_2$ % of the length of the body) occupies in most adult specimens 10 rings, in some 9 or partially 11, and in young specimens 8. Its height, which is only slightly greater at the middle than at either end, is generally equal to the length of the lower jaw.

In the Deep-nosed Pipefish as in the Great Pipefish, we have not been able to find more than 3 rays in the anal fin. According to KRØYER and DAY, however, it may contain 4 rays. It is set at a distance from the tip of the snout that measures in the males about $40^1/_2—42^1/_2$ %, in the females about $44^1/_2—45^1/_2$ %, and in young specimens as much as $48^1/_2$ % of the length of the body.

The caudal fin, which is distinguished by the bluntly pointed form of the hind margin, measures as a rule about $3^1/_2$ or 4 % of the length of the body, and thus corresponds most nearly in this respect to the caudal fin of the Lesser Pipefish. But in consequence of the greater length of the head in the Deep-nosed Pipefish, the length of the caudal fin is only about $^1/_5$ of that of the head, though it varies between 18 and 25 % thereof. In most cases it consists of 10 rays; in one single instance we found 8.

All the fin-rays are of the same type as in the two preceding species; but in the caudal fin they are sometimes articulated.

Of the coloration of the Deep-nosed Pipefish FRIES remarks: "In both localities, both in the Baltic and the Cattegat, two colour-varieties occur, the first green with yellow spots and with the belly shading decidedly into brassy yellow, the second olive-brown strewn with numerous whitish dots and spots and with whitish belly. These two varieties are not constant, however; we find a series of intermediate forms between them. They do not stand in any fixed relation either to age or sex." The relation of these two colour-varieties to each other has been explained in recent times by HEINCKE[c] as follows:

"The power which the *Syngnathi* possess of adapting their colour to their environments, is the most perfect instance of the kind that we know among fishes. If we place some Deep-nosed Pipefishes in a large aquarium, together with a quantity of seaweed (*Zostera marina*) such as that which grows in the

[a] In a female 255 mm. long, from Bohuslän, the longitudinal diameter of the eyes is only 55 % of the length of the lower jaw.

[b] In the fry the lower jaw is, of course, considerably shorter — cf. A. H. MALM's figures (l. c.).

[c] Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein, Band I, p. 257.

native haunts of the fishes, after some time we may make an extremely interesting observation. The leaves of the seaweed have partly risen vertically or obliquely through the water, and stand motionless, slowly swaying to and fro if the aquarium be slightly shaken. Among them, motionless or swaying with the leaves, the slender Pipefishes have chosen their positions, and we can only just see how the gill-covers expand and contract, or how the perfectly transparent dorsal fin ceaselessly continues its vibrating and undulating motion. The colour of the fishes, often down to the most delicate shades, is exactly like that of the seaweed. Often we imagine that we are gazing at a blade of seaweed, and only on closer inspection do we discover that it is a Pipefish, and *vice versa*. The same light or dark, green or yellowish green hue covers both seaweed and Pipefishes; the singular, lighter tint of green which the former sometimes shows in isolated patches, is faithfully reproduced in the latter. Among the green, still living seaweed there lie here and there a number of partly or entirely dead leaves, in all shades of colour from green to dirty-brown and brownish black. At these spots the Pipefishes assume a different hue, their colour passing gradually, according to their different surroundings, into brown or brownish black, until, whether their position be vertical or horizontal, they are scarcely to be distinguished from a dead blade of seaweed. — The time occupied by this adaptation of colour varies considerably. Mechanical irritation of the skin and psychical irritation seem distinctly to accelerate the process. Large Pipefishes, which were quite dark when taken in the hand, at once assume a pale green colour, all the time struggling violently to get loose; and if they are transferred to a vessel with darker bottom, their dark coloration returns pretty soon. Full-grown Pipefishes, if left undisturbed, seem to require at most an hour to change colour; but in young specimens, about $2^1/_2$ cm. long, which have just emerged from the marsupium, the change is effected with extreme rapidity, in a fraction of a minute. — The inner layers of the skin contain greenish yellow chromatophores, the outer layers darker ones, black when contracted, brown when expanded. The contraction of the latter, which affords a beautiful sight under the microscope, may take place with astonishing rapidity. The handsome, stellate figures of the chromatophores, which at many spots appear to be united by their projections, distinctly shrink until they form small dots, with one or two grains of pigment detached from the central mass of colour. I have not been able to observe the contraction and expansion of the greenish yellow chromatophores, which would thus seem to perform their alterations much more slowly than the dark chromatophores. The light cells never expand into figures of so varied form as the black."

Our figure (Plate XXIX, fig. 1) represents a specimen of the green variety.

The geographical range of the Deep-nosed Pipefish extends along the whole west coast of Europe, from Norwegian Finmark to Gibraltar. Tromsö Museum received it in 1881, according to COLLETT, from Belstad Fjord, a little south of Tromsö; and according to LILLJEBORG Upsala Museum has received it through Professor TH. FRIES from Vadsö. On the south coast of Scandinavia it is very common, and it penetrates into the Baltic at least to the south of the Gulf of Bothnia and almost to the head of the Gulf of Finland (MELA). In the island-belt of Stockholm, according to SUNDEVALL, it is plentiful wherever *Fucus vesiculosus* grows luxuriantly. In the island-belt of Mörkö it is taken in quantities, according to EKSTRÖM, when the seine is drawn for other fish, except during May and June, when it seldom, if ever, visits the shores or the shallows. On the coast of Gothland it is common among *Zostera marina*, according to LINDSTRÖM. It is quite as common, if not more so, in the south and west of the Baltic, on the west coast of Sweden, on the Danish coast, and on the south coast of Norway. Further north and further south it grows less common, and is said to be rare in the Mediterranean, where its place is taken to a great extent by another species, *Syngnathus Rondeletii*, with deeper snout (least depth of the snout greater than the depth of the body at the beginning of the tail), shorter dorsal fin (length of the base less than $11^1/_2$ % of that of the body), and more rings on the trunk (20 or 21), or thus related in the most essential respects to our Deep-nosed Pipefish in the same way as the Great Pipefish to the Lesser species.

Except in the spawning-season the Deep-nosed Pipefish generally keeps close to the shore, in a few metres of water or even less, among grass-wrack (*Zostera marina*) and bladder-wrack (*Fucus vesiculosus*), where it has shrimps and their young, small crustaceans, minute mollusks, and worms as its usual comrades and principal diet. Young fishes and tiny Gobies also fall a prey to it. Though the mouth is small, it is capable of quite considerable extension, as we have already remarked of the two preceding species. There is no doubt, however, that the Deep-nosed Pipefish undertakes roving expeditions at the surface of deeper water: one of the Bohuslän fishermen who have collected marine animals for the Royal Museum, has handed over to Professor S. LOVÉN a specimen taken "in the North Sea, off Bergen."

EKSTRÖM's experience in the island-belt of Mörkö was that, "though the Deep-nosed Pipefish haunts the shore, in shallow water, it still repairs to deep water during the warmer part of the year[a]. In autumn, winter, and the early part of spring it is met with in the inlets, in water of little depth. From the end of April to the beginning of November it is less plentiful in these localities, and during the whole of May and a part of June it is taken extremely seldom and invariably in deep water. In temperament it seems to be sluggish and not very timid. Its movements in the water are stiff, and betoken but little activity."

It was the history of the Deep-nosed Pipefish that gave EKSTRÖM the clue to the explanation of the hitherto obscure sexual relations of all the Lophobranchs. "It has long been known," he writes in 1831, "that the Deep-nosed Pipefish carries the roe as well as the new-hatched young under its tail. Even ARISTOTLE[b] remarked in this species the peculiarity, otherwise rare among fishes, that the eggs seem to pass, not as in most fishes through the vent, but through a slit in the body. He did not pay any attention, however, to the organ that envelops the eggs and the young during their development, but supposed that the eggs were metamorphosed within the abdominal cavity, and that the belly itself was opened by the development of the eggs, at the slit which appears behind the vent. He thus seems to have been the first to promulgate the long persistent theory that this slit did not belong to a distinct organ, but was due to the bursting of the belly by the growth of the eggs. ÆLIAN[c] maintained the same opinion. PLINY quotes the very words of ARISTOTLE, with the only alteration that the bursting of the belly was due to the number of the eggs. RONDELET[d] was the first to remark that the eggs are contained in a special organ." RONDELET further stated that the females are distinguished by the possession of this organ from the males, an opinion which survived until EKSTRÖM published his observations at Mörkö. "The spawning-season of the Deep-nosed Pipefish," says EKSTRÖM, "occurs here in the month of May, when the male is forced to seek his female, or *vice versa;* and as a regular copulation between the sexes is necessary, the spawning takes a longer time than among fishes in general[e]. At the end of April the females desert the shore and the shallows to begin their spawning in deeper water. As the spawning season approaches, the foliate lids that close the opening of the marsupium of the male, become tumid, and the marsupium is gradually filled with a white, clear, and thick mucus, which serves as a bed for the eggs. The eggs lie imbedded in this mucus, which decreases in quantity according to the growth of the young, until little or none of it remains by the time that the fry are large enough to swim and independently to move through the water. — The eggs, which lie in regular, moniliform rows, are large[f] in proportion to the fish and, when they are deposited, yellow, but gradually turn white and become transparent with a fine, dark yellow point, the rudiment of the embryo. — At the middle of June the fish gradually return to the shore from their spawning-places. At the end of July, in some cases, the young are so developed that they can leave the marsupium and follow the movements of their father. In other cases the roe has been only just deposited. In a female about 2 dm. long I counted 240 eggs in the ovaries. In the marsupium of the male I never found a quarter of this number[g]. Many of the eggs must, therefore, be lost during copulation, and we must thus

[a] KRØYER has remarked that at this season the shrimps also retire to deep water.

[b] *Hist. anim.*, lib. VI, cap. XIII. This remark applies rather to the more common Mediterranean species *Syngnathus Rondeletii.*

[c] Lib. II, cap. XIII.

[d] *De Pisc.*, lib. VIII, p. 229.

[e] More recently it has been discovered that the copulation must be repeated several times, for a female never discharges all her eggs at once into the marsupium of the male, the anterior end of which is open during copulation, and is penetrated by the oviduct, now projecting to a length of several millimetres. Cf. LAFONT, Actes de la Soc. Linn. de Bordeaux, 1871, t. 28, p. 251, HEINCKE, Arch. f. Naturg., l. c., p. 330, and LILLJEBORG, l. c., p. 438.

[f] About 2 mm. in diameter.

[g] In the marsupia of the largest males from Kiel Bay, however, HEINCKE found 150—200 eggs.

refrain from inferring the fecundity of this fish from the number of eggs in the female. To judge by the numbers among these islands, the males are so few in comparison to the females that hardly one of the former can be found among ten of the latter."

Ekström's observation that during the spawning the Deep-nosed Pipefish retires to deeper water, at least two fathoms or more in depth, has been corroborated in Bohuslän by A. H. Malm (l. c., p. 18), who supposes that the spawning is most general there from the middle of June to the beginning of August.

Besides the protective likeness which the Deep-nosed Pipefish attains by means of its changes of colour, Heincke has remarked another, which is given to the males while their marsupium is distended with eggs or young. The marsupium with its long slit at the middle then presents a striking resemblance to the spathe of *Zostera*, and still further increases the difficulty of distinguishing these fishes from the flowering grass-wrack.

The young stay in the marsupium or take refuge therein (see above) until they have attained a length of about 25 mm. As A. H. Malm and Lilljeborg have remarked, they are destitute of the embryonic vertical fin, which is present, however, in the larvae of the Great Pipefish. They grow rapidly, according to Heincke, attaining a length of at least one decimetre by the end of the first year; and the marsupium of the males may sometimes be fully developed even at an earlier period. The number of the caudal rings increases during growth from 32 to 37 or 38, but even in specimens about 6 cm. long the number of rings on the trunk is complete or at least 17.

The Deep-nosed Pipe-fish is of no greater economical value than the rest of the Lophobranchs. It may be employed, however, as food for swine or as bait for Cod and Bullheads.

Genus NEROPHIS.

Pectoral and anal fins wanting. The males carry the impregnated eggs in a layer of mucus on the ventral side of the trunk.

Fries bestowed upon this genus, which he characterized, but regarded merely as a subdivision of the genus *Syngnathus*, the Swedish name of *Hafsnålar* (Sea-Needles)[a]. Rafinesque had indeed established a genus *Nerophis*[b] in 1810, but Kaup was the first (in 1853[c]) to give this name a fixed application. Duméril[d] treated this division as a distinct subfamily, *Nerophini*, which he distributed among three genera.

As we have mentioned above, this group is distinguished from the preceding *Syngnathinae* not only by the constant absence of the anal fin and the disappearance of the pectoral fins and, in most cases, of the caudal fin, but also by the weaker covering of plates and the less distinct carinae on the body. The skin that covers the plates, on the other hand, is more strongly developed and sometimes elevated at the middle of the back and the belly in the form of a dermal carina or even (in *Protocampus*) of an embryonic, but persistent vertical fin. Another essential difference is that the upper row of plates on the trunk (the dorsal row) advances on each side of the body even along the tail, and that the middle lateral row on the trunk passes in the same manner into the lower caudal row, the lower lateral rows of the trunk and its ventral row being thus unrepresented in the plate-armour of the tail.

Fries has remarked the significant sexual distinctions that prevail in the species of this group, partly in the position of the vent (comparatively further back in the females), partly in the form of the trunk (deeper and narrower, with more distinct dorsal and ventral carinae, in the females). He has also pointed out that the most trustworthy specific characters must be sought in the position of the dorsal fin, the number of rings on the trunk, and the length of the snout in proportion to its depth and to the length of the head. Guided by these observations, he arrived at a safe stand-point for

[a] *Syngnathi ophidii* as opposed to the preceding group, which he called *Syngnathi marsupiales*.

[b] *Indice d'ittiologia Siciliana*. We have not seen this rare work. The name is formed from the Greek *νηρεύς, -έως* (or *Νηρεύς*, a minor sea-god) and *ὄφις, snake*.

[c] Arch. Naturg., Jahrg. XIX, Bd. I, p. 234; *Cat. Lophobr. Fish. Brit. Mus.*, p. 65.

[d] *Hist. Nat. Poiss.* (Suit. à Buff.), tom. II, p. 600.

the elucidation of the confusion that had previously involved the synonymy and definition of these species. He divided them into two groups:

* Caudal fin rudimentary, with 4 or 5 (6) short rays; greater part of the dorsal fin situated in front of the perpendicular from the vent.

** Caudal fin entirely wanting; greater part of the dorsal fin situated behind the perpendicular from the vent.

The former group received in 1856 of DUMERIL the Elder[a] the generic name of *Pterurus*[b]. As this name had already been employed in 1810 by RAFINESQUE among the Eels, it was exchanged in 1870 by DUMERIL the Younger[c] for *Entelurus*[d]. As a well-marked stage of development in the gradual disappearance of the caudal fin, a genus of this nature might well claim a place within the European fauna, where the character derived from the rudimentary remnant of the caudal fin coincides with the above-mentioned character drawn from the position of the dorsal fin. But KAUP has described a species, *Nerophis Heckelii*, which shows (provided that the description is correct) that the remnant of the caudal fin may be found in conjunction with the opposite position of the dorsal fin; and the developmental character loses its validity from a systematic point of view, as it is not based on any actual divergency.

The genus *Nerophis* contains 7 known species from the Atlantic, the Baltic, the Mediterranean, the Black Sea, and the Indian Ocean. They lead the same life as the species of the preceding genus, but are still more whip-like in form, and employ the tail as a more or less developed prehensile organ.

THE ÆQUOREAL PIPEFISH (SW. STORA HAFSNALEN).

NEROPHIS ÆQUOREUS.

Fig. 173 and Plate XXIX, fig. 2.

Tip of the tail generally furnished with a rudimentary and fragile fin, containing 4—6 rays. Vent situated below the posterior part of the dorsal fin, the distance between which and the tip of the snout is less than 85 % (81 %?) of that between the vent and the same point and less than 5 times the length of the head.

Fig. 173. Head of a *Nerophis æquoreus* 285 mm. long. Natural size. F. v. WRIGHT in B. FRIES.

D. (37) 40—44 (46); *C.* (4—6[e]); *Ann.* 90—95 (100) + (29—31) + *x*.

Syn. Acus nostras cauda serpentina, SIBB., *Scot. Ill.*, pt. 2, tom. 2, p. 24, tab. 19.

Sæ-Naal, No. 2, STRÖM, *Sondm. Beskr.*, pt. 1, p. 312.

Syngnathus æquoreus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 337; MONT., Mem. Wern. Nat. Hist. Soc., vol. I, p. 85, tab. IV, fig. 1; PALL., *Zoogr. Ross. As.*, tom. III, p. 121; SWAINS. (*Acus*) *Nat. Hist. Fish. Amph. cett.*, vol. II, p. 333; JEN. (*Syngnathus*) *Man. Brit. Vert.*, p. 486 (♀); FR., Vet. Akad. Handl. 1837, p. 35, tab. III, fig. 3; KR., *Danm. Fiske*, vol. 3, p. 705; KP (*Nerophis*), *Cat. Loph. Fish. Brit. Mus.*, p. 66; NILSS. (*Scyphius*, ex RISSO), *Skand. Fn.*, *Fisk.*, p. 692; GTHR (*Nerophis*), *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 191; DÜM. (*Entelurus*) *Hist. Nat. Poiss.*, tom. II, p. 605; (♀); COLL. (*Nerophis*), Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 202; N. Mag. Naturv. Chrnia, Bd. 29, p. 114; MALM, *Gbgs. Boh. Fn.*, p. 596; WINTH., Nat. Tidskr. Kbhvn, ser. 3, vol. XII, p. 53; MOR. (*Entelurus*), *Hist. Nat. Poiss.*, *Fr.*, tom. II, p. 62; DAY (*Nerophis*), *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 261, tab. CXLIV, fig. 4; STORM, N. Vid. Selsk. Skr. Trondhj. 1883, p. 42; LILLJ., *Sv.*, *Norg. Fisk.*, vol. III, p. 465.

Syngnathus anguineus, JEN., *Cat. Brit. Vert.*, p. 30 (♂); YARR., *Brit. Fish.*, ed. 2, vol. II, p. 445; KP (*Nerophis*), l. c., p. 65; DÜM. (*Entelurus*), l. c., p. 606; MOR., l. c., p. 63.

Syngnathus ophidion, BL. (p. p., nec LIN.), *Fisch. Deutschl.*, pt. III, p. 115, tab. XCI, fig. 3; JEN., *Man. Brit. Vert.*, p. 487; YARR., *Brit. Fish.*, ed. 1, vol. II, p. 338.

[a] *Ichthyologie Analytique*, p. 169.

[b] πτερόν, *fin* and οὐρά, *tail*.

[c] *Hist. Nat. Poiss.*, tom. II, p. 605.

[d] ἐντελής, *perfect*.

[e] Sometimes 7, according to KRØYER.

The Æquoreal Pipefish is the largest of all our *Syngnathinæ*. It attains a length of at least 6 dm.[a] The females are largest, their usual size in Scandinavia, according to FRIES, being 45—55 cm., while the length of the males is usually between 32 and 40 cm. The form of the trunk also shows a considerable sexual difference. It generally displays more lateral compression than in the preceding forms, but most in the females, this being due to the more or less advanced development of the dermal carina that runs along the dorsal and ventral margins of the trunk, but which is wanting in the males and young specimens. The tail is more slender and more terete (its section more circular) than in the preceding forms. A section of the trunk shows an oval, octagonal form, in the females pointed at both ends; the section of the tail is a rounded square. The greatest breadth of the trunk measures in the females about 70 %, in the males about 90 % of its greatest depth; the young specimens stand about midway between these two extremes. The greatest depth of the body in the males is about $2\frac{1}{2}$ %, in the females about $2\frac{3}{4}$ % of the length thereof. At the beginning of the tail the depth of the body measures in the females about 60 %, in the males about 70 % of the greatest depth, or in the former about 11 %, in the latter about 12 or 13 % of the length of the base of the dorsal fin.

In addition to the above-mentioned generic character that the caudal rows of plates form a continuation of the two uppermost rows of the trunk on each side of the body, this species and the following one are especially remarkable for the great number of rings on the body, a number which, at least in this species, may rise to 100. The last caudal rings are so small, however, that they can scarcely be counted with the naked eye. The so-called occipital plates are without carinæ, but are as usual grooved; the anterior is about half the size of the posterior.

The head is most like that of the Lesser Pipefish, but is comparatively smaller, with smaller eyes and with less prominent carinæ both on the snout and especially on the gill-cover, where scarcely a trace of a middle carina can be found. The snout is terete and straight, ascending only slightly. The forehead is hollowed into a long, shallow concavity. The length of the head varies in adult specimens between about $7\frac{1}{2}$ and 9 % (7.6—8.8 %, according to our measurements) of that of the body. In young specimens (between 12 and 17 cm. long) the length of the head measures about 27 % of the distance between the dorsal fin and the tip of the snout, in old specimens 22—$24\frac{1}{2}$ % thereof. The length of the snout varies between about 44 and 54 % of that of the head, and generally begins to exceed $\frac{1}{2}$ of the latter in specimens 37 cm. long. The postorbital length of the head varies between about 43 and 38 % of its entire length, and this percentage generally begins to sink below 40 in specimens 37 cm. long. The longitudinal diameter of the eyes may measure about 14 % of the length of the head even in specimens 35 cm. long; in specimens 44 cm. long it measures about $\frac{1}{10}$ of the same. The least depth of the snout varies in different individuals and according to age between about 29 and 18 % of its own length.

The dorsal fin is of fairly uniform height, this being always distinctly greater than the depth of the body at the vent. It begins at a distance from the tip of the snout that in the males does not exceed 35 % ($31\frac{1}{2}$—$34\frac{1}{2}$ %, according to our measurements) of the length of the body, but in the females (at least the older ones) does not fall below 37 % thereof[b]. The length of its base increases with age from about 12 % to $14\frac{1}{3}$ % of that of the body. The vent lies below the posterior part of the fin, at a distance from the tip of the snout that in the males measures about $39\frac{1}{2}$—$43\frac{1}{2}$ % (39·6—43·6 %, according to our measurements of specimens between 12 and 37 cm. long), in the older females 47—49 % of the length of the body. One result of this is that the length of the trunk behind the gill-covers, in young specimens less than 17 cm. long (we have never examined any young females), measures only slightly more than $\frac{1}{2}$ (about 54 %), in the older males about $\frac{3}{5}$ (59—64 %), and in the older females about $\frac{3}{4}$ (74—78 %) of the length of the tail. In these differences, depending on age and sex, lies the most important character that has been employed as a specific distinction between *Nerophis æquoreus* (♀) and *Ner. anguineus* (♂).

[a] From Ireland we hear of still larger specimens. "Last winter," writes BLAKE-KNOX in August, 1866 (Zoologist, vol. XXIV, p. 508), "I met with an immense fish of this kind: seeing a boy "whacking" a donkey with a gutta-percha stick, as I thought, I asked him where he got it. "It is only a stalk of a snot (seaweed), sir; see:" and I did see a fine æquoreal, 3 feet 5 inches long. Of its toughness you may judge. Is not uncommonly taken in the baskets with whelks and crabs."

[b] KRØYER, however, mentions a female (sign. *B* among the specimens mentioned by him) in which this sexual character is absent.

The caudal fin is extremely small, pointed, and so fragile that it now and then disappears with age.

In the living fish, according to FRIES, the coloration is of a handsome flame-yellow or brownish yellow. Straight across the sides of the trunk and some way along the tail the body is marked with somewhat undulating, parallel, whitish bands, framed with brown. These bands are arranged in such a manner that they lie alternately at the middle of a ring of plates, alternately on the diamond-shaped space between two rings, the number of the bands thus being double that of the plates. The dorsal carina of the females is edged with blackish brown (LILLJ.). The ventral side is as usual lighter, in the males even whitish. A reddish streak runs from the tip of the snout to each eye and so on across the temples to the gill-opening.

The Æquoreal Pipefish was known as a Scandinavian species to STROM (*Söndm. Beskr.*, 1762), but was first introduced into the Swedish fauna by FRIES. It had been described from Scotland by SIBBALD in 1684; and the centre of its geographical range seems to lie on the coast of Great Britain. It is common among the Orkneys and Shetlands as well as on the west coast of France. It also occurs in the Mediterranean and the Black Sea (PALLAS[a]); but it does not penetrate into the Baltic, though from the Cattegat it enters the Sound, where NILSSON met with it on several occasions off Landskrona. According to WINTHER it also enters Liim Fjord. To the north, according to COLLETT, it is a stationary fish "almost up to Tromsö."

FRIES, who has left in the Royal Museum numerous specimens of the Æquoreal Pipefish from Bohuslän, found it to occur sparingly, though not rarely, in that locality, among the seaweeds that fringe the seaward side of the island-belt. KROYER says that it is met with fairly often in the Cattegat, though in comparatively deep water. MALM, who obtained his large specimens in 6—14 fathoms of water, and found only small ones at a depth of 2—4 fathoms, makes the same statement of Bohuslän. At Tylö, off Halmstad, we have found young specimens 14 cm. long, also in about 2—4 fathoms of water.

"This species," says COUCH[b], "is more especially an inhabitant of the open ocean, where in summer our fishermen report that they see it near the surface over a depth of more than fifty fathoms, at a distance from land of ten or fifteen leagues." "Sometimes," he says in another passage[c], "it abounds in incalculable numbers from near the shore to several miles in the open sea; and it is then they appear to perform a perhaps limited migration or change of quarters; for they swarm at the surface in fine weather from the early part of summer to its declension; but after this time they are not seen, and probably have gone to the bottom, and into deeper water. When on our coast their actions are amusing, as with their slender and prehensile tail they lay hold of some loose and floating object; with the aid of which, and the anterior portion of the body free, they steer their wandering course by the waving action of the dorsal fin." Their progress thus costs them but little trouble; but they also run great risk of being devoured by fishes-of-prey. The stomach of a Pollack has been found, according to COUCH, to be crammed with Æquoreal Pipefish.

The Æquoreal Pipefish spawns in summer. The male and female attach themselves beside each other to some sprig of seaweed or stalk of grass-wrack[d], and the eggs are imbedded in the layer of mucus developed on the ventral side of the male, from the vent to the isthmus. This layer hardens into a solid disk, which, at least at the beginning of the period of gestation, may be peeled from the belly, though it then leaves in the skin traces of the honeycombed depressions which have been occupied by the eggs. The eggs are considerably smaller than those of the Deep-nosed Pipefish, but also far more numerous. In a female 44 cm. long the ovaries were 84 mm. in length and the eggs about $^1/_2$ mm. in diameter. On the ventral side of a male, where at the middle of the length of the belly the eggs were set in 12 or 13 somewhat irregular, longitudinal rows, the largest eggs were not much more than $^1/_2$ mm. in diameter. The narrow embryos lie coiled in several rings within the egg; when 11 mm. long they have burst the membrane, but lie with the head fixed in the cavity where they were developed. The head is far less developed than in the larvæ described by FRIES of *Nerophis lumbriciformis* (Plate XXIX, fig. 4, *a*); but the form of the body is

[a] RATHKE did not find it, however, among the fishes of the Black Sea.
[b] *Fish. Brit. Isl.*, vol. IV, p. 356.
[c] ibid., p. 359.
[d] ANDREWS, Zoologist, vol. XVIII (1860), p. 7053.

still more elongated, the pectoral fins are comparatively larger, the still rudimentary dorsal fin is hardly so advanced in development, and the embryonic vertical fin of the tail, though it is distinct in some of these embryos preserved in spirits, in others is indistinct, because it is either shrivelled up, or as yet undeveloped. I have not succeeded in discovering the least trace of the future caudal fin.

The food of the Æquoreal Pipefish is probably the same as that of the other *Syngnathinæ*. Still, to the best of our knowledge, we have no other direct information on this point than that ANDREWS (l. c.) has seen these fishes stripping the stems of *Zostera marina* of the young of *Anthea cereus*, which were attached in a semiglutinous state.

THE STRAIGHT-NOSED PIPEFISH (SW. TÅNGSNIPAN).

NEROPHIS OPHIDION.

Fig. 174 and Plate XXIX, fig. 3.

Caudal fin wanting. Vent situated below the anterior part of the dorsal fin, the distance between which and the tip of the snout is more than 90 % (92 %?) of that between the vent and the same point and more than 7 ($7^1/_2$?) times the length of the head.

Fig. 174. Head and forepart of a *Nerophis ophidion* (♀) from Mörkö (C. U. EKSTRÖM), twice the natural size.

D. 34—40; *Ann.* 90—100 = (29—33) + *c.*

Syn. *Syngnathus* teres, pinnis pectoralibus caudæque carens, ART., *Descr. Spec. Pisc.*, p. 1 (excl. syn.); LIN., *Fn. Suec.*, ed. I, p. 126.

Syngnathus Ophidion, LIN., *Syst. Nat.*, ed. X, tom. I, p. 337; RETZ. A. J., *Fn. Suec. Lin.*, p. 312; EKSTR., Vet. Akad. Handl. 1831, p. 280, tab. II, figg. 3 et 4; NILSS., *Prodr. Ichth. Scand.*, p. 67; RETZ. A., Vet. Akad. Handl. 1833, p. 157, tab. V; FR., ibid. 1837, p. 36, tab. III, fig. 4; YARR., *Brit. Fish.*, ed. 1, Suppl., part. II, p. 47; KR. (*Nerophis*), *Danm. Fisk.*, vol. III, p. 716; NILSS. (*Scyphius*), *Skand. Fn., Fisk.*, p. 694; SUNDEV. (*Syngnathus*), Stockh. L. Hush. Sällsk. Handl., H. 6 (1855), p. 164; MGRN, (*Nerophis*), *Fnl. Fiskfn.* (disp. Helsingf.), p. 70; LINDSTR., (*Scyphius*), Gotl. L. Hush. Sällsk. Årsber. 1866, p. 24 (sep.); GTHR (*Nerophis*), *Cat. Brit. Mus., Fish.*, vol. VIII, p. 192; DUM., *Hist. Nat. Poiss.*, tom. II, p. 602; CANESTR., *Fn. D'Ital., Pesci*, p. 145; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 202; ibid. 1879, No. 1, p. 101; N. Mag. Naturv. Chrnia, Bd. 29, p. 114; MALM (*Scyphius*), *Gbgs., Boh. Fn.*, p. 597; WINTH. (*Nerophis*) Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 54; BNCKE (*Syngnathus*), *Fisch., Fischer., Fischz. W., O. Preuss.*, p. 190; HCKE (*Nerophis*), *Arch. Naturg.*, Jahrg. 46 (1880), I, p. 335; MOR., *Hist. Nat. Poiss. Fr.*, tom. II, p. 68; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 262, tab. CXLIV, fig. 5; STORM, N. Vid. Selsk. Skr., Trondhj. 1883, p. 42; MÖB., HCKE, *Fisch. Osts.*, p. 104; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 470.

Syngnathus lumbriciformis, JEN., *Man. Brit. Vert. Anim.*, p. 488.

The Straight-nosed Pipefish never attains so great a size as the preceding species; even 3 dm. is quite a considerable length for it, and though the females may exceed this measurement by some millimetres, it is improbable, on the other hand, that the males ever attain it. The largest male we have had the opportunity of examining (from Norway, through MARKLIN), is $2^1/_2$ dm. long[a].

The form of the body is still more elongated than in the preceding species, and its greatest depth, even in the females (excluding their vertical dermal carinæ), does not exceed 2 %[b] of its length, while in the males this percentage is between $1^1/_2$ and $1^3/_4$. At the beginning of the tail (the anal ring), here as in the preceding species, we find a sharp break, at which the depth of the body in the young specimens and the females measures only about 1·1 % of its length, in the older males 1·2 % thereof, and from which the tail gradually tapers backwards almost to a filament. Both in the females and the males the tail is terete (of circular section); and in the latter the breadth of the trunk may be even greater than its depth, though as a rule the case is the reverse; but in the older females

[a] The largest male from Mörkö presented to the Royal Museum by EKSTRÖM is 197 mm. long.

[b] The highest percentage we have found is 1·9.

the trunk is distinctly compressed, and its depth increased by two longitudinal dermal folds, one at the middle of the back and one at the middle of the belly, both of inconstant height and occurrence, the former always small, but the latter sometimes almost as deep as the body. The depth of the body at the middle of the trunk, including these dermal folds, may rise in the females to at least 2·8 % of its length.

In adult specimens the middle carina of the plates on the body is extremely indistinct, and the grooves that otherwise radiate (vertically) from this carina, are for the most part effaced and exchanged for small, round or square hollows, which at the middle of the central plates of the body, are arranged in vertical rows, a distinct trace being thus left of the original grooves. The hind part of the head, the forehead, and the opercula, which are without carinae, are also punctated more or less irregularly with similar cavities.

The length of the head in proportion to the length of the body is less here than in any of the other Scandinavian *Syngnathinae*. In specimens about 2 dm. long the length of the head may still measure rather more than 6 % (according to KRØYER even $6\frac{1}{2}$ %) of that of the body; but in older specimens this percentage sinks to $5\frac{1}{2}$ or even a little less. While this change is taking place, the length of the snout increases from about 41 % to $46\frac{1}{2}$ % of that of the head, and the longitudinal diameter of the eye decreases from about $\frac{1}{2}$ to about $\frac{3}{10}$ of the length of the snout. The form of the snout is also remarkable for its fairly prominent dorsal margin and broad ossa symplectica, the muzzle, when seen from the side, thus showing scarcely any break from the rest of the head, and also tapering evenly forwards and being only slightly turned up at the tip. The least depth of the snout, just behind the articulation of the lower jaw, measures about $\frac{1}{3}$ of its length, varying, however, between 30 and 38 % thereof. The tip of the lower jaw falls short of the upper margin of the tip of the snout, and in this species as in the preceding and the following ones the length of the lower jaw is about equal to the longitudinal diameter of the eyes.

The dorsal fin is of fairly uniform height, or a little higher at the middle, and its height in proportion to the length of the body is about the same as in the preceding species (about 2 %); but its base is shorter (about 10—$11\frac{2}{3}$ % of the length of the body[a]), and its position entirely different. In the males the distance between its beginning and the tip of the snout is about 45[b]—48 % of the length of the body, in the females 52—$53\frac{1}{2}$ % thereof. The vent is also situated far back, though it lies further forward in relation to the dorsal fin, generally below the beginning of the second third thereof. In the males the distance between the vent and the tip of the snout is about 48[c]—52 %, in the females 55[d]—58 % of the length of the body. These proportions bring about a more striking difference between the sexes, namely that in the males of this species the length of the trunk behind the gill-covers is less, in the females greater than the length of the tail.

The coloration of the living fish, according to FRIES, is olive-green above, with a dash of yellow below. The sides are marked with rows of numerous, often round, small, bluish white spots, and the gill-covers are crossed by fine streaks of a handsome azure blue, which are interrupted by the branchiostegal membrane, but continued a little way along the sides of the body. The iris is brownish red according to MALM, silvery white according to EKSTRÖM, with fine, gray and coarser, red spots. In coloration the sexes are hardly distinguishable; but according to EKSTRÖM the colours of the male are darker and dirtier.

In Sweden the Straight-nosed Pipefish is quite as common as the Deep-nosed species, in some localities even commoner; and both species generally occur together. In the Baltic this species was known even to ARTEDI from the coast of Ångermanland, and according to MELA it penetrates to the head of the Gulf of Finland. On the Norwegian coast it is unknown north of Trondhjem Fjord, but in the south of Norway it is as common as in Sweden. In Kiel Bay, according to HEINCKE, it is less common than the Deep-nosed Pipefish. On the English coast and the north-west coast of France it seems to be less common than in Scandinavia; but in the Bay of Biscay, according to MOREAU,

[a] In the smallest of KRØYER's specimens, however, this percentage was 12·3.

[b] According to MOREAU, however, 41.

[c] This percentage may also occur, however, in females of the preceding species, and according to MOREAU it may be 45 in this species.

[d] According to KRØYER 54

it is fairly common. It occurs in the Mediterranean off Nice, according to MOREAU, and on the coast of Algiers, according to GUICHENOT and DUMERIL. According to CANESTRINI it lives round all the coasts of Italy and is common in the Adriatic — assuming that these Mediterranean fishes are really identical in species with our Straight-nosed Pipe-fish[a]. Like the rest of our Pipefishes this species is unknown in the western region of the Atlantic.

The most important contributions to our knowledge of the habits and life of this species have been made by EKSTRÖM and FRIES. As it glides through the grass-wrack or algæ with its serpentine or Eel-like movements, it shows greater litheness and also greater timidity than the Deep-nosed Pipetish, but possesses the same protective likeness to a stalk of seaweed. From its long, terete, tapering, highly flexible, and finless tail, writes FRIES, it derives little, if any, assistance in its progress through the water. This organ is generally kept still, as the fish quietly swims along, and is to be regarded rather as a rudder than an oar. When the Deep-nosed Pipefish is stationary or at rest, it sinks, stretched at full length, to the bottom, and lies on the belly with tail extended. The Straight-nosed Pipefish, on the other hand, coils its flexible tail with great skill round the objects near at hand, and by the help of this organ preserves an upright position in the water. It may be seen continually attaching itself in this way, if it can find anything round which to twine; and when it fails in this, but has several companions in the same vessel, one may often see them twist their tails together and form groups, not unlike tufts of grass-wrack, which remind us in a manner of the old figures we see of so-called "Ratzen-Könige."

The most striking resemblance of the Straight-nosed Pipefish, however, is its similarity to *Chorda filum*, to which it is often found attached, in those localities where this seaweed floats about at the surface. Like the rest of the Pipefishes this species lives on minute marine animals of various kinds, worms, crustaceans, and mollusks, of a size suitable for its tiny mouth.

"Towards the end of April," writes EKSTRÖM from the island belt of Mörkö, "the females desert the shore and the shallows to join the males in deep water and to perform the operation of spawning. The eggs, which are fairly large in comparison with the fish, about 1 mm. in diameter, are attached to the surface of the belly from the head to the vent in 2, 3, or 4 rows, not exactly opposite each other, but so to speak, decussating. They are somewhat depressed in the skin, united by or rather packed in tough mucus, and coated with a membrane so extremely fine that it can scarcely be detected and cannot bear the least touch without breaking. When this membrane is removed, and the eggs are loosened from the belly, they hang together like the beads of a necklace. As soon as the fish is dead, the roe falls from the body, accompanied, however, by the said layer of mucus in which the roe-strings have been imbedded. The eggs seem as though they might easily be detached from the almost smooth skin of the belly; but they have a triple fastening, first to the skin, by means of the glutinous mucus, then to each other, by the union of the poles, and finally, also to each other, by means of the said membrane. The laying of the eggs begins at the end of May, but is not simultaneous in all the specimens, being considerably protracted: I have seen males with eggs even on the 11th of August. When the eggs are deposited, they are golden yellow in colour; but they gradually fade. At the middle of July most of them are white, with a yellow spot on the part of the surface most remote from the body of the male. In some cases the yellow spot is already furnished with two extremely fine, black dots, the first signs of the embryo with its eyes. We can thus state with certainty that the spawning-season, which begins during the first days of May, lasts throughout this month and also during June and July. — Neither before May nor after September have I seen a male with roe."

The new-hatched embryos are about 9 mm. long, according to LILLJEBORG, with the snout turned up like a pug's, the eyes and the postorbital part of the head about equally long, the entire length of the head about $^1/_6$ of that of the body, the vent situated distinctly in front of the middle of the body (at a distance from the tip of the snout equal to about 44 % of the length of the body), and the sides of the trunk furnished with a number of prominent protuberances. The embryonic vertical fin runs along the dorsal edge, back from the middle of the trunk, round the tip of the tail, and along the ventral edge forward to the remainder of the vitelline mass, but with a sharp break at the vent. The larval pectoral fins are comparatively large. All these fins are

[a] Cf. notes *b* and *c* on the preceding page.

as usual entirely destitute of fin-rays. According to Möbius and Heincke young specimens less than 1 dm. long have longitudinal carinae on the body like those of the Deep-nosed Pipefish, and these carinae are fringed with spines growing in a backward direction on the plates of the body, so that the body, when seen from the side, presents a serrated appearance. The pectoral fins do not begin to be reduced until the fish is 9 cm. long; and according to Collett these fins may still be persistent, with a length of 1 mm., in specimens 112 mm. long. The Straight-nosed Pipefish thus undergoes a remarkably complete series of developmental changes, a retrogressive metamorphosis, with the earlier stages possessing the structure and external form of more fully equipped *Syngnathinae*. The history of its development is the most distinct and complete illustration we possess of the development (phylogeny) of the whole family.

The Straight-nosed Pipefish is of no greater importance in an economical respect than the rest of our *Syngnathinae*. Whether it can do any harm by devouring the deposited eggs of other fishes, or by reducing the supply of food for the fry of more valuable species, is a point on which we have no information. That it may be used, at least in its younger days, as human food, is shown, however, by its appearance amongst whitebait[a], for, like the Sticklebacks, it now and then forms a part of this favourite English dish, which consists chiefly of Herring-fry. Its common occurrence renders it well-known to the fisherman, and on the east coast of Sweden it is this species in particular that bears the name of *hafsnål* (Needle-fish), which Fries adopted for the whole genus *Nerophis*. In Halland it is called *tangsnipa*[b], a reminiscence of the Danish *snippe*, which Krøyer has transferred to the following species.

THE WORM PIPEFISH.

NEROPHIS LUMBRICIFORMIS.

Fig. 175 and Plate XXIX, fig. 4.

Caudal fin wanting. Vent situated below the anterior part of the dorsal fin, the distance between which and the tip of the snout is at least 90 % (90—92 %) of that between the vent and the same point, but less than 5 times the length of the head.

Fig. 175. Head and forepart of a *Nerophis lumbriciformis*, ♀, from the Weather Islands (Bohuslän). Twice the natural size.

D. 25—26; *Ann.* 69—73 (17—19) + *x*.

Syn. *Acus lumbriciformis aut Serpentinus*, 1. *Ophidion lumbriciforme*, Willughby, *Hist. Pisc.*, p. 160; Ray, *Synops. Method. Pisc.*, p. 47. *The little Pipe-fish*, Penn., *Brit. Zool.* (ed. 1776), p. 124, tab. XXIII, No. 62.

Syngnathus Ophidion, Flmng, *Brit. Anim.*, p. 176 (nec Lin.).

Syngnathus lumbriciformis, Yarr., *Brit. Fish.*, ed. 1, vol. II, p. 340; Fr., Vet. Akad. Handl. 1837, pp. 38 et 59, tab. III, figg. 5 et 6, tab. IV; Kr. (*Nerophis*), *Danm. Fisk.*, vol. III, p. 723; Nilss. (*Scyphius*) *Skand. Fn., Fisk.*, p. 695; Günth. (*Nerophis*), *Cat. Brit. Mus., Fish.*, vol. VIII, p. 193; Dum. *Hist. Nat. Poiss.*, tom. II, p. 604; Coll., Forh. Vid. Selsk. Christia. 1874, Tillægsh., p. 203; Malm (*Scyphius*) *Gbgs. Boh. Fn.*, p. 598; Winth. (*Nerophis*), Naturh. Tidskr. Kbhvn. ser. 3, vol. XII, p. 54; Heke, Arch. Naturg., Jahrg. 46, 1, p. 339. Mob., *Hist. Nat. Poiss. Fr.*, tom. II, p. 65; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 263, tab. CXLIV, fig. 6; Lill., *Sv., Norg. Fisk.*, vol. III, p. 477.

Obs. That it was not this species that Jenyns referred to (*Man. Brit. Vert. Anim.*, p. 488), appears partly from his statement that it may attain a length of 9 inches (228 mm.), partly from his description, which, as Fries has already remarked, can apply only to the preceding species.

The Worm Pipefish is one of our smallest *Syngnathinae*: its length is seldom more than 15 cm., and the maximum size which the species is known to attain, is 165 mm.[c] The largest specimens in the Royal Museum are 141 mm. (♂) and 122 mm. (♀) long.

The body is of the same serpent-like form as in the preceding species, but less elongated and still more terete. The greatest depth is situated in full-grown males at the beginning of the trunk, in the females at the middle of the trunk. In the former it measures

[a] Cf. Buckland, *Nat. Hist. Brit. Fish.*, p. 170.

[b] *Tang*, tang and *snipa*, anything long and pointed, e. g. a boat. Tr.

[c] Collett (in Lilljeborg, l. c.). The specimen was a female.

about $2—2\frac{1}{2}$ % of the length of the body, in the latter at least as much as $3\frac{1}{4}$ % thereof. The terete tail tapers regularly to its end. Here, as in the Æquoreal Pipefish, the difference between the sexes is most distinctly expressed externally by the form of the trunk. In the males this part is somewhat flattened, especially at the middle of its length, and the breadth of the flat ventral side, to which the eggs are attached, is greater than the depth of the body at the same point. In the females the trunk is laterally compressed, and also furnished, when the fish is in full dress, with a longitudinal carina at the middle both of the back and the belly, the latter carina being here too the more prominent. Thus the structure of the males in this respect comes very near the form of the body in the Australian genus *Stigmatophora*, which is furnished, however, with pectoral fins, and in which the males carry the eggs under their tails.

In specimens from 10 to 12 cm. long the length of the head varies between 8 (7·8) and $7\frac{1}{2}$ %, in older specimens between $7\frac{1}{2}$ and 7 % of the length of the body, or between about $25\frac{1}{2}$ and $23\frac{1}{3}$ % of the distance from the dorsal fin to the tip of the snout. The most characteristic point in the head of this species is the form of the snout, a reminiscence of the larval stage of all the other *Syngnathinæ*. The snout is comparatively short, measuring in young specimens — between 10 and 12 cm. long — only about $\frac{1}{4}$, in older specimens about $\frac{1}{3}$ (30—$32\frac{1}{2}$ %) of the length of the head, and also turned up like a pug's nose, with a more or less selliform depression in the superior profile. The tip of the lower jaw projects upwards to a level with the tip of the snout, which is hollowed to receive it. The longitudinal diameter of the eyes is about half the length of the snout. The postorbital length of the head measures about half its entire length.

The dorsal fin is of uniform height. The length of its base is about 9 or 10 % (8·8—10·5 %) of the length of the body. The distance between it and the tip of the snout is about 30 % (29·6—30·5 %) of the length of the body. The vent lies below its anterior part, at a distance from the tip of the snout that measures about $\frac{1}{3}$ (32·5—33·3 %) of the length of the body. The length of the tail is thus always more than twice that of the trunk behind the opercula.

The coloration is far from ugly. "Its usual ground-colour," writes FRIES, "is chestnut-brown, in some cases lighter, in others darker. Along the back lie large, irregular spots of whitish gray, which are broken up on the tail into numerous, smaller spots and give this part of the body a mottled appearance." The head is also mottled above and below with whitish gray spots, framed with darker colour, and two or three of these spots are especially constant and prominent, obliquely in front of, below, and obliquely behind the eyes, rising from the isthmus. On the tail the spots are arranged more or less distinctly in transverse rows; and in a female from the Weather Islands (Bohuslän), which has lain in spirits for some years, but preserved its coloration remarkably well, this arrangement is distinct on the forepart of the body also. The dermal carina on the belly of this specimen seems to have been edged with darker colour. The iris is yellow, with a ring of round spots.

This coloration is probably connected with the habits of the fish. The Worm Pipefish seems to prefer deep water, where the brown tint prevails among the algæ. It has even been found crawling on a clayey bottom, where it has been taken in the dredge in company with those marine Annelids, crustaceans, and mollusks whose young and larvæ probably form the chief part of its food. On the Irish coast too, according to THOMPSON[a], this species has been taken in the dredge in deep water, though it also lives between the tide-marks, where it hides under stones.

The spawning-season seems to be somewhat later than in the preceding species. The eggs are set in four, more regular rows and less firmly attached (less deeply imbedded in mucus). COLLETT estimated their number in different males at 63 and 78; in a male 135 mm. long we have counted 88 eggs, about $1\frac{1}{3}$ mm. in diameter.

It was in this species that FRIES made the first observations of the retrogressive metamorphosis of the genus *Nerophis*, observations which have since been extended, as we have seen, to all the Scandinavian species of the genus. One of the last days in September, 1837, FRIES had obtained a male specimen to which the eggs still adhered. He placed the specimen in a vessel of water, and endeavoured to keep it alive for some time, in order to observe the hatching of the eggs and the relations between the young and their father. As the latter had no marsupium in which the young might hide at the approach of danger, FRIES expected to see

[a] *Nat. Hist. Irel.*, vol. IV, p. 242.

them attach themselves in some way with the tail to the parent fish; but in this expectation he was disappointed. After the lapse of six days the fish showed signs of weakness, and some of the eggs began to acquire a sickly appearance. Life endured, however, for some days more, and on the morning of the ninth day of the captivity FRIES observed three young specimens at the surface. Later in the day the fourth appeared, and on the following morning two more; but no more eggs were hatched. The whole mass of eggs now presented a half-decomposed appearance, became detached, together with the adhesive layer of cells, from the body, and broke up piecemeal. The fish died on the same day towards evening. The larvæ lived seven days, and during this time their size increased from 9 to 15 $^1/_2$ mm.

The first point that surprised FRIES, was the behaviour of the young amongst themselves and towards the parent fish. They swam in an upright position, careless of each other, and paying still less attention to their father, who lay at the bottom and was equally oblivious of them. In order to elucidate this discrepancy from EKSTRÖM'S account of the young of this genus, FRIES began to examine the fry more minutely, and found their structure to present the appearance shown in our figure (Plate XXIX, fig. 1, *a*). The whole body is white and transparent, the spinal column and the intestine within the abdominal cavity shining through. The head measures about $^1/_8$ of the length of the body. The length of the snout, which curves upwards, is greater in proportion to that of the head than in older specimens. It is also worthy of remark that, whereas in all adult *Syngnathinæ* the margin of the opercula is united by a membrane and by the general dermal covering to the shoulder girdle, leaving on each side of the occiput only a small foramen for the passage of the respiratory water, in the young on the other hand this margin is entirely free, the gill-openings thus being large, as in the generality of fishes. The lower figure shows this point with tolerable distinctness. The vent, though it occupies its right place in relation to the dorsal fin, lies nearer the tip of the tail than in older specimens, only a little in front of the middle of the body. The plates of the body seem as yet undeveloped; but when the young specimen is examined from above, we see along each side of the body a projecting row of fine teeth, which must be the tips of the transverse vertebral processes that in older specimens support the dermal rings of plates. FRIES counted, as far as he could judge, 18 of these points in front of, and at least 50 behind the vent. The pectoral fins are small, but distinct, with widened, somewhat rounded tip. Their motion is extraordinarily brisk, but the rays are extremely rudimentary. The true dorsal fin is distinct, but the traces of the incipient rays are only faint. Along the dorsal margin behind this fin, round the tip of the tail, and along the ventral margin forward to the vent, runs the embryonic vertical fin, the chief organ of locomotion in the fry. Such is FRIES'S description of his find; and the equipment of the larvæ with comparatively well-developed organs of motion explains, it is true, their capability of independent life. But here this explanation stops, for the larvæ of the preceding genus may be equally well equipped in this respect, though they still take refuge in the marsupium of the male.

The geographical range of the Worm Pipefish, as far as we know at present, does not extend so far north as that of the preceding species. STORM never found it in Trondhjem Fjord; but on the coast of the Government of Bergen it has been met with at several spots, according to COLLETT. In Christiania Fjord it is not rare. Off the Weather Islands and outside Gullmar Fjord it has been taken on several occasions. KRØYER and PETER MÜLLER have found it on the north coast of Zealand (Hornbæk and Hellebæk), but further south in the Sound and in the Baltic it is unknown. All round Great Britain and Ireland it is common enough, according to DAY. This is also the case on the northwest coast of France, according to MOREAU, at least at certain spots; and according to the same author it occurs, though rarely, even in the Bay of Biscay. No instance is known of its occurrence in the Mediterranean.

TELEOSTEI PHYSOSTOMI.

Osseous fishes with the air-bladder (if present) furnished with pneumatic duct. Ventral fins (if present) abdominal. No spinous rays proper (unarticulated) in the fins[a].

Each of these three characters calls to mind an era in the history of ichthyology. The last was ARTEDI'S[b] character of the order *Malacopterygii* (pinnis inermibus); it was by the second that LINNÆUS[c] defined the order *Abdominales* (pinnæ ventrales pone pinnas pectorales); and the first-mentioned character was MÜLLER'S[d] expedient for the better definition of *Malacoptérygiens abdominaux*, the order which CUVIER[e] had adopted in his system, and for the combination therewith of CUVIER'S *Malacoptérygiens apodes*.

The order or rather suborder which has thus arisen, is hardly more natural than that of the Physoclysts, just as the whole Teleosteous order is merely an expression of the community of those characters which the fishes belonging to the several directions of development of this type have retained or acquired during their development from a common prototype, the Ganoids. The independence of the directions of development asserts itself everywhere, and the characters of the system must therefore be employed with discrimination.

The Physostomes in general stand nearer the Ganoids, which were probably also furnished with a pneumatic duct from the air-bladder. This connexion with the Ganoids appears in the abdominal position of the ventral fins, which have besides retained not unfrequently a greater number of rays, just as the pectoral fins may display more numerous transverse rows of basal bones, though the outer (distal) rows are not ossified[f]. Another sign of this connexion is given by the exceptions which occur in certain Physostomes, to the character that otherwise distinguishes the Teleosts with regard to the structure of the arterial bulb of the heart, a structure which in this suborder may be almost Ganoid. These resemblances to the Ganoids range the Physostomes lower in the system, assuming that the system should be an expression of the development. But for all this we must not regard the structure of the Physostomes as more primitive; many of them on the contrary possess more highly developed organs than the corresponding organs in the Physoclysts. Among these organs we find, for example, the stronger supporting-apparatus which the pectoral fins have acquired in several Physostomes by the addition to the scapular disk of a special bone for this purpose (*os præcoracoideum*[g]). Another example of this is the far more frequent occurrence in the Physostomes than in the Physoclysts of the connexion between the air-bladder and the organs of hearing, a connexion which is effected in several of them by a special chain of bones[h].

The preponderant part of the Physostomes, as opposed to the Physoclysts, is composed of fresh-water fishes; but the family most important among marine fishes in an economical respect, that of the Herrings, is Physostomous. This order also contains the families of the Salmons, Carps, Pikes, and Eels, all of which have been of great importance in human economy since time immemorial.

The Physostomes are not so numerous as the Physoclysts — we know about 1,900 species of the former, as opposed to 3,300 of the latter — but the distinction of form is sufficiently wide to require the establishment of several independent series which we here give prin-

[a] The rays which in these fishes are termed spines, as being hard and stiff, show their Malacopterygian nature in their internal structure, being articulated, although the joints are coalesced.

[b] *Gen. Pisc.*, p. 1.

[c] *Syst. Nat.*, ed. X, tom. I, p. 241. CUVIER completed the Linnæan character by the addition that the ventral fins not only lie behind the pectoral fins, but are also destitute of any immediate connexion with the shoulder-girdle.

[d] Abh. Akad. Wiss. Berl. 1844, Phys. Abh., p. 175.

[e] *Règne Animal*, ed. 1, tom. II, p. 159; ed. 2, tom. II, p. 269.

[f] Cf. GEGENBAUR, *Unters. Vergl. Anat. Wirbelth.*, 2:te Heft, p. 153, taf. VIII, figg. 8 et 9.

[g] Præcoracoid, PARKER, *Shoulder-girdle and Sternum*, p. 56, pl. II, fig. 8, *p. cr*; Knochenspange, GEGENBAUR, l. c., p. 117, taf. VII, figg. 1—5, *x*.

[h] SAGEMEHL (Morphol. Jahrb., Bd. X, p. 22) gave these fishes the name of *Ostariophysete Teleosts*, from ὀστάριον, *a small bone*, and φῦσα, *bladder*.

cipally after COPE, but with names more adapted to our previous treatment of the Physoclysts:

- I: The shoulder-girdle suspended from the head.
  - A: An internal supporting bone (os praecoracoideum) for the coraco-scapular disk rises from the coracoid bone to the inside of the clavicle or of the scapula.
    - a: Anterior vertebræ more or less confluent; air-bladder connected with the hearing-apparatus by a row of ossicles.
      - α: No distinct os symplecticum; no suboperculum; maxillary bones rudimentary, forming in most cases the base of a maxillary barbel on each side............ *Glanomorphi*[b].
      - β: Os symplecticum distinct; suboperculum present; maxillary bones normal .... *Cyprinomorphi*[c].
    - b: Anterior vertebræ normal; air-bladder without osseous connexion with the hearing-apparatus .... *Thrissomorphi*[d].
  - B: No os praecoracoideum .... *Esociformes*[e].
- II: The shoulder-girdle suspended from the spinal column .... *Enchelymorphi*[f].

GLANOMORPHI.

The shoulder-girdle suspended from the head (as usual in the Teleosts). *Coraco-scapular disk internally strengthened by an arch formed by a special bone (os praecoracoideum) from the coracoid bone to the clavicle or the upper (anterior) margin of the scapula. Most of the first four or five vertebræ more or less altered from the ordinary form and more or less completely confluent with each other or even with the occipital bone. Some of the ribs belonging to these vertebræ metamorphosed into a connecting chain of bones between the air-bladder and the auditory apparatus. No os symplecticum in the hyomandibular arch. Each palatine arch composed of only two bones, os pterygoideum and os palatinum. Opercular apparatus without suboperculum. Maxillary bones reduced, generally forming, together with their supplementary bones, the mobile base of a maxillary barbel on each side. No true scales, body naked or covered with plates.*

VALENCIENNES[g] ranged the Glanomorphs at the head of the Malacopterygians (nearest to the Acanthopterygians), because they possess the most strongly ossified fin-rays. This character — the possession in the foremost pectoral rays and the first (second) dorsal ray of admirable weapons of defence and attack — is indeed fairly constant in its appearance, but still variable enough to render it useless to the systematist. The Glanomorphs also vary so greatly both in the rest of their structure and in the form of the body that the distinction between them and the next series of families consists principally in the negative characters given above, the simpler (less complete) structure of the opercular apparatus, which is without suboperculum, of the hyomandibular arch (the suspensory arch of the lower jaw and the hyoid bone), which is made up on each side of only two bones, *os hyomandibulare* and *os quadratum*, and lastly of the palatine arch, which is also composed on each side of only two bones, *os pterygoideum* and *os palatinum*.

The systematic arrangement of the Glanomorphs has always presented great difficulty. BLEEKER[h] based his division of this series into families in the first place on the singular respiration of certain forms. Apart from the fact that some (*Plotosus*) are furnished behind the vent with ramified dermal excrescences[i], which BLEEKER explains as respiratory organs, others (*Heterobranchus* and *Clarias*) possess similar growths of the mucous membrane of the branchial cavity, on the second, third, and fourth branchial arches, this apparatus being concealed in a cavity behind the branchial cavity proper. Others again (*Saccobranchus*) are destitute of

[a] Trans. Amer. Philos. Soc., vol. XIV, n. ser. (1871), p. 452.
[b] *Nematognathi*, COPE.
[c] *Plectospondyli*, COPE.
[d] *Isospondyli*, COPE.
[e] *Haplomi*, COPE.
[f] *Apodes*, LIN., auct.
[g] CUV., VAL., *Hist. Nat. Poiss.*, vol. XIV, p. 309.
[h] *Atl. Ichth. Ind. Or. Neerl.*, tome II, p. 2.
[i] Cf. VALENCIENNES in CUV., VAL., *Hist. Nat. Poiss.*, vol. XV, p. 411.

these growths, but are furnished instead on each side of the body with a long, cylindrical duct penetrating into the dorsal muscles, a backward continuation of the branchial cavity, containing a respiratory sac which is lined with a continuation of the mucous membrane of the said cavity. This continuation of the membrane is abundantly furnished with ramifications of the branchial arteries (the first artery on the right side, the last on the left[a]), which convey hither a great portion of the venous blood of the heart. The blood oxygenated in each of the respiratory sacs by inhaled air[b] is partly carried off by arterial ramifications in the surrounding muscles, but most of it is collected in a main artery, that discharges it into the great dorsal artery. The whole of this arrangement, it is true, stands in a physiological respect beside the structure just described in *Heterobranchus* and *Clarias*; but the form of the body and the structure of the fins range *Saccobranchus* immediately beside *Silurus*. An amphibious manner of life has produced a development of special respiratory organs for the breathing of air; but nevertheless the natural kinship may be most safely expressed by the form of the body and the structure of those external organs which otherwise afford the most tenable characters within this series of families.

This is also true of the variations of the air-bladder. In our Sheatfish it is externally simple, but internally divided in a longitudinal direction. In *Bagrus* these divisions are transverse. In *Malapterurus* the anterior part is externally set off, though not internally divided, from the posterior, which is partitioned internally, though incompletely, both in a longitudinal and a transverse direction; and the anterior part itself is externally divided in a longitudinal direction into two oval chambers, which communicate, however, with each other internally. In *Rhinolepis*[d] the posterior part of the air-bladder has disappeared, and the two oval, anterior chambers lie side by side, each enclosed in an osseous capsule. These among other variations in the structure of the air-bladder in the different Glanomorphous genera show that the form of this organ is highly plastic; but up to the present the differences are far too little known to be employed in the system. Kner also came to the conclusion that within the *Doras* group the differences in the form of the air-bladder may well be employed in the distinction of the species, but not in the definition of the genera. Day[f] has, however, employed these relations in the classification of the genera; but he remarks on this head that the marine Glanomorphs in general have a thick air-bladder, not enclosed in an osseous capsule, as well as the majority of the freshwater forms; but that the further we penetrate into the highlands of India, the oftener we meet with Glanomorphs whose air-bladder is cased in this manner. It would thus seem that here too the amphibious manner of life exerts a determinative influence.

The incasement of the air-bladder is also merely a part of the marked ossification that takes place in the anterior portion of the spinal column. Here, as we have mentioned, the anterior vertebræ are more or less completely confluent; and their ribs are transformed into so-called acoustic bones (Weberian ossicles[g]), which serve to connect the air-bladder with the organs of hearing, and may well deserve their name, though they do not possess the least homology with the otosteals (*ossicula auditus*) of the higher Vertebrates. Here this ossification of the first vertebræ — conjoined in many Glanomorphs with occipital plates (interneural growths) — forms a strong support for the spinous ray of the first dorsal fin, one of the powerful weapons of these fishes. Both these structures are also connected, according to Sorensen, with the power possessed by several Glanomorphs of producing sounds[h]. The dorsal spines — the rudimentary (first) and the great (second) spinous ray — produce noises (like the spinous ray of the pectoral fins) by means of the friction between their articular surfaces and those of the interspinal bones; and the air-bladder utters sounds partly in the same way as in the Gurnards, Filefishes, and others (see Part I), partly by means of the vibration produced by the violent contraction of the special muscles running from the occipital region or the foremost (confluent) vertebræ to the acous-

[a] Hyrtl, Stzber. Akad. Wiss. Wien, Math. Naturw. Cl., Bd. XI (1853), p. 305.

[b] This according to Day. Günther states, however, (*Introd. Study Fish.*, p. 565) that the lung-like extensions of the branchial cavity receive water.

[c] Geoffroy, *Descr. de l'Egypte, Poiss.*, pl. XII, fig. 4.

[d] Reissner, Arch. Anat., Physiol., 1859, p. 421, Plate XII

[e] Stzber. Akad. Wiss. Wien, Math. Nat. Cl., Bd. XI, p. 145.

[f] *Fishes of India*, p. 440.

[g] Weber, *De aure et auditu* etc., Lips. 1820, p. 53.

[h] Sorensen, *Om Lydorganer hos Fiske*, Kbhvn 1884, p. 121 etc.

tic bones, which are attached to the anterior end of the air-bladder. Several circumstances, of which we shall give an account below, seem, however, to assign to the Weberian apparatus its most important function as a barometrical apparatus for the fish. As in the File-fishes, we sometimes find here that the air-bladder is connected with the skin in the scapular region on each side of the body; and this is effected either immediately, by means of lateral processes from the bladder, or by a ligamentous connexion between the skin or the first lateral plate and the acoustic bone that coalesces with the air-bladder.

In the same parts of the body, the sides of the scapular region behind the clavicles, we find in some Glanomorphs (*Plotosus*, *Malapterurus*[a]) special cavities, one on each side of the body, more or less completely closed bulbs of the abdominal cavity (secondary abdominal cavities), in which a part of the liver and (on the right side) the gall-bladder or a portion of the kidneys may find room. In several Glanomorphs (*Doras*, *Arius*, *Aspredo*, *Silurus* etc.) we meet with a singular sac beneath the skin behind each of the clavicles, usually opening into a hole (*porus lateralis* l. *pectoralis*) at the upper angle of the pectoral fin, somewhat above or a little behind it. We have already remarked a similar cavity in the case of the Batrachoids (Part I, p. 133). It has been interpreted as a saccate poison-gland; but in neither case has its signification been yet explained. In our Sheatfish the pore leads upwards to the cavity under the flat, backward process from the posterior corner of the angular clavicle.

These fishes are known in English as Catfishes on account of their long and sometimes numerous barbels, sensory threads (corresponding to whiskers) round the mouth. These barbels, accompanied sometimes by large labial flaps, are by their extraordinary development especially characteristic of the Glanomorphs.

The variety of form among the Glanomorphs (Nematognates) is fairly great. About 660 species have been described, and BLEEKER has distributed them among 185 genera, arranged in 6 families. The form of the body varies from the ordinary piscine form, usually with flattened head and well-separated caudal fin, to the Anguilliform type, with the vertical fins continuous round the tip of the tail. The plated Glanomorphs, as COPE has remarked, present in their armour an obvious resemblance to the Sturgeons, to which the Glanomorphs possess another likeness in the barbels on the jaws. That the resemblance between these two groups of fishes is not merely external, has been already shown by PARKER[b] in his account of the analogy between the different parts of the scapular arch in the armoured Glanomorph *Callichthys* and in a Sturgeon, with *posttemporale*, *supraclavicula*, *clavicula* and *interclavicula* equally distinct as dermal growths. Thus the Glanomorphs — in the majority of which, however, the structure of the scapular arch reminds us most strongly of the Carps — rank as the most distinct intermediate forms in this respect between the Sturgeons and the Teleosts.

Most of the Glanomorphs belong to fresh water, especially to the lakes and rivers of the Tropics, with their deltas and brackish water; but many live in the sea, where they keep, however, to the littoral region. To the natives, especially within the Tropics, these fishes are in many localities of great economical value; but they are generally despised by Europeans on account of their repulsive appearance. Many of them too, especially in the tropical regions, are dreaded for their formidable spines, which are said to be poisonous, though as yet we have no trustworthy evidence on this head.

FAM. SILURIDÆ.

Body naked (without plates on the sides); head also covered with skin. Only one (if any) dorsal fin furnished with rays, short and situated on the abdominal part of the body. Caudal part of the body and the anal fin long. Branchial arches simple (without appendicular branchiæ). Gill-openings large; branchiostegal membranes free from the isthmus.

Thus defined, the family of the Sheatfishes corresponds to BLEEKER'S subfamilies *Siluriformes* and *Ailiaformes* — the former without, the latter with a small adipose fin on the posterior part of the dorsal margin — as well as to his *Saccobranchiformes*, with their singular, tubular, respiratory cavity along each side of the body, and contains about 50 known species from the Old World and the Sunda Islands. In GÜNTHER

[a] CUV., VAL., *Hist. Nat. Poiss.*, vol. XV, pp. 415 and 525 and HYRTL, l. c., p. 302.

[b] *Shoulder-girdle and Sternum* (Ray Soc. 1867), p. 23.

the family is represented chiefly by the subfamily *Siluridae Heteropterae*, with the single exception that BLEEKER has referred the *Pangasinae*, with stronger spinous ray in the comparatively longer dorsal fin and with comparatively shorter anal fin, to the Bagriform division, which in conjunction with a more advanced development of the dorsal spine possesses a support for this spine in a distinct cuirass on the head and the anterior part of the back. The essential character of the Siluroids proper thus lies in the reduction of the dorsal fin (or fins, both of the rayed, anterior fin and of the adipose fin), combined with the elongation of the anal fin. GÜNTHER'S *Heteroptera* (with different fins) expresses this character fairly well. The whole Glanomorphous series is so nearly continuous, however, that up to the present the limits of the families which we are compelled to establish by the great number of the species, are in a measure arbitrary.

GENUS SILURUS.

No adipose fin. Dorsal fin soft-rayed (without spinous ray). Dense cards of pointed teeth in the lower jaw, on the intermaxillary bones, and on the head of the vomer. Barbels 4 or 6, two of which belong to the upper jaw, the rest to the lower. Anal fin united at the base by a membrane to the rounded caudal fin, but at the margin separated from the latter fin.

The genus *Silurus*, the name of which occurs even in ÆLIAN and ATHENÆUS (in the second century A. D.), was in ARTEDI[a] a combination of the Burbot and the Sheatfish, though the former was also included in the genus *Gadus*. In LINNÆUS[b] it embraced, together with the genus *Loricaria*, the whole of that series of families which we have now called Glanomorphs. At present, with the definition given it by GÜNTHER, it contains 5 known species, 3 from India, 1 from Dauria, China, and Japan, and 1 from Europe. An East Indian genus of small fishes, *Silurichthys*, comes extremely near *Silurus*, but is distinguished therefrom by the oblique shape of the caudal fin, with the upper corner considerably longer than the lower, a character of which we find at least traces in *Silurus*, and by the closer union of this fin to the anal fin.

THE SHEATFISH (SW. MALEN).

SILURUS GLANIS.

Plate XXX, fig. 1.

Six barbels. Dorsal fin situated in front of the middle of the abdomen, about half-way between the vertical lines from the anterior ends of the insertions of the pectoral and ventral fins. Vomerine card of teeth continuous, with only a slight indentation at the middle of the hind margin. Lower jaw projecting beyond the tip of the snout. Coloration olive-green, above dark, almost blackish, below pale, fading even into whitish, on the sides spotted; all the fins reproduce the coloration of the body (darker base, lighter margin), except the dorsal fin, which is plain, of the same colour as the back.

R. br. 15 l. 16; *D.* $\frac{1}{2-3}$; *A.* $\frac{1}{(83)\ 87\ (89)}$; *P.* $\frac{1}{(14)\ 15\ (17)}$; *V.* $\frac{1}{(10)\ 11\ (12)}$; *C.* $x + 17 + x$; *Vert.* 20 + 51 (54).

Syn. *Gadus*, LIN., *Fn. Suec.*, ed. 1, p. 109, No. 291; *Silurus*, *It. Scan.*, p. 62. *Silurus* cirris duobus ad maxillam superiorem, quatuor in mento, GRONOV., *Mus. Ichth.* (1754), p. 6; *Mal*, OSB., Vet. Akad. Handl. 1756, p. 34. *Wels*, BL., *Fisch. Deutschl.*, part. 1, p. 242, tab. XXXIV.
Silurus Glanis, LIN., *Syst. Nat.*, ed. X, tom. I, p. 304; HELM. D. Vid. Selsk. Skr., XII (1779), p. 133, tab. I et II; RETZ., *Fn. Suec. Lin.*, p. 343; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 82; BDT, RTZB., *Medic. Zool.*, part. II, p. 31, tab. V, fig. 2, C, D, E, tab. VI, figg. 1—4; NILSS., *Prodr. Ichthyol. Scand.*, p. 38; CUV., VAL., *Hist. Nat. Poiss.*, tom. XIV, p. 323, tab. 409; KR., *Danm. Fiske*, vol. III, p. 120; NILSS., *Skand. Fn., Fisk.*, p. 359; LLOYD, *Ant. 20-år. vist. Skand.*, p. 40; HECKL., KN., *Süsswasserf. Oestr. Mon.*, p. 308, fig. 165; SIEB., *Süsswasserf. Mitteleur.*, p. 79; MGRN, *Finl. Fiskfn.* (disp. Helsingf. 1863) p. 35; GTHR, *Cat. Brit. Mus., Fish.*, vol. V, p. 32; SEIDL., *Fn. Balt.*, p. 100; BUCKL., *Nat. Hist. Brit. Fish.*, p. 357; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 439; MELA, *Vert. Fenn.*, p. 310, tab. X; BNCKE, *Fisch.*,

[a] In ARTEDI the Sheatfish is mentioned only in the Appendix (*Gen. Pisc.*, p. 82 and *Syn. Pisc.*, p. 110), and has probably been introduced thither by LINNÆUS during his revision of ARTEDI'S *Ichthyology*. See *Skånska resan*, p. 62.

[b] *Syst. Nat.*, ed. X, tom. I, pp. 304 and 307; ed. XII, tom. I, pp. 501 and 508.

Fischer. Fischz. W., O. Preuss., p. 103, fig. 83; GRIMM, *Fish., Hunt. Russ. Wat.*, pp. 12 et 19; APOSTOL., *Pêche en Grèce*, p. 31; NORBACK, *Handl. Fiskev., Fiskafv.*, p. 373; BENECKE, *Handb. Fischz., Fischer.* (M. V. D. BORNE), p. 142, fig. 150; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 358.

The Sheatfish is the largest osseous fish in the fresh water of Europe. According to trustworthy verbal statements[a] it attains in the south of Russia, in the Dnieper, a length of at least 48 dm. and a weight of about 295 kgm. KRAMER (1756), quoted by HECKEL and KNER, mentions a still larger Sheatfish from the Danube, "so large that two men could scarcely join hands round its body," which thus might have measured between 6 and 7 metres in length. The Sheatfish described by OSBECK (l. c.) was from Lake Bafven in Södermanland and weighed $10^3/_5$ kgm. at a length of $11^1/_3$ dm. In Sweden the species seldom attains a length of more than $2^1/_2$ metres, though we sometimes hear of specimens half as long again[b].

The form of the body reminds us strongly of the Burbot, with flattened head, terete trunk, and laterally compressed tail, though these three parts pass evenly into each other. Lithe as the Burbot — or even more so — and still more like the Eel in its movements, with loose and slippery skin, the body of the Sheatfish may assume different forms in different position; but when extended and at rest it presents the appearance given in our figure. The dorsal profile is almost straight, only slightly elevated at the end of the first quarter, where the dorsal fin is situated, from this point slightly curved towards the tip of the snout, and with a downward curve just behind this fin. The ventral profile is more regularly curved, more sharply ascending in front when the mouth is closed. The flat snout, the convex forehead, and the forepart of the back, which is also convex, but furnished at the middle with a more or less deep, longitudinal groove all the way from the occiput, are continued behind by the narrow, but terete dorsal edge of the tail. The ventral side, on the other hand, is indeed terete in front and along the belly itself more or less tumid; but behind the vent it is so sharp that the interhaemal spines (supporting bones) of the anal fin are even externally perceptible beneath the skin. The greatest depth of the body, which occurs at the dorsal fin, measures in young specimens, 2 or 3 dm. long, about 19 % of its length; while in older specimens 2 metres long this percentage usually sinks to 13[c]. The thickness at the same spot is in young specimens usually distinctly less than, in old specimens generally about equal to the depth. The least depth of the body, just in front of the caudal fin, measures in the said young specimens about 5 % of its length, in the older ones about $4-3^1/_2$ % thereof.

The length of the head (from the tip of the snout to the extreme end of the branchiostegal membrane) measures $^1/_5$—$^2/_{19}$ of that of the body (from the tip of the snout); but in old specimens the lower jaw projects in front of the tip of the snout for a distance that sometimes measures at least $^1/_3$ of the length of the head. The broad, flat snout, with its sides sharply rounded (forming a broad ellipse) in front, passes very gradually into the terete form of the occiput and the forepart of the trunk, without any sharp lateral break, the head thus resembling a broad wedge with rounded sides. The breadth of the head across the opercula is the greatest breadth of the body (in old specimens about 14 % of the length of the body); but we are most struck by the great breadth of the gape, the width of which, measured straight across the corners of the mouth when closed, is about $^1/_5$ of the greatest breadth of the head, and occupies almost the entire breadth of the snout. The lips are fleshy, the dermal folds at the corners of the mouth being especially thick. In young specimens the mouth shuts so tightly that the upper and lower lips are contiguous; but in older ones the lower jaw projects so far that a considerable portion of its card of teeth is left bare. The eyes are round and small, and sometimes even difficult to distinguish, as their colour differs only slightly from that of the head. Their relative size varies considerably according to age. In specimens between 1 and 2 dm. long the longitudinal diameter of the eyes measures about 10 % of the length of the head, 20—19 % of the breadth of the interorbital space, or 30—27 % of the distance between them and the middle of the tip of the snout (the length of the snout). In specimens between $^1/_2$ and 1 m. long these percentages have sunk, the first to about 6, the second to about 13 or 12, and the third to about 18 or 17. In a Sheatfish 19 dm. long (the original of our figure) the longitudinal diameter of the eyes was 5 % of the length of the head, only slightly more than 9 % of the

[a] KESSLER, Bull. Soc. Natur. Mosc., tom. XXIX (1856), 1, p. 350.

[b] On the 10th of August, 1870, a Sheatfish 12 Sw. ft. ($3^1/_3$ m.) long is said to have been brought to market at Eskilstuna.

[c] In gravid females, or when the stomach is distended with food, the belly of course becomes both deeper and broader.

breadth of the interorbital space, and also only a little more than 14 % of the length of the snout. As appears from these measurements, the breadth of the low, but rounded interorbital space measures about $^1/_2$ (varying, however, between 55 and 48 %) of the length of the head, and the length of the snout usually a little more than $^1/_3$ (varying between 38 and 33 %) of the same length. Here, however, as usual, the length of the snout is measured obliquely (from the anterior margin of the eyes to the middle of the tip of the snout): its real length (the distance between its tip and the middle of the line joining the anterior margins of the eyes) is in young specimens rather more than $^1/_2$, in specimens 1 m. long rather less than $^1/_2$, and in our largest specimen about $^2/_5$ of the breadth of the interorbital space. In proportion to the entire length of the head the real length of the snout decreases, during the growth of the fish from a size of 3 dm. to one of 2 m., from $^1/_4$ to only $^1/_5$ of the said length of the head, and at the same time from about 41 to 28 % of the postorbital length of the head. The eyes thus lie invariably in the foremost third of the head, just behind the line between the hind margins of the corners of the mouth. Just in front of this line, or exactly in it, lie the posterior pair of nostrils. These nostrils are small and round, and are situated so far inwards that the distance between them, which is relatively less in old specimens, measures only about 66—56 % of the breadth of the interorbital space. The anterior pair of nostrils lie far out on the snout, in the line between the maxillary barbels, and at a somewhat smaller distance from each other. The margin of all the nostrils is tubular, the posterior pair being more elevated in a funnel-shape.

Of each of the maxillary bones there remains, as we have indicated above, hardly more than the articular knob itself, a small, triangular or scaphoid bone, hollow on the outside and articulating on the inside, which is button-shaped, with the lateral ethmoid (prefrontal) bone and the intermaxillary bone. But on the lower anterior side of this bone we find another, still smaller, supplementary bone, forming the base of the maxillary barbel, which is long and narrow, but compressed, and may be moved in all directions. The length of this barbel is, however, extremely variable. Now and then the barbel on one side of the body differs from that on the other. As a rule too, these barbels are comparatively shorter in old specimens than in young: in a specimen 1 metre long the longest barbel measured somewhat more than $^1/_{10}$ of the length of the body, in a specimen 2 metres long not quite $^1/_6$ of the same length or, in other words, a little more than the length of the head. The two pairs of barbels on the lower jaw are considerably shorter, the anterior pair being also shorter than the posterior, which generally extend to about a line with the hind margin of the preoperculum or with the articulation of the operculum. These barbels are not set on the lower jaw itself, but a little farther inwards, on the skin between the branches of the jaw, the anterior pair nearly below the anterior nostrils, the posterior pair below the anterior margins of the eyes.

The surface of the head is smooth, and the bones and cavities which otherwise give many Glanomorphs one or more important characters, are perceptible only to the touch. Within this series of families we rather constantly find, in the forms that have a more or less fully armoured head, a longitudinal groove, or an oblong, naked patch, along the middle of the forehead and snout. Here, as in the other forms the head of which is destitute of dermal ossifications, no groove of this kind is externally perceptible; but in the skull we find a long opening (fontanel) between the anterior parts of the frontal bones proper, and this opening is continued between the posterior parts of the ethmoid bone.

In the same way we find no external trace of the suborbital ring; but in the skeleton it displays some striking peculiarities. The foremost bone in this ring (the preorbital bone) is comparatively small, flat, triangular, and acute-angled in front. One side of this bone lies on the outer top of the lateral ethmoid bone, and the point in front is united by ligaments to the top of the long lateral process of the ethmoid bone proper. With its inside this bone forms the outer margin of the nasal cavity, the inner margin of which is formed by the long, but also fairly broad nasal bone with its somewhat crescent-like shape. Both the nasal bone and the preorbital bone are furnished on their upper surface with hollows and grooves for the ramifications (muciferous ducts) of the lateral line. The second suborbital bone forms the anterior margin of the orbit and occupies a singular position, straight outwards and downwards from the lateral ethmoid bone, while its length is so great that the tip lies above the lower jaw, though without coalescing with the latter, just in front of the articulation thereof. At the distal part of this suborbital bone, with its anterior side united to the posterior side thereof, lies the third suborbital bone, which is angular, and forms with the shorter (inner) arm a part of the outer margin of the orbit. These two suborbital bones thus form with their outer parts an osseous ridge projecting from the orbital ring, a structure reminding us of that which in the Cottoids and the Lump Suckers unites the orbital ring to the preoperculum. The fourth suborbital bone, which is the longest, is curved in an S-shape. With its lower curve it forms a part of the lower (outer) and the whole of the posterior margin of the orbit. With its upper curve it bends backwards to be united by ligaments to the outside of the anterior extremity of the posterior frontal bone, which at this point, outside the frontal bone proper, meets the hind extremity of the lateral ethmoid (prefrontal) bone.

The crescent-shaped, obliquely set preopercula are also externally indistinct, being entirely covered by the skin; but a distinct dermal fold on each side marks the position of the margins of the operculum and interoperculum. The former is triangular, with the upper margin convex and the lower posterior margin slightly concave. The interoperculum too, which also replaces the suboperculum, is triangular in form, but forked behind, with the upper posterior corner projecting obliquely under the operculum. The anterior extremity of the interoperculum is united by a long and strong ligament to the hind extremity (angular part) of the lower jaw; but this ligament runs along the inside of the interoperculum as well, and is attached here and also, no less firmly, to the outside of the upper part of the epihyoid bone[a]. Behind the said dermal fold marking the hind margin of the opercular apparatus proper, the head is continued on each side by a broad branchiostegal membrane, which lies in a rather indistinct flap above the upper angle of the base of the pectoral fin. Both of the branchiostegal membranes are entirely free from the isthmus and united to each other only at the extreme front for a very short distance, nearly below the corners of the mouth; but the left branchiostegal membrane overlaps the right under the isthmus to a considerable extent. The branchiostegal rays are numerous; 13 or 14 of them are set on the ceratohyoid bone and are fairly uniform in thickness and terete, but narrow and pointed. The last two of these rays are set on the epihyoid bone, and the last in particular is flat towards the tip, externally grooved (hollowed in a longitudinal direction), and fairly broad.

The cards of teeth in the lower jaw, on the intermaxillary bones, and on the head of the vomer are of similar form and parallel, curved like a crescent and of fairly uniform breadth, but growing narrower as usual behind (distally on the vomer). They are composed of dense, pointed, and somewhat recurved teeth of uniform size, which are comparatively small, but in so large a fish still form a powerful weapon. In the lower jaw and on the intermaxillary bones the halves of the cards are separate in front; but the vomerine card of teeth presents an unbroken surface[b]. Of the three upper pharyngeals on each side only the hindmost is furnished with teeth, and this bone is also the only one of the three that is visible in the pharynx, having extended under the other two, which are small and serve to support it and to attach it to the under surface of the skull. The patch of teeth on the first-mentioned pharyngeal is fairly large, convex and elliptical. Each of the two lower pharyngeals is furnished with an oblong patch of teeth, broader in front, narrower behind (above), and concave on the inside[c]. All the pharyngeal teeth are pointed and resemble the jaw-teeth, but are smaller, smallest on the lower pharyngeals and in the outer posterior corner of the upper cards. The gill-rakers are scattered and fairly short, but pointed like teeth. On the first and second branchial arches they are set in a single row, and on the front of the first arch we find 9 or 10 on the ceratobranchial bone and 2 on the lower part of the epibranchial bone. In some cases the lower pharyngeals are also furnished on their outer margin with a row of short, similar spines. The palatal folds within the cards of jaw-teeth are well-developed, but the upper is quite shallow. The upper jaw is not capable of the slightest protrusion, for the intermaxillary bones are firmly united by ligaments not only to the large anterior process of the ethmoid bone proper, but also, though at a somewhat greater distance, to the

[a] Cf. above, p. 664, note *b*, on the singular position of the interoperculum in the *Syngnathina*.

[b] In a Sheatfish 2 metres long the patch of teeth on each half of the lower jaw is 29 mm. broad in front and 118 mm. long, though the posterior (outer) part for a distance of 40 mm. is considerably narrower than the anterior part; the patch on each intermaxillary bone is 85 mm. long and 22 mm. broad, a breadth also attained by the vomerine card of teeth, which measured across the palate is 96 mm. in length.

[c] In a Sheatfish 2 metres long each of the cards of teeth on the upper pharyngeals is 47 mm. long and 30 mm. broad, on the lower pharyngeals 85 mm. long and 24 mm. broad at the broadest point. In a Sheatfish 1 metre long each of the two cards of teeth on the upper pharyngeals is 30 mm. long and 21 mm. broad, on the lower pharyngeals 47 mm. long and 14 mm. broad at the broadest point.

lateral ethmoid bones. The tongue is wanting. The urohyoid bone is of a singular form. Its anterior, shorter part (corpus) resembles a parallelopiped. Its posterior part is expanded into a rhombic, horizontal disk, with the two anterior sides curved upwards and the two posterior sharp, but deeply concave. Above this disk, and at right angles to it, rises a strong, elevated ridge, from the extreme beginning of the bone.

The form of the dorsal fin is especially characteristic of the Sheatfish and reminds us strongly of the adipose fin in our Salmonoids, resembling an obliquely linguiform flap on a fairly narrow stalk, snapped, as it were, and bent backwards at the middle. The fin lies at a distance from the tip of the snout that measures in young specimens about 27 %, in old about 23 % of the length of the body[a], or in the former about 69 %, in the latter about 63 % of the distance between the anal fin and the tip of the snout. Its four interspinal bones coalesce into one supporting bone, the lower extremity of which is attached between the tops of the fifth and sixth neural spines (belonging to the sixth and seventh vertebræ). The first ray is simple but distinctly articulated, the posterior two[b] or three rays are branched and articulated.

The anal fin, the length (base) of which usually measures more than half (about 53 or 54 %[c]) of the length of the body, is of almost uniform height throughout its length, though its height increases behind in the same proportion as the depth of the body decreases. Its greatest height (longest ray) is as a rule about $^1/_{16}$—$^1/_{13}$ of the length of the body, but may sometimes rise to about $^1/_9$ thereof. The fin begins just behind the vent with its fairly large genital papilla, at a distance from the tip of the snout that measures in young specimens about 40—43 %, in old about 36 % of the length of the body. Its last ray is united by a fin-membrane to the lower margin of the caudal fin, as far as the black colour extends over its base.

The caudal fin, which during life seems always to be directed downwards, sometimes almost at a right angle to the longitudinal axis of the body[d], may, however, be raised and brought without violence into the position which it occupies in our figure. In this position, however, the skin forms a protuberance at the dorsal margin just in front of the fin. The length of this fin generally measures in young specimens about 14 %, in old about 9—8½ % of that of the body; but the variations in this respect are quite as great as in the case of the height of the anal fin, and in a specimen 1 metre long we have found the length of the longest caudal rays to be 11½ % of that of the body.

The pectoral and ventral fins are the only ones in whose various relations we apparently find perceptible external differences between the sexes. These fins are relatively larger in the males than in the females, to judge by our measurements of two males respectively about 1 and 2 metres long and two females respectively 57½ and 73½ cm. long, our only specimens in which the viscera were sufficiently well preserved to enable us to decide the sex with certainty.

The pectoral fins are broad, but obliquely oval. Their insertion is partly covered at the upper angle by the broad branchiostegal membrane. Their first (uppermost) ray is strong and spinous, though articulated at the tip, and forms a weapon which in old specimens develops a number of spines on the inside of the outer (distal) part. When this weapon is employed, the spinous ray is erected in an outward direction, a creaking sound is heard, a sound which the fish probably uses to inspire terror, and the articulation is locked, so that the ray cannot be forced back. This is a faculty especially common among the fishes of this family, and the manner in which this result is attained is as follows. The base of the spinous ray is not only furnished as usual with two articular knobs—one for each of the two articular surfaces which lie on the hind margin of the firm osseous connexion between the scapular and coracoid parts of the shoulder-girdle, and of which the outer (the one nearer to the clavicle) is an obliquely-set and circularly hollowed groove—it is also furnished on the outside with a tumid, pulley-shaped, articular knob, which fits into a corresponding ear-shaped groove on the in-

[a] To judge by these changes of growth, as well as by the vomerine cards of teeth, which in the Indian *Silurus wynaadensis* (DAY, *Fish. Ind.*, p. 480, pl. CXI, fig. 6) are separated from each other, this Indian form seems to stand nearer the original type common to both species, though we must not forget that the Indian species is known only in specimens at most 12 in. (305 mm.) long. Besides, external differences of sex are unknown in these species.

[b] In old specimens we have only found two branched rays in the dorsal fin.

[c] According to KRØYER, however, sometimes (in young specimens) 49 or 50 %.

[d] This downward curvature of the caudal fin and its union to the anal fin are given by SAGEMEHL (Morphol. Jahrb., X 1884), p. 51 as one of the proofs of the close relationship between the Gymnotoids (the so-called Electric Eels) and the Siluroids.

side of the angle of the clavicle. When the spinous ray is erected, it is simultaneously twisted in a forward and downward direction — the result of the above-mentioned oblique position of one of the two articular surfaces on the scapulo-coracoid bone — and during this twisting process the last-mentioned, pulley-shaped knob rubs against the wall of the clavicular groove — thus producing the creaking noise — until this articular knob is so firmly wedged in the lower end of the groove that the ray cannot be bent without being twisted back at the same time. Another consequence of the erection of the spinous ray is that the insertion of the fin, which previously occupied an oblique position, in a backward and downward direction, now becomes horizontal. The other rays of the pectoral fins are repeatedly branched, the first being sometimes twice as long as the spinous ray, the first (uppermost) three or four gradually increasing in length, the lower ones from this point very gradually decreasing in length down to the last two or three, which grow rapidly shorter, one after another. The last ray is not even half so long as the spinous ray. The entire length of the fins, from the upper angle of the insertion to the tip of the longest ray, is in our males more, in our females less than $^2/_3$ of the length of the head[a].

The ventral fins are of a broad oval shape. Their first ray is simple but short. They are inserted at about the end of the first third of the body, so far back that the distance between the dorsal fin and the tip of the snout measures only about 75—70 % (in young specimens 80 %) of the distance between the ventral fins and the same point. Their length is in the males more, in the females less than $^2/_5$ of the length of the head[b]. The pelvic bones are of a shafted spade-shape, with the outer posterior margin forming an arc. They meet each other partly in a fairly firm suture between the posterior (extended) parts, partly in a ligamentous connexion between the anterior ends.

The lateral line follows a straight course along the middle of the sides of the tail (sometimes a little higher, sometimes lower), but in front it rises in a greatly elongated arch up to the temporal region, and may often be traced distinctly in a straight line across the cheek below the eye, as shown in our figure. The slimy surface of the skin, as we have mentioned above, is entirely scaleless.

The coloration seems to vary considerably according to local circumstances. The ground-colour is above olive-green, below white. The back is always darker, sometimes shading even into black. The sides are irregularly spotted (mottled), in light specimens with large and distinct spots of the dark colour of the back on the ground-colour of the belly, which grows lighter and lighter below. The dorsal fin is of the same dark colour as the back, olive-greenish or black. The other fins in common repeat the coloration of the body, the base bearing the colour of the back, the margin or outer part that of the belly. Such was at least the appearance of the large Sheatfish, a male, from which our figure is taken. It reached Stockholm alive, and was kept alive while the artist painted it. But as its strength began to fail, the lighter parts, especially of the pectoral, ventral, and anal fins, became more and more suffused with blood, and finally, when the fish was in a moribund state, blood oozed in drops from the margins of these fins. The maxillary barbels are on the upper side of the same colour as the back, underneath paler or even of the same colour as the belly. During life the outer parts of the eyes were blackish blue, the inner parts lighter blue, with the iris yellow but punctated with dark dots and set off by a sharply-defined, yellow inner margin from the pupil, which was black.

The length of the abdominal cavity measures in young Sheatfish about $^1/_5$, in older ones about $^1/_4$ of that of the body. The peritoneum is white. The œsophagus is continued straight backwards by the large and muscular stomach, the pointed or rounded bottom of which lies almost above the middle of the length of the pelvic bones. Rather far forward, at about the middle of the stomach and on its under surface, the pyloric part projects in a forward direction. This part is bounded from the intestine by a more or less strong contraction, and internally divided from the same by a valve[c]. The duodenum, which is without appendages, is of about the same thickness as the pyloric part, runs first forward nearly to the diaphragm, then bends upwards to the right of the œsophagus, and curves backwards, decreasing in thickness and thus passing imperceptibly

[a] In the former 72—81 %, in the latter 54—55 % of the length of the head.
[b] „ „ „ 48—53 %, „ „ „ 34—36 % „ „ „ „ „ „
[c] In a male nearly 2 metres long the total length of the œsophagus and stomach is about 35 cm., and the distance between the pylorus and the bottom of the stomach about 1 dm.

into the small intestine, often in several small curves, above and behind the stomach. Here the intestine again bends forwards, below and to the left of the stomach, to about a line with the pylorus, then returns in a sharp curve, and proceeds to the vent. The liver is large, though its length varies: the left lobe is the longer, extends to about a line with the bottom of the stomach, sometimes not quite so far, sometimes much farther, and is divided at the tip into two secondary lobes of varying length[a]. The gall-bladder, which lies between the duodenum and the anterior part of the left lobe of the liver is saccate and large[b]. The pancreas lies nearer the duodenum, in the shape of a horse-shoe with the prongs directed forwards and surrounding the gall-duct. The spleen is situated above the stomach, between this organ and the air-bladder, to the left of the first coil of the intestine and sometimes entirely in front of, sometimes half in front of and half behind and above the anterior angle of the last coil of the intestine. It is rounded (elliptical) and flattened[d]. The structure of the large air-bladder is mentioned above[e]. The under surface of its posterior division is furnished with a longitudinal groove, at the anterior end of which the pneumatic duct descends into the œsophagus. The anterior end of the air-bladder is attached partly to the lower surface of the tip of the foremost transverse processes (belonging to the second abdominal vertebra), partly to the anterior part of the side of the large vertebra which, as we have mentioned above, is produced by the coalescence of the original second, third, and fourth vertebrae. Within the latter fastening of the air-bladder lies the descending blade of the hindmost and largest, so-called acoustic bone (*malleus*), which is loosely folded in beside the large, composite vertebra. The second blade of this acoustic bone lies horizontally, pointing in a forward direction, at right angles to the descending blade, and glides along the under surface of the base of the first transverse process. This acoustic bone is thus both bent and twisted; and within the angle of the bend the base of the descending blade forms a free margin, which, when the bone is in its natural position, lies as a continuation of the upper margin of a lateral groove on the body of the vertebra. As only the third (hindmost) of the coalescent vertebrae is furnished with ribs, the so-called *malleus* thus corresponds to a rib of the middle vertebra (the third abdominal vertebra). The malleus coheres at its inner anterior corner with the vertical, flat *incus*[f], which should thus correspond (if this homology with the ribs should receive the corroboration it still requires from the history of development) to a rib of the foremost of the coalescent vertebrae (the second abdominal vertebra). The first abdominal vertebra, which in the Sheatfish is separated both from the following vertebrae and the occipital bone, is without either transverse process or neural arch, unless these be represented on each side by the angular *stapes*, which is united by ligaments to the subjacent incus, and by the flat, but oblong *claustrum*, which lies above this point, is also united to the stapes, and covers the *atrium sinus imparis* on this side of the body. This *atrium*, which lies beside the spinal cord, is a lateral extension of the *sinus impar* situated in the occipital bone, a membranous, saccate extension of the cerebral membrane that lines the labyrinth. The anterior end of this *sinus* is furnished in the Carp-fishes[g] — and probably here as well[h] — with a connecting duct between the *sacculi* of the labyrinth. The air-bladder is thus connected by means of the acoustic bones, not indeed immediately with the true hearing-apparatus, but with the lymphatic, subdural chamber that surrounds the latter. Modern scientists have therefore adopted the opinion[i] first maintained by Hasse[j], and regard this connexion less as a conductor of sound than as a barometrical apparatus which conveys to the consciousness of these fishes a sense of the varying atmospheric pressure to which their air-bladder is exposed at different moments.

[a] In the above-mentioned specimen the length of the left lobe of the liver is $36^1/_2$ cm. and its greatest breadth nearly 8 cm. The length of the right lobe is $14^1/_2$ cm., its breadth nearly 5 cm.

[b] In the specimen just mentioned the gall-bladder is about 14 cm. long and, when collapsed, about $6^1/_2$ cm. broad.

[c] The length of this gland from the middle of the round posterior margin to the end of one of the prongs is (in the same specimen) about equal to the breadth of the gall-bladder.

[d] In the same specimen the spleen is 11 cm. long, 5 cm. broad, and about $8^1/_2$ mm. thick.

[e] In the same specimen the air-bladder is $25^1/_2$ cm. long and rather more than 9 cm. broad. In a female 575 mm. long it is 89 mm. long and 46 mm. broad.

[f] Cf. Weber, *De Aure et Auditu Hominis et Animalium*, tab. V, fig. 30.

[g] Cf. Nusbaum, Zoologischer Anzeiger, 1881, p. 553.

[h] Cf. Retzius, *Das Gehörorgan der Wirbelthiere*, I, p. 77, taf. XIII, fig. 1, *si*.

[i] Cf. Sagemehl, Morphol. Jahrbuch, X (1884), p. 14.

[j] *Anatomische Studien*, No. XIV, p. 596.

The ovaries are fusiform or cylindrical sacs with fairly thick walls; the testes are flat, lobate, and thin-walled. The kidneys lie as usual between the air-bladder and the spinal column, forming an anterior division and a larger, posterior one, beside and behind the air-bladder. The urinary bladder is large, and is most developed on the right side.

The principal habitat of the Sheatfish lies in the south-east of Europe, the species being commonest in Russia and Austria. It is there too, in the Caspian and Black Seas and the rivers that flow into these waters, that it attains its maximum size. According to PALLAS and GRIMM the Sheatfish occurs throughout European Russia, with the exception of the basin of the White Sea and its rivers. In the Danube too, especially towards the mouth, the species is plentiful and of great size. In the Greek Peninsula it is common, according to APOSTOLIDES, in the River Peneus, off Larissa, and in Livadia. In Italy and the Iberian Peninsula it is wanting, and also in France and Belgium, except in the River Doubs in the extreme east of France, where it has been caught occasionally near the town of Döle. In Switzerland its occurrence is confined to the Lakes of Constance (the basin of the Rhine) and Morat (Murten), a small lake east of Neuchatel, where it lives, strange enough, outside its strict geographical range, which lies on the other side of the Rhine. In England, as well as in Scotland and Ireland, it is wanting, though repeated attempts have been made to plant it there. Before Haarlem Meer was drained (1836—53), the Sheatfish, according to GRONOVIUS, was very common in this lake, which was chiefly formed, however, by an inroad of the sea in the fifteenth century. It is still found in several of the small lakes of Holland. In the rivers and lakes of Germany the Sheatfish is widely spread, and also in the Baltic Provinces of Russia, according to SEIDLITZ. Nor does it shun the brackish waters of the North, for it occurs, according to BENECKE, in the Haffs of Northern Germany. In Finland, according to MALMGREN, it is found only in the lakes near Tavastehus and is very seldom caught, though, according to GADD[a], it attains so great a size "that a yoke of oxen are required to move it from the spot". Nor is the Sheatfish a common species in Sweden, though it occurs at many scattered spots in the south-east of the country, principally in three separate districts: one to the north, including Lakes Mälar, Hjelmar, Borsjö, and Båfven in Södermanland and Lake Hunn in Östergothland: one more to the east, the neighbourhood of Oscarshamn, where it is known from Lakes Hunnel, Nejer, Versjö, Tvinger, Storutter, Greater and Lesser Ramsjö, Göten, Maren[b], Bodasjö (Fliseryd), and the River Emm; and one to the south, the neighbourhood of Christianstad, where it is found in Lakes Immel, Ifösjö, Ousby, and the River Helge. NILSSON also quotes a doubtful newspaper statement of the occurrence of the Sheatfish in Lake Bolmen, in Smaland. In Denmark the Sheatfish was common at the end of the last century, according to HOLM, in Lake Sorö, where it had probably been introduced from Germany; but it is now exterminated there. It has also been taken once in a river near Kjoge, into which KRØYER supposed it had wandered after some roving excursion in the Baltic. In Norway the Sheatfish has never been found.

The Sheatfish is a sluggish but voracious fish-of-prey. Its very appearance is repulsive. Slimy and slippery as an Eel, with its broad gape, small, blinking eyes, and long, warily plied barbels, it looks as though fashioned especially to lie in wait for the destruction of others. Its size too has rendered it an object of dread even to man. An old Bohemian proverb says, "One fish is another's prey, but the Sheatfish eats them all;" and we have numerous accounts of the Sheatfish attacking domestic animals and children. Hidden among the rushes or in the mud, the tints of which are reproduced in its coloration, it lies motionless the greater part of its time, only waving its barbels to and fro, until some victim approaches so near that only a sudden movement is requisite to seize and devour its prey. Or one of its senses tells it that a dainty morsel, some decomposing body or baited hook, is not far off, and it wriggles thither. During a part of the year, the cold season, it retires to deeper water; in spring and summer, till the spawning is over, it keeps to shallower spots and the shore.

The Sheatfish generally leads a solitary life, though not to such a degree that it does not seek company. One of the authors who have most contributed to our knowledge of its habits, the Dane HOLM, who published in 1779 his observations of the Sheatfish in Lake Sorö in Zealand, even tells us: "The Sheatfish is fond of company and is therefore seldom found alone; but only three or four, and these always of about the same

[a] Abo Tidningar, 1772, p. 366.

[b] From these nine lakes the observations were collected in 1890 by Mr. E. SVEDMARK the geologist.

size, have ever been seen together at Sorö. Of them we are told that they pursue and drive their flying victims in common, until, sure of their prey, with one consent and with open mouth they dart about with incredible speed, seizing and devouring their victims. In order to attain this great velocity the Sheatfish chiefly employs its tail, by whose serpentine movements and quick blows it sculls itself along like the Eel. Fortunately for the fishes it pursues, the Sheatfish by its violent movements and rapid pace sets the water in commotion and thus betrays itself." When the Sheatfish, on the other hand, lies lazily at rest and allows small fishes, frogs, crustaceans, insects, and even worms to glide down its maw, we may well conjecture that here too (cf. above, pp. 263—264) the inner transverse curtains of the mouth act as valves, so to speak, in pumping the tiny victims into its gape. However, the Sheatfish is not exclusively carnivorous; vegetable substances also enter into its diet.

From older times we have accounts of assaults made by the Sheatfish upon higher animals as well, even upon man, or at least of its devouring the bodies of drowned persons. GESNER tells us that the stomach of a Sheatfish was found to contain a human head and a right hand with two gold rings, and that geese, ducks, and animals that were being watered, have been seized by the same fish. PALLAS says of the Sheatfish in Russia that it is so voracious that it does not fear to seize bathers by the legs. VALENCIENNES quotes several accounts from Hungary of its attacking children. HECKEL and KNER state that at Vienna on one occasion a poodle was found in the stomach of a Sheatfish, and that at Pressburg a similar discovery was made of the remains of a boy. E. SVEDMARK, the geologist, who has collected the instances of the occurrence of the Sheatfish in the District of Calmar, was told there that "long ago" a person had stood on the shore of Lake Versjö and watched a Sheatfish seize a lamb. The Sheatfish is therefore feared, this being also due in all probability, as HECKEL and KNER have remarked, to the bitter experience that a few may have had of the obstinate wounds caused by the spines on the first pectoral ray of the Sheatfish. Specimens of large size may also prove no easy booty to their captors. "On Lake Storutter," writes SVEDMARK, "a fisherman speared in the back a monster that drew the punt all round the lake before it finally surrendered." LILLJEBORG tells a similar tale of a Sheatfish that was caught on a longline in Lake Immel.

The Sheatfish is eminently sensitive to changes in the weather, especially to thunder, when it may often be seen at the surface, as well as at other times on warm summer days with drizzling rain (HOLM). In many places too the Sheatfish passes for a weather-prophet. "When it breathes air," says the fisherman—and this is a necessity to most fishes, but above all to the Physostomes — "it raises itself out of the water like a big, black man" (SVEDMARK). It is extremely tenacious of life. A male 19 dm. long was sent by rail on the 30th of May, 1889, in a wooden box containing straw and a little ice, from Lake Bafven to Stockholm. It was still living on its arrival, and was kept alive for several days in a vessel where the water was just sufficient to cover it.

The spawning-season occurs in the summer (May—July), generally about midsummer. "At this season," says HOLM, "the Sheatfish is sluggish and lethargic, being easy to surprise and capture. This applies in particular to the females, which for some time previous to the spawning lie among the rushes, where, it is said, the female deposits her roe, after first providing a secure and convenient receptacle for it by scooping with her tail a hole in which the young subsequently stay for some time." The ancient account of ARISTOTLE, that the male watches the roe, is now regarded as dubious. The number of eggs varies as usual according to the size of the fish. In a female 1·87 kgm. in weight BENECKE counted more than 60,000 eggs. The eggs are slightly yellow, 3 mm. in diameter, and are hatched in 8—14 days. The fry grow quickly, where food is abundant, attaining in the first year, according to BREHM[a], a weight of $^3/_4$ kgm., in the second a weight of $1^1/_2$ kgm. A fisherman of Strasburg, BALDNER by name, who has left a manuscript written in 1666 and containing an account of all the birds, fishes, and other animals he had taken, tells us that a Sheatfish caught in the River Ill near Strasburg was kept in captivity from 1569 to 1620 and during this period attained a length of about $1^1/_2$ metres.

Young Sheatfish, less than 1 metre in length, are quite eatable, though not exactly easy of digestion. The tail is the best part of the body. The flesh is soft, white, and rather sweetish in taste. VALENCIENNES compared its flavour most nearly to that of the Eel, but

[a] *Thierleben*, Abth. III, Bd. 2, p. 201.

found it much inferior to the latter. The flesh of older specimens is tough and rank. "As the Sheatfish has no scales," says HOLM, "the Jews are not allowed to eat it — a privation which, in my opinion, they need not regret. To render the flesh eatable, the fat must first be boiled away, and the fish then boiled again in wine and with plenty of spices to remove its nauseous flavour." In Sweden, however, the Sheatfish is so seldom caught that it is of little economical importance. To the fish-mongers of Stockholm it seems to be almost unknown. In Russia the case is different. From Astrachan for example, according to GRIMM, about $1^2/_3$ million kilogrammes of salted Sheatfish are annually exported. In 1881 three-fifths of this quantity was taken in the River Koora and one-fifth in the Black Sea. The total annual catch of Sheatfish in the Black and Caspian Seas, including the nearest parts of the Russian rivers that flow into them, is estimated by GRIMM at $4^1/_3$ million kgm. of flesh and 16,000 kgm. of fish-glue, the latter manufactured from the air-bladder. This is a tough glue, but inferior to (more impure than) genuine isinglass. The skin of the Sheatfish is used by the Russians and Tartars to glaze their windows; and they boil down the fat into lamp-oil (PALLAS).

The usefulness of the Sheatfish is counterbalanced by the damage caused by its voracity, and DAY congratulates his country on the failure of the attempts to introduce the Sheatfish into England.

CYPRINOMORPHI.

Physostomes with the shoulder-girdle (as usual among the Teleosts) suspended to the head. Coracoscapular disk strengthened internally by an arch formed by a special bone (os præcoracoideum) from the coracoid bone to the clavicle or the upper (anterior) margin of the scapula. The first four abdominal vertebræ deviating more or less distinctly from the normal vertebral form, and partly metamorphosed into so-called acoustic bones. Hyomandibular and pterygo-palatine arches as well as the opercular apparatus complete. Maxillary bones fully developed. No jaw-teeth. Body naked or covered with cycloid scales. Head generally naked, at least on the sides and snout[a].

This series of families was established, as we have mentioned above, by COPE under the name of *Plectospondyli*, but according to his definition thereof is far less natural than the preceding series. On the one hand it includes in his works the so-called Salmon-Carps (*Characinidæ*), inhabitants of the tropical regions of Africa and America, with the posterior part of the edge of the mouth formed, as in the *Salmonidæ*, by the maxillary bones and, in the great majority of the genera, with an adipose fin on the posterior part of the dorsal margin, as in the Salmons. On the other hand the series excludes the so-called Toothed Carps (*Cyprinodontidæ*), a tropical and subtropical Carp-like family with range extending round the globe, destitute, it is true, of the osseous connexion between the air-bladder and the saccate extensions of the cranial cavity and also without præcoracoid bone, but with the edge of the mouth formed, as in the Carp-fishes, by the intermaxillaries alone, though these bones, in contradistinction to those of the Carp-fishes, are furnished with teeth. If we add to this that the Salmon-Carps, like the Salmons, have well-developed pyloric appendages, while the Toothed Carps, like the Carp-fishes, are destitute thereof, we have sufficient anatomical grounds for breaking up the series *Plectospondyli*. The series then acquires, with the above characters, the same limitation as GÜNTHER'S family *Cyprinidæ*, its members being restricted to the chiefly Asiatic Loach-fishes (*Cobitidæ*) and Stone Carps (*Homalopteridæ*), the Carp-fishes (*Cyprinidæ*) of the Old World and North America, and the Suckers (*Catostomidæ*), chiefly from North America. All these fishes have the edge of the mouth formed, at least for the most part, by the intermaxillary bones, with the maxillaries lying above and behind them, and all are without jaw-teeth. Only two of these families are represented in the Scandinavian fauna.

A: Air-bladder entirely or partly enclosed in an osseous capsule; at least six barbels ...... Fam. *Cobitidæ*.
B: Air-bladder without osseous capsule; at most four (or no) barbels ...... Fam. *Cyprinidæ*.

[a] The genera *Lepidocephalus* and *Lepidocephalichthys*, *Cobitida* from India and Further India, are furnished, however, with scales on the sides of the head. See BLEEKER, *Atl. Ichth. Ind. Or.*, tome III, p. 12 and DAY, *Fish. Ind.*, p. 609.

Fam. COBITIDÆ.

Air-bladder more or less reduced, entirely or partly enclosed in an osseous capsule. Mouth fringed with six or more barbels. Pseudobranchiæ wanting.

This family was established under the name given above by Bonaparte[a] in 1846, but subsequently received of Heckel and Kner[b] the name of *Acanthopsides*, derived from the generic title which Agassiz had supposed to be deserved by our most common species. By most authors, however, the family has been regarded as a subfamily among the Cyprinoids. Still it possesses so many distinctive characters that it may well maintain its position in the system. The most prominent among these characters are those which suggest an alliance with the Glanomorph series. Among these we find externally the slimy skin, generally naked, otherwise with small scales, and the comparatively numerous barbels round the mouth; while internally the capsule of the air-bladder reminds us of the corresponding structure in many of the Glanomorphs, and the ossification of the head shows a fronto-parietal fontanel similar to that we have remarked above in the Siluroids. The intestinal respiration of the Cobitoids may also be in some degree a trace of their connexion with the preceding series of forms, where we have seen the respiration of air accomplished in various ways, and where the respiration of water seems in certain fishes to be assisted by an apparatus consisting of ramified appendages in the anal region. In the present series, on the other hand, it has long[c] been known that under certain circumstances, where there is scarcity of water or of the oxygen contained therein, our European Cobitoids ascend to the surface and swallow air, which they audibly eject after a time through the vent, with the oxygen now changed to carbonic acid gas.

The Cobitoids are distinguished from the following family not only by the capsulate air-bladder and the greater number of the barbels, but also by the absence of pseudobranchiæ — this is also the case in the great majority of the Glanomorphs — and the comparatively small size of the gill-openings, the branchiostegal membranes being united underneath for the greater portion of their length to the isthmus. The lower pharyngeals are destitute of the strength which they possess in the following family, are more like branchial arches, and are armed with a row of weaker, but in general more numerous teeth.

The air-bladder is partly free, it is true, in several fishes of this family, a posterior division thereof lying free within the abdominal cavity. But in others, and in particular in all our European species, it is completely enclosed in a porous or retiform, osseous capsule, or only a small, rounded expansion of the air-bladder[d] juts out at the hind orifice of the capsule, where otherwise only the pneumatic duct descends to the œsophagus. The osseous capsule of one of the European species, *Cobitis* (*Misgurnus*) *fossilis*, is excellently described and figured by Weber (l. c.). Its morphological explanation consists in a tumidity and transformation of the osseous structure originally belonging to the lower and inner parts of the transverse processes of the third vertebra and to its pair of ribs. The upper and outer (dorsal) part of this transverse process on each side may still be distinguished in the wall of the capsule; and in our Spined Loach (*Cobitis tænia*) the top of this process, as well as each of the ribs behind it, bears a scleral (epipleural, muscular) bone branched at the top. The osseous point that projects downwards on each side of the capsule, also presents an unmistakable resemblance to the ends of the ribs behind this point. The same explanation is given of the hollow bone extending from each side of the body of the second vertebra and from the lower part of its neural arch, backwards, outwards, and downwards, above the anterior upper part of the surface of the osseous capsule. Within this hollow bone are contained the so-called acoustic bones. In the Spined Loach this hollow bone — the outcome of the material of the

[a] *Cat. Met. Pesc. Europ.* pp. 5 and 26.

[b] *Sussurasserf. Oesterr. Mon.*, p. 296.

[c] See Erman i Gilbert's Annalen der Physik, Bd. XXX (1808), p. 140. Cf. also Siebold, *Sussurasserf. Mitteleur.*, p. 340.

[d] See Weber, *De Aure* etc., tab. VI, fig. 48, sign. 8.

lateral parts of the second vertebra — bears on its top a scleral bone, the second in order from in front: — the first (sometimes double) lies on each of the lateral occipital bones.

Such is the osseous capsule in *Cobitis fossilis* and *C. tænia*, in form a transversely-set ellipsoid, entire, and contracted only at the middle of its ventral side by a shallow groove in the longitudinal direction of the body; but in our second species, the Loach (*Cobitis barbatula*), this contraction has gone so far that the two lateral parts of the osseous capsule are separated from each other, though posteriorly united on the ventral side by a hollow osseous bridge. In this species we also find, strange to say, a well-developed pair of ribs on the first vertebra.

On each outer (lateral) side of the osseous capsule (or on the outside of its divisions in the Loach) we find two holes, one of which leaves room for the union of the hind extremity of the so-called *malleus* with the air-bladder, while the second, posterior, and larger hole admits into the osseous capsule, to the lymphatic chamber surrounding the air-bladder[a], a membranous duct from the subcutaneous connective tissue. A communication (*introitus capsulæ vesicæ*) is thus formed between the air-bladder and the side of the body exactly above the insertion of the pectoral fin and on a level with the upper angle of the gill-opening[b], where this duct passes between the dorsal and lateral divisions of the great lateral muscle. The latter communication has its analogue, as we have seen above, both in *Balistes* and the Glanomorphs; but here we have no evidence to show that it is connected in any way with the production of sound. On the other hand, the signification which HASSE and SAGEMEHL have attributed to the connexion between the air-bladder and the apparatus of hearing, that of a barometrical apparatus, here finds perhaps its strongest corroboration, for we know that these fishes are so sensitive to changes of atmospheric pressure that they have long been trusted as weather-prophets. One species (*Misgurnus fossilis*) has received in Germany the name of *Wetterfisch*[c]. "It has been observed," says BLOCH[d] "that at the approach of storm this fish rises from the bottom towards the surface and is particularly restless in its movements. It may therefore be used instead of a weather-glass, if set in a glass vessel containing river-water or rainwater and a little rich soil at the bottom. Twenty-four hours before a storm of wind or thunder it invariably grows restless, disturbs the water till it becomes turbid, and rises and sinks up and down in the vessel. In settled weather, on the other hand, it usually lies still at the bottom. The fish may be kept alive almost a whole year, if the water and soil are changed only twice throughout the summer and once a week during the winter. In winter, however, it must be placed in a warm room and at a window."

The Cobitoid family consists exclusively of freshwater fishes, the great majority belonging to Asia and the neighbouring islands. According to BLEEKER the number of species exceeds 80; DAY knew 46 from India. The former distributes these species among 12 genera, GÜNTHER[e] recognises 11. The three species that occur in Europe belong, according to these opinions, each to a distinct genus, the first (*Misgurnus*) with barbels on both jaws — this character is possessed by *Misgurnus fossilis*, an inhabitant of the regions south and east of the Baltic —, the second genus (*Nemachilus*) without erectile spine below the eyes (like *Misgurnus*), but without barbels on the lower jaw — this genus is represented by the Loach (*Nemachilus barbatulus*), which has been observed in several localities in Scandinavia —, and the third (*Cobitis*) containing our common Spined Loach (*Cobitis tænia*), without barbels on the lower jaw, but with an erectile spine (at other times directed backwards) below each eye. It has already been remarked, however, by VALENCIENNES[f] that on a very minute examination of *Misgurnus fossilis* we discover a small crevice in the skin below each eye, and that

[a] Cf. HASSE, *Anatomische Studien*. Bd. 1, p. 595.

[b] See WEBER, l. c., tab. VI. figg. 45 and 46.

[c] HECKEL and KNER, *Susswasserf. Oesterr. Mon.*, p. 300.

[d] *Naturg. Fisch. Deutschl.*, Th. I, p. 218.

[e] *Introd. Stud. Fish.*, p. 604.

[f] CUV., VAL., *Hist. Nat. Poiss.*, vol. XVIII, p. 6. In our specimens of *Misgurnus fossilis* we easily discover a longitudinal groove below the eyes; but the crevice in the skin is impossible to detect, and the spine that may be felt at the lower anterior corner of the eye, lies in front of the said groove. On dissection, however, it appeared that WEBER (*De Aure* etc., figs. 43 and 44) was perfectly correct in representing in his figure a preorbital spine in *Misgurnus fossilis*. This spine lies hidden among the muscles, but is movable as in *Cobitis tænia* and has the same form, the analogy being so complete that the other spine, which is more easily felt externally, corresponds to the lateral spine on the true preorbital spine of *Cobitis tænia*.

in this crevice may be felt the tip of a spine, which does not, however, admit of erection. Again, DAY observes of the Indian species of the genus *Nemachilus* that "sometimes the preorbital is raised and with a free lower edge, while this may not occur in all examples of the same species". Several authors too, MOREAU and LILLJEBORG for example, have abandoned the attempt to distinguish the genera within this family exclusively by the presence or absence of the preorbital spine. On the other hand, it seems highly probable, to judge by our knowledge of the remaining genera, and also when we consider the analogous relations within the Glanomorph series, that the presence or absence of barbels on the lower jaw affords a constant and more useful generic character, though in many species that are otherwise without them, these barbels are indicated by contractions and interposed swellings on the underlip. Whether we choose on this ground to retain the genus *Misgurnus* for the European *Misgurnus fossilis* and a few other species, or whether we regard this group as a subgenus of the genus *Cobitis*, a course for which we shall find strong reasons below, is a matter of no great importance in the Scandinavian fauna, for though *Misgurnus fossilis* has once been planted in Sweden — in ponds at Ulriksdal, according to LINNÆUS — it has not spread, so far as is known, to any extent in this country.

GENUS COBITIS.

Six barbels[a], none on the lower jaw. Body elongated, terete, or compressed. Head naked (without scales). Dorsal fin short and situated above the ventral fins. Caudal fin rounded, truncate, or slightly concave.

This genus comprises the great majority of the family. Including the species that have previously been referred to the genus *Nemachilus*, as being without movable preorbital spine below the eyes — by far the greater number belong to this class — 67 species have been adopted and described by GÜNTHER, DAY, HERZENSTEIN, and BLEEKER. DAY enumerates 31 species from India. HERZENSTEIN assigns 17 species to the highlands of Central Asia (Tibet). From Syria and Palestine 7 species are known, described by HECKEL and GÜNTHER. BLEEKER cites only two species from Java and Sumatra, CASTELNAU two from Cape Town[b]. Europe also possesses two species of the genus. It thus appears that the genus thrives best in the rivers and brooks of the Asiatic Highlands; and it is probably thence that it has spread to the lowlands.

In one of our European species (*C. tænia*) CANESTRINI[c] remarked in the structure of the pectoral fins an external difference between the sexes, an observation which HERZENSTEIN has subsequently verified with one or two modifications, in the majority of the species that inhabit Central Asia. In the males of these species the second ray of the pectoral fins is more or less thickened and broad, and furnished during the spawning-season with tubercles or spines.

The members of this genus are in general of insignificant size[d], though, as VALENCIENNES has pointed out, not to such an extent that we are justified in assuming that it was to these fishes that ARISTOTLE referred when he included **Κωβῖτις** among the *Aphyæ* (cf. above, p. 264). The genus *Cobitis* of modern ichthyology dates from ARTEDI.

In Scandinavia only two species are found:

1: Preorbital bone furnished with a spine... *Cobitis tænia*.
2: No extensile spine below the eyes .... *Cobitis barbatula*.

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[a] In one Indian species there are 8 barbels; but all of them belong to the snout and the upper jaw.

[b] These two species are recognised by GÜNTHER, however, merely as doubtful.

[c] *Fn. Ital.*, part III, Pesci, p. 21.

[d] One species, *Cobitis yarkandensis* from the Asiatic Highlands, attains, however, a length of at least 5 dm., and is thus only slightly inferior in size to the European *Misgurnus fossilis*, which sometimes measures $3^1/_2$ dm.

THE SPINED LOACH (SW. NISSÖGAT).

COBITIS TÆNIA.

Plate XXXI. fig. 4.

Body laterally compressed. Breadth (thickness) of the head at the eyes less than $^2/_5$ of its length; breadth of the interorbital space less than the diameter of the latter. Below each eye a movable preorbital spine pointing in a backward direction.

R. br. 3; *D.* $\frac{(2)+1}{7-8}$; *A.* $\frac{(2)+1}{5}$; *P.* $\frac{(1)+1}{8}$; *V.* $\frac{(1)+1}{6^a}$;
C. $x+1+14+1+x$; *Vert.* 45[b].

Syn. *Cobites aculeata*, ROND., *Pisc.*, part. II, p. 204. *Tænia cornuta*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 74. *Cobitis*, aculeo bifurco infra utrumque oculum, ART., *Gen. Pisc.*, p. 2: *Syn. Pisc.*, p. 3; *Spec. Pisc.*, p. 4.

Cobitis Tænia, LIN., *Syst. Nat.*, ed. X, tom. I, p. 303; *Fn. Suec.*, ed. II, p. 121; BL., *Naturg. Fisch. Deutschl.*, I, p. 221, tab XXXI, fig. 2; PALL., *Zoogr. Ross. As.*, tom. III, p. 166; FLMNG (*Gobitis*), *Brit. Anim.*, p. 189; NILSS. (*Cobitis*), *Prodr. Ichth. Scand.*, p. 35; JEN., *Man. Brit. Vert.*, p. 417; AGASS. (*Acanthopsis*), Mem. Soc. Neuch., tom. I, p. 36; YARR. (*Botia* ex GRAY), *Brit. Fish.*, ed. 1, vol. I, p. 381; KR., *Danm. Fiske*, vol. III, p. 564; CUV., VAL. (*Cobitis*), *Hist. Nat. Poiss.*, vol. XVIII, p. 58; NILSS., *Skand. Fn., Fisk.*, p. 345; KESSL., Bull. Soc. Natural. Mosc., tom. XXIX (1856), p. 352; HCKL, KN., *Susswasserf. Oesterr. Mon.*, p. 303; *Costa*, *Fn. Regn. Nap.*, *Pesci*, Abdom. Malacott. Cypr., p. 31; SIEB., *Susswasserf. Mitteleur.*, p. 338; MGRN, *Finl. Fisk.* (disp. Helsingf.), p. 37; STEIND., Stzber. Akad. Wiss. Wien, Math. Naturw. Cl. LII, I (1865), p. 490; BLANCH., *Poiss. d. eaux. douces Fr.*, p. 285; CANESTR., Arch., Zool., Anat., Fisiol., vol. IV, fasc. I, p. 146; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 362; CANESTR., *Fn. Ital.*, part. III, Pesci, p. 20; CEDERSTR., Öfvers. Vet. Akad. Föth. 1874, No. 9, p. 47, tab. XI; FEDDERS. (*Botia*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 92; MOR. (*Cobitis*), *Hist. Nat. Poiss. Fr.*, tom. III, p. 434; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 147; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 201, tab. CXXXVII, fig. 3; MELA, *Vert. Fenn.*, p. 314, tab. X; NORBÄCK, *Handl. Fisker.*, *Fiskafr.*, p. 144; LILLJ., *Sv.*, *Norg. Fisk.*, vol. III, p. 345; FATIO, *Fn. Vert. Suisse*, vol. IV, tab. V, fig. 2; vol. V, p. 10.

Cobitis caspia, EICHW., Bull. Soc. Nat. Mosc. 1838, II, p. 133.

Cobitis tænia japonica, SCHL., *Fn. Japon.*, p. 222, tab. CIII, figg. 3 et 3. *a*.

Cobitis elongata, HCKL, KN., l. c., p. 305.

Cobitis larvata, DE FIL., Mem. Accad. Torin., XIX, p. LXXI, vide CANESTR. Arch. Zool., Anat., Fisiol., vol. IV, fasc. I, p. 150, tav. VI, fig. 7.

The Spined Loach is in general the smallest of the European Cobitoids, its ordinary length being between $^1/_2$ and 1 dm., though according to MOREAU it may sometimes attain a length of 12 cm. From Krain (Austria), however, HECKEL and KNER have described examples of this species, under the name of *Cobitis elongata*, that measured nearly 16 cm.

The body is shallow and compressed, but of fairly uniform depth. The greatest depth of the body, which generally lies about half-way between the head and the dorsal fin, is about $^1/_8$ of its length[c]. The thickness at the same point is about $^7/_{11}$ of the depth in our most terete specimen; but as a rule the body is still thinner, the greatest thickness being sometimes no more than half the greatest depth. The body is of almost uniform thickness throughout its depth, with obtusely rounded dorsal and ventral edges, at the tip of the tail ribbon-shaped, in front with the snout obtusely rounded at the sides. This species, like the next one and the majority of the species within the family, is characterized in general by a slightly marked (comparatively deep) peduncle of the tail, the least depth thereof varying between 7 and 8 % of the length of the body. But in the aforesaid form (*Cobitis elongata*) described by HECKEL and KNER, this depth seems from their figure to have been only 5 % of the length of the body.

The length of the head measures $16^1/_2$[d]—$14^1/_2$ % of that of the body. It gives the fish a singular appearance on account of its sharply arcuate upper profile, with the deep snout projecting beyond the mouth and lower jaw, which lie on the same plane as the lower profile, which is generally straight. The specific

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[a] Sometimes 5, according to HECKEL and KNER.

[b] 41, according to VALENCIENNES. 40—42, according to CANESTRINI. 43—44, according to CEDERSTRÖM.

According to CANESTRINI'S measurements of 23 specimens the greatest depth of the body varies between 10 and $16^1/_2$ % of its length, increasing generally with age.

[d] In young specimens (less than $^1/_2$ dm. in length) even $18^1/_2$ %, according to CANESTRINI.

character also appears with considerable distinctness in the compressed form of the head, the thickness at the eyes being less than $^2/_5$ of the length of the head[a], or than $^3/_4$ of the length of the base of the dorsal fin[b]. The deep form of the snout is due to the marked development of the vertical plate of the ethmoid bone in front of the narrow frontal bones, which are arched above the orbits. The small round eyes are set high and turned somewhat upwards, above the more or less tumid cheeks, the distance between them and the upper profile of the forehead being about half their diameter[c]. Their position is such that the length of the snout[d] (from their anterior margin obliquely downwards to its tip) is less than the postorbital length of the head[e] (from the posterior margin of the eyes obliquely downwards to the hindmost part of the margin of the branchiostegal membrane). As in *Misgurnus fossilis* they are entirely covered with a thin skin (*oculi velati*, BLEEKER), the orbits being externally destitute of any sharp limits. The anterior part of the orbits is coasted below by a longitudinal slit in the skin, out of which slit the fish can erect the preorbital spine, which otherwise points in a backward direction. This spine is formed, as LILLJEBORG has pointed out, by the anterior frontal (lateral ethmoid) bone on each side. This circumstance may be most easily elucidated by a comparison with the following species, where the anterior frontal bone occupies exactly the same position as the extended (vertical) base of the spine in this species, forming the anterior margin of the orbit in a vertical position between the frontal and parasphenoid bones, but with a firm osseous connexion (suture) with the anterior outer margin of the orbitosphaenoideum, which even separates the frontal bone proper from the upper anterior corner of the triangular anterior frontal bone. Here, in the Spined Loach, the said osseous connexion is loose and transformed into an articulation. The bone is also of much harder texture, white and firm as dentine. Its base, which forms the long, vertical articulation with the orbitosphenoid bone, is almost terete and curved in a rounded obtuse angle, but is set in a somewhat oblique position, the lower (shorter) arm of the angle running obliquely inwards and forwards, while the upper arm is vertical. The tooth projects backwards in a direction approaching to that of the lower arm, at least below the middle of the basal part. It is curved backwards and inwards and is generally bicuspid, a shorter, but equally pointed tooth being set at the middle of the outer surface of the main tooth[f]. The base of the tooth is united by a strong ligament to the hind margin of the orbit. The suborbital bones seem otherwise to be entirely wanting both in this species and *Misgurnus fossilis*. In front of the preorbital spine a dentiform protuberance belonging to the palatine bone may be felt beneath the skin, at the point where

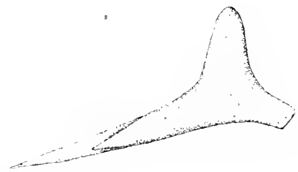

Fig. 176. Right preorbital spine of a *Cobitis tænia*, seen from without. About 15 times the natural size.

this bone is elongated in a backward direction to meet the entopterygoid bone. The nostrils are set rather high on the sides of the snout, somewhat nearer to the eyes than to the tip of the snout. The posterior nostril on each side is round and somewhat larger than the anterior, which lies just in front of it, and the hind superior margin of which is canaliculate or elevated in an obliquely-cut, tubular form. The mouth is small and toothless; it lies on the under surface of the head, fringed by a comparatively thin upper lip, thickened only at the corners of the mouth, and small barbels, which comprise one pair in front and one on each side at the middle of the upper jaw, belonging to the dermal fold that runs from the cheeks over the mouth and forms the tip of the snout. The hindmost (largest) pair of barbels, on the other hand, lie at the corners of the

[a] 26—36 %, according to our measurements of specimens between $^1/_2$ and 1 dm. long. The greatest thickness of the head measures, according to CANESTRINI, 27—40 % of its length in the typical *Cobitis tænia*; but in the form which has received the name of *C. larvata*, it is said sometimes to measure $47^1/_2$ % thereof.

[b] 48—69 %, according to our measurements.

The diameter of the eyes is about 20—15 % of the length of the head.

[d] About 38—43 % of the length of the head.

[e] About 49—56 % of the length of the head.

[f] G. C. CEDERSTRÖM (l. c.) has remarked as an external sexual difference that in the males the preorbital spine is furnished with several lateral denticulations. In the males examined by us, however, this character does not hold good.

mouth and belong to the thick part of the lip. On the lower jaw too, the lip runs back in a dermal flap on each side. This flap, as KRØYER[a] has already pointed out, may now and then be denticulated or even produced at some spot so as to resemble a barbel, thus depriving the above-mentioned generic difference between *Cobitis* and *Misgurnus* to some extent of its validity. The intermaxillary bones are small and narrow, with the main branches only slightly longer than the straight nasal processes. The maxillaries, on the other hand, are high and of singular form. Behind the articular knob they expand into a square, but again contract, and at the hind extremity once more expand into a rounded lobe curved in a downward direction. In the upper jaw we find a well-developed palatal fold. There is no free tongue. On the first branchial arch the gill-rakers are set in a single row (containing 11—14) corresponding to the posterior row on the other

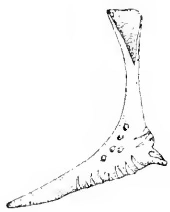

Fig. 177. Right lower pharyngeal of a *Cobitis tænia*, seen from within and above. About 15 times the natural size.

arches, where they are set in a double row, and on the lower pharyngeals in one row (containing 7) on the outer anterior margin of these bones. They are short and depressed. The pharyngeal teeth are subulate, pointed, and curved; they are set in a row (10 or a few more, 3 of which lie on the upper arm) on the inner (posterior) margin of the lower pharyngeals, which are geniculate, like branchial arches. Sometimes, however, we find one or two smaller teeth (supplementary teeth?) beside the principal row. The gill-openings are merely vertical slits, the branchiostegal membrane on each side of the body coalescing with the skin at the anterior end of the insertion of the pectoral fin. The height of the opening is about equal to the thickness of the head at the eyes; but the branchiostegal membrane is loose, the gill-openings being thus capable of expansion by means of the three long, sabre-like branchiostegal rays on each side. The preoperculum extremely narrow, the other opercular bones well-developed. The hind inferior margin of the operculum proper is curved in an S-shape, with the anterior lower corner produced in a downward direction, but the breaks are filled by the suboperculum. As we have mentioned above, the head is scaleless; but the ducts belonging to the system of the lateral line are usually quite distinct on its surface, being marked by rows of small pores, often raised in a tubular form, along the temples, straight across the occiput, along the preoperculum and the branches of the lower jaw, on the forehead and at the upper orbital margin on each side, and along each of the cheeks, below the slit containing the preorbital spine and forward on the snout below the nostrils.

The body, on the other hand, is densely covered with small, round, thin, imbricated, cycloid scales. The lateral line is distinct only at the very beginning, where it forms a backward continuation of the temporal canal, first sloping downwards and then straight, for a distance of about twice the longitudinal diameter of the eyes.

The dorsal fin is obliquely rectangular, with the upper angles rounded, the upper posterior margin being thus more or less convex. Its base is somewhat elevated in front, forming a slight break in the otherwise straight contour of the back. Its beginning lies at a distance from the tip of the snout that measures about 41—43 % of the entire length of the body, 47—50 % of the length of the body *minus* the caudal fin, or 67—65 % of the distance between the anal fin and the tip of the snout, and is generally situated somewhat in front of the perpendicular from the insertions of the ventral fins. At its origin we find two rudimentary, unarticulated rays (supporting rays), the first extremely small, the second about one-third as long as the third ray. The third ray is simple (undivided) but articulated, and only slightly shorter than the fourth, which is the longest ray in the fin and, like the remaining rays, branched. The last ray is about half as long as the longest one, and there is no fin-membrane behind it. The shape of the fin is highly inconstant, the length of its base (on an average about $8^1/_2$ % of the length of the body[b]) varying between 64 and 76 % of its height (the length of the longest ray).

The anal fin is of the same structure and shape as the dorsal, only that the branched rays are fewer and

[a] *Danm. Fiske*, III, p. 568.

[b] Varying, according to CANESTRINI's measurements, between 7·2 and 10 % of the length of the body.

the base shorter, on an average about 6 % of the length of the body[a]. Its shape varies otherwise exactly as that of the dorsal fin. The lips of the vent protrude in a tubular form within a triangular depression, which is situated just in front of the beginning of the anal fin, or at a distance in front of this point hardly as great as the diameter of the eyes.

The pectoral fins consist of 8 or 9[b], sometimes 10 rays. In the last case we find two simple rays (the first only rudimentary) at the anterior margin of the fins; while otherwise only the first ray is simple and not much shorter than the second, which is branched and either longest or about equal in length to the third ray. The remaining rays gradually decrease in length and are all deeply branched, except the last, which is simple and about $\frac{1}{3}$ as long as the longest ray. The fins are set low down and when expanded occupy a horizontal position. Besides the above-mentioned sexual difference first remarked by CANESTRINI in the structure of the pectoral fins, we also find in the Spined Loach a second one, which was pointed out by BONIZZI to CANESTRINI. At the base of the posterior (upper or inner) side of the pectoral fins we find a cartilaginous lobe, set in an obliquely transverse position. This lobe is large and of more general occurrence in the males[c], smaller, rudimentary or, most commonly, entirely wanting in the females. CEDERSTRÖM noted a third external difference between the sexes, consisting in the fact that in the males the pectoral fins are as a rule longer, and therefore more pointed, than in the females. In 7 males, between 50 and 73 mm. long, the length of the pectoral fins varied between 15 and 18 % (on an average $16\frac{1}{2}$ %) of that of the body; in 5 females, between 88 and 96 mm. long, this percentage varied between 10 and $11\frac{1}{2}$ and was on an average 11[d].

The ventral fins are of the same structure as the pectoral, but shorter and more rounded. In the males their length is about 14—13 %, in the females about 9—10 % of that of the body. In this relation, however, we must also take into consideration the changes of growth, for the relative length of the ventral fins decreases with increasing age. At the outer angle of the insertion of each ventral fin — where in the Teleosts in general a triangular dermal flap, free at the top and pointing in a backward direction, is furnished with singular, generally elongated scales — we find a small, vesiculate, oblong and posteriorly blunt, dermal swelling, which is, however, without scales of a special type[e].

The caudal fin, which in specimens between $\frac{1}{2}$ and 1 dm. long occupies about 13—12 % of the length of the body, is truncate with rounded corners. The middle 14 rays are branched. The small, short, supporting rays generally number 3 or 4 (sometimes 5[f]) above and 2 or 3 (sometimes 4[f]) below. The base of the fin advances, in the form of a thin ridge, forward along the upper and lower margins of the peduncle of the tail.

The digestive canal is extremely simple, consisting of a straight tube of almost uniform thickness from the pharynx to the vent, with only a slight expansion in the anterior half to indicate the presence of a special stomach. The peritoneum is silvery white. The liver is long, with two lobes, the right lobe being generally the longer[g]. The ovary is simple, but the testicles are paired. At the spawning-season both the ovary and the testicles extend forward along almost the whole length of the abdominal cavity[h]. When the ovary is as full of eggs as possible, it is deeply forked underneath, thus appearing double when seen from below.

The ground-colour of the body is yellowish, sometimes even orange, on the back more or less dashed with gray, on the belly white. The singular markings consist of dark gray or even blackish spots and streaks. Large spots are set in a longitudinal row at the middle of the back, along the dorsal sides, and along the middle of the sides of the body, where they sometimes coalesce into bands, especially behind; and between these rows

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[a] Varying, according to CANESTRINI's measurements, between 5·4 and 7·1 % of the length of the body.

[b] Sometimes only 6 or 7, according to HECKEL and KNER, CANESTRINI, and BENECKE.

[c] Cf. the similar growth in the Bramoids and Blennioids; see above, pp. 76 and 219

[d] According to CANESTRINI's measurements this sexual difference is less marked.

[e] In the following species this dermal swelling is equally insignificant, in *Misgurnus fossilis* we have failed to find it at all.

[f] According to LILLJEBORG.

[g] As usual, however, varying in length. In a gravid female 108 mm. long the right lobe of the liver extends to a line with the tip of the pelvic bones, the left to the end of the second third of the distance between the insertions of the pectoral and ventral fins. In a male almost ready to spawn and 69 mm. long, the left lobe of the liver is somewhat longer than the right and extends about as far back as the left lobe in the female just mentioned.

[h] In the female just mentioned the eggs were about $\frac{3}{4}$ mm. in diameter. In another female, which had partly deposited its spawn, eggs $1\frac{3}{4}$ mm. in diameter were found.

lie smaller, somewhat lighter spots arranged in a network or scattered. Similar small spots of an oblong shape or even vermiculated also appear on the top of the head and on the cheeks. The most prominent and most persistent parts of this design, even in specimens preserved in spirits, are two black markings, the one on the head, the other on the peduncle of the tail. From the anterior margin of the eye a blackish streak runs obliquely downwards to the tip of the snout, and a similar streak often appears behind the eye horizontally across the temple. At the upper corner of the base of the caudal fin (sometimes at the lower corner as well) we find a black spot, edged during life, like the spots in the large, inferior row on the sides of the body, with a lighter colour. These two markings recur, however, though they are generally less sharply defined, in other species of the genus. The fins are more or less transparent, with lustrous rays, which in the dorsal and caudal fins, sometimes in the pectoral and anal fins as well, are marked with dark spots, distinctly arranged, at least on the first-mentioned fins, in transverse bands. The iris is yellow.

The Spined Loach occurs in the brooks, rivers, and lakes of almost all Europe, and is probably spread throughout Northern Asia, except perhaps the colder regions, for according to SCHLEGEL (l. c.) it lives in Japan. PALLAS also quotes special names for this fish not only from the Ostiacs of Siberia, but also from the Tungs of the River Katunga and Lake Baikal. The Spined Loach goes westward at least to England and Scotland; but in Ireland, according to THOMPSON, it is wanting. VALENCIENNES knew it as a Spanish species. According to CANESTRINI it also occurs in Sicily. In Scandinavia the Spined Loach is common enough in scattered localities in the south and east of Sweden, at least up to Lake Wener and the Mälar Valley. It seems to be commonest in Öster Gothland and in the basin of Lake Mälar. To the best of our knowledge it is wanting in Halland and Bohuslän[a], as well as in Norway. It is assigned to the Danish islands of Fünen, Laaland, and Zealand by FEDDERSEN, who states that it is especially common in Lake Mariebo (Laaland). The Royal Museum possesses specimens from the River Köpinge in Scania and from Jönköping (C. SUNDEVALL), from Lilla Halsviken (Wetter, N. W. of Motala; H. WIDEGREN), from the River Skeninge (numerous specimens; Dr. CNATTINGIUS), from the River Lida in Wester Gothland (J. W. DALMAN), from Lake Wener (1836, Mr. GOEBEL[b]), from Lake Sotter in Nerike (1842, Colonel ANKARSVÄRD), from Lake Mälar off Flottsund (MESCH), from Heleneborg (Liljeholmen), and from Hammarby Lake near Stockholm. In the Norrström (Stockholm) a Spined Loach was taken on the 16th of April, 1846, among specimens of the Smelt. In 1869 CEDERSTRÖM caught a specimen 12 mm. long in the channel off Beatelund in the island-belt of Stockholm, a proof that the Spined Loach can also live in the brackish water of the Baltic. CEDERSTRÖM found the Spined Loach especially plentiful in the River Orsunda in Westmanland. LILLJEBORG assigns it to several other localities in Sweden, and surmises with reason that the Spined Loach is fairly common in Scandinavia, though on account of its insignificant size and its manner of concealing itself it easily escapes notice. This is probably true of Finland as well, though both MALMGREN and MELA state that the Spined Loach is extremely rare in that country and is known with certainty only from the neighbourhood of Viborg and Lake Vuoxen.

The Spined Loach prefers running water, in small streams with a stony bottom, where it can conceal itself under the stones, or with a bottom of gravel, sand, or even mud, in which it can bury itself with only the head visible and ready, when danger threatens, to hide itself entirely or even to creep some distance, burrowing its way through the loose ground. The fish also occurs, however, in still water, as we have seen, in lakes and meres with a suitable bottom. It is oftenest found in company, though not in shoals properly so called. It generally lies still; but when disturbed or when shifting its position it is rapid in its movements. CEDERSTRÖM saw "these fishes dive into the thick, moist ooze and hide themselves there as speedily as a Sand-Eel plunges into wet sand to conceal itself. When they felt themselves prisoners, they at once bent down the head and pressed the flat part of the cheek firmly against the skin of my fingers, thus causing in some instances a slight but disagreeable irritation, most like that of sucking (cupping), on the part of the skin affected." The fisherman may sometimes complain with reason[c] that "when pursuing

[a] HOLMBERG's statement (*Boh. Hist., Beskr.*, p. 30) that the Spined Loach occurs in Ramtvet Mere (Bullar), has received no subsequent confirmation, according to MALM. See *Gbgs. Boh. Fn.*, p. 569.

[b] The Spined Loach has since been taken in Lake Wener (Hammarövik), according to Dr. S. W. TENOW, *Verml., Dals Ryggr. Dj.*, p. 106.

[c] See LLOYD, *Scandinavian Adventures*, vol. I, p. 71. On the 11th of June, 1858 I took some specimens of this species in the River Motala, not far from its outlet in Lake Roxen. There I was told that the Spined Loach was dreaded "for its bite", which was said to be incurable.

his avocation barefooted in the summer the fish not unfrequently wounds his feet;" and if the spine be broken off and left in the wound, it may well cause some trouble. But, as BLANCHARD[a] has already remarked, these spines cannot serve as any formidable weapons of defence, even if they are employed in this capacity in case of need. CEDERSTRÖM assumes their function to be the protection of the eyes, as the fish burrows along in the sand or gravel. Perhaps they may also be organs of adhesion, like the opercular and interopercular spines of the *Stegophilidæ*, those small Brazilian Glanomorphs[b] which usually take refuge in the branchial cavity of larger fishes, and retain their position there by means of the said spines, but which also try to force their way into other cavities, or to attach themselves with the spines to the skin of larger aquatic animals or of persons bathing or wading.

The spawning-season occurs in spring and early summer, from April to July; but as yet we know nothing of its course. It is generally stated that the males are far rarer than the females; but in a consignment of some thirty specimens from the River Skeninge there were as many males as females. The former being, however, as a rule smaller than females of the same age, they probably manage more easily to escape observation.

The food of the Spined Loach consists principally of small crustaceans, *Entomostraca* (*Lynceidæ*, according to CEDERSTRÖM); but the fish also preys on all other minute animals that come in its way. According to KRÖYER it is "fairly voracious and lives on worms, but also on fish-roe, small fry, and other minute aquatic animals." The Spined Loach shows the same propensities in aquaria, where it is "interesting by reason of the eagerness with which it roots up the bottom in quest of food, casting sand and gravel in pellets out of its gill-openings" (BENECKE).

The Spined Loach is of little use as human food, the flesh being dry and tough; but as bait for Eels, Pike, and other predatory fishes it may be employed with advantage[c].

In the Mälar Provinces the Spined Loach is known by several names: *tanglake* (Tang Burbot), according to ARTEDI; *ormfisk* (Snake-fish), according to GYLLENSTJERNA (in NILSSON); *stenlake* (Stone Burbot), according to IVERUS (in LILLJEBORG). In Scania LILLJEBORG heard it called *stenbit* (Stone-biter).

THE LOACH (SW. GRÖNLINGEN).

COBITIS BARBATULA.

Plate XXXI, fig. 5.

Body rather terete. Head somewhat depressed; its breadth (thickness) at the eyes more than $^2/_5$ of its length; breadth of the interorbital space greater than the longitudinal diameter of the eyes. No preorbital spine below the eyes.

R. br. 3; *D.* $\frac{(3\ 1.\ 2) + 1}{6\ 1.\ 7}$; *A.* $\frac{(2\ 1.\ 1) + 1}{5\ 1.\ 6}$; *P.* $\frac{1}{11\ 1.\ 12}$; *V.* $\frac{1}{(6)\ 7\ 1.\ 8}$; *C.* $x + 1 + 16 + 1 + x$; *Vert.* 41[d].

Syn. Cobitis barbatula, ROND., *Pisc.*, part. II, p. 204. *Cobitis* tota glabra maculosa, corpore subtereti, ART., *Ichthyol.*, *Gen. Pisc.*, p. 2; *Syn. Pisc.*, p. 2; LIN., *Fn. Suec.*, ed. I, p. 125.

Cobitis Barbatula, LIN., *Syst. Nat.*, ed. X, tom. I, p. 303; PENN., *Brit. Zool.*, vol. III (ed. 1776), p. 247, tab. LVIII, No. 142; BL., *Naturg. Fish. Deutschl.*, part. I, p. 224, tab. XXXI, fig. 3; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 164; NILSS., *Prodr. Ichth. Scand.*, p. 35; CUV., VAL., *Hist. Nat. Poiss.*, vol. XVIII, p. 14, tab. 520; KR., *Danm. Fisk.*, vol. III, p. 539; NILSS., *Skand. Fn.*, *Fisk.*, p. 343; KESSL., Bull. Soc. Natural. Mosc., tom. XXIX, p. 350; THOMPS., *Nat. Hist. Irel.*, vol. IV, p. 139; SUND., v. WR., *Skand. Fisk.*, ed. 1, p. 207, tab. 53; HCKL., KN., *Susswasserf. Oesterr. Mon.*, p. 301; MGRN, *Finl. Fisk.* (disp. Helsingf.), p. 36; CANESTR., Arch. Zool., Anat., Fisiol., vol. IV, fasc. I, p. 144; STEIND. Stzber. Akad. Wiss. Wien, Math. Naturw. Cl., LIII, I (1866), p. 203; BLANCH., *Poiss. d. eaux douces Fr.*, p. 280; GTHR (*Nemachilus*), *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 354; SUNDSTR., *Fn. Sverig. Ryggradsdj.*, p. 278; FEDDERS. (*Cobitis*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 92; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 432; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.* *W. Preuss.*, p. 145; MELA, *Vert. Fenn.*, p. 313, tab. X; DAY (*Nemacheilus*), *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 203, tab. CXXXVII, fig. 2; MÖB., HCKE (*Cobitis*), *Fisch. Osts.*, p. 123; LILLJ., *Sv.*, *Norg. Fisk.*, vol. III, p. 332; FATIO (*Nemachilus*) *Fn. Vert. Suisse*, vol. V, p. 19.

[a] *Poiss. d. eaux douces Fr.*, p. 287.

[b] See REINHARDT, Vid. Meddel. Naturh. For. Kbhvn, 1858, pp. 83 et seqq. LÜTKEN, ibid. 1891, p. 55, note.

[c] BLANCHÈRE, *La pêche et les poissons*, p. 449.

[d] Sometimes 39 (LILLJEBORG), 40 (KRÖYER), or 42 (VALENCIENNES).

The Loach is generally a little larger than the preceding species. In Scandinavia and Western and Northern Europe it seems never to attain a greater size than 10—13 cm. In the Crimea, however, according to PALLAS, it may sometimes measure nearly half a foot (about 16 cm.); and in the mountain brooks of Persia, he says, it attains a still greater size. The largest specimens we have examined were from Finland and measured 112 mm. in length.

The body is in front more or less terete, behind more and more compressed. The head is entirely different in form from that of the preceding species, but the rest of the body is of almost exactly the same shape, the tail being only slightly shallower than the forepart of the body. The greatest depth of the body measures between 13 and 11 % ($10^1/_2$ %) and the least depth of the peduncle of the tail between about 7 and $8^1/_2$ % of the length of the body.

The length of the head is about 20—18 %[a] of that of the body. Seen from above it is almost parabolical. It is also broader than in the preceding species, somewhat depressed, flattened at the top, with sloping facial line and blunt snout. Underneath it is broad, flat, and even. The entire head is scaleless; but the skin is here finely granulated, the canals of the system of the lateral line being marked by several rows of small, raised tubercles, each pierced with a duct. One row, thin and almost double, runs below the eye from the upper rostral barbel to the lateral line. Another row, containing some few pores, runs above each eye and the nostrils. A third row coasts the margin of the preoperculum and follows the under surface of the lower jaw. A transverse canal across the occiput may also be traced in three scattered pores, set in a row. The eyes are small and somewhat oblong, their longitudinal diameter in specimens between 87 and 112 mm. long being about 16 % of the length of the head. The orbits are distinctly bounded by a dermal fold (*oculi liberi*, BLEEKER). They are set high, at the sides of the flat forehead, separated by a distance of about three times their vertical diameter, and at a distance from the tip of the snout at least (in our specimens) a little greater than the postorbital length of the head, which length in young specimens is almost equal to the breadth of the head at the eyes, in older ones perceptibly less. The cheeks are soft and fleshy, without spine or hollow depression. The nostrils lie just in front of the eyes, each lateral pair being so close together that the anterior nostril does not extend half-way from the eyes to the tip of the snout. The posterior is the larger and simple, the anterior has a raised, tubular margin, which projects behind in a point and thus resembles in form a quill pen. The mouth lies, as in the preceding species, under the tip of the snout and is very small and transversely set. The lips are thick, and the upper seems double, as in so many other fishes, this being due to the formation of an upper fold by the projecting skin of the snout itself, in addition to the fold starting from the intermaxillary bones. These two folds send out, as in the preceding species, 6 thick, soft barbels, so arranged that two pairs originate from the under surface of the upper fold, the smaller pair at the very tip of the snout and the other pair just behind this point; while the third pair starts from the very corners of the mouth and contains the largest barbels, their length being a little more than $^1/_3$ of that of the head. The underlip is more fleshy and at the middle — often on the sides as well — cloven or divided into lobes. The gill-openings are small, the branchiostegal membrane passing, in the same way as in the Spined Loach, into the skin of the belly just below the base of each pectoral fin, so that the openings are separated by the entire breadth of the broad, flat breast. This membrane contains 3 long, but not broad rays, which extend almost below the tip of the operculum. The operculum itself as well as the small, oblong suboperculum is distinct; the other opercular bones are well covered by the thick skin. The apparatus of the branchial arches exhibits in the form of the urohyoid bone a striking resemblance to the corresponding bones in the Sheatfish.

The dorsal fin begins somewhat in front of the middle of the entire length of the body, or about half-way — sometimes a little farther back — along the body *minus* the caudal fin: the distance between this fin and the tip of the snout measures in our specimens about 42—48 % of the entire length of the body, 48—55 % of the length of the body excluding the caudal fin, or 65—71 % of the distance between the anal fin and the tip of the snout. The length of its longest ray is about equal to the greatest depth of the body or somewhat greater than this depth, and is much greater than the length of the base of the fin, which seems as a rule to vary between

[a] 19—16·6 %, according to CANESTRINI's measurements.

about 9 and 11 %[a] of the length of the body. The rays are actually 11 in number, but the first two are so small and fine as to be difficult of detection; the third ray is also quite short; the fourth ray does not extend quite to the top of the fin and, like the rays in front of it, is simple; the fifth and sixth rays are the longest and, like the following ones, branched.

The anal fin is much smaller and generally contains 8 or 9 rays, among which the first branched ray (the 3rd or 4th from the beginning) is the longest. The vent occupies the same position as in the preceding species.

The caudal fin is truncate at the hind margin, with rounded corners. Of its 18 articulated rays the 14 middle ones are equal in length, but the two uppermost and the two lowest somewhat shorter. The outermost of these rays above and below is simple, the others are branched. Besides these there are a few quite short, unarticulated, supporting rays. The median length of the fin varies between about 11½ and 14 % of that of the body or between 60 and 75 % of that of the head.

The pectoral fins are fairly large — their length greater than the greatest depth of the body — broad, and rounded, with 11—13 rays (usually 12), among which the first is simple, articulated, and rather short, the others are multifid and deeply branched, the second and third being the longest, the last two very small and difficult to distinguish with accuracy.

The ventral fins are much smaller than the pectoral, their length being only slightly greater than the height of the anal fin. They begin almost vertically below the beginning of the dorsal fin, are oval in shape, and contain 7—9 rays (usually 8), among which the outermost is simple, articulated, and rather short, the others are deeply branched, the innermost two closely united, and the second and third the longest.

The scales are rather small — in specimens 12 cm. long their breadth is less than 1 mm. — and circular, densely set, but not imbricated, numbering about 15 from the lateral line to the dorsal edge. On the forepart of the body, on the back and belly, we find only a few, scattered here and there; on the hind part of the body they are firmly inserted and set close together. The lateral line is straight. Neither here nor in the Spined Loach does it pierce any scales. It starts from the upper angle of the gill-opening and then follows the middle of the side. In front it is furnished with distinct, prominent pores, but behind these pores become indistinct, being hidden by the scales.

The coloration is of a fairly bright, grayish brown with darker, large spots along the back and the lateral line; but these spots are not so distinct and constant as in the Spined Loach; below they are broken up into an inconstant pattern, with which the sides of the body as well as the cheeks are mottled. As a rule we find a black streak on the sides of the snout as in the Spined Loach; and an oblong, black spot usually appears at the lower corner of the base of the caudal fin; but even these markings are less defined than in the Spined Loach. The dorsal, caudal (sometimes the anal as well), and pectoral fins bear transverse bands of dark spots. The ventral fins as well as the anal fin are in most cases plain, in others marked with a few dark spots.

The internal organs differ from those of the Spined Loach partly in the liver being somewhat shorter and behind not divided into lobes but collected in a mass, which envelops the stomach below and on the sides, partly in the stomach being furnished with a pyloric part pointing in a forward direction: the intestine also forms a coil, which runs forward beside the posterior part of the stomach. The ovary is forked in front.

According to observations made in the vicinity of Kuopio in Finland and communicated by W. von Wright to Sundevall, the Loach is there common[b] in streams and brooks with fairly clear water, a gravelly bottom, and a depth of a foot or two. It is said to keep close to the bottom and generally to hide under stones, but not to burrow in the bottom, as the Spined Loach does. In the said locality it spawns at the beginning of June, about a fortnight after the breaking up of the ice. In Germany, according to Bloch and other writers, it spawns in March and April, or early in the spring, there as in Finland. Its habits are otherwise not unlike those of the Spined Loach.

Linnæus tells us in the *Fauna Suecica* that this species was introduced from Germany into Lake Mälar by King Frederick I; and the Royal Museum possesses two specimens with no assigned locality, but marked in the same way as the other fishes from the Museum of Drottningholm, where Linnæus examined and de-

[a] Sometimes about 8 %, according to Canestrini's measurements.

[b] According to Qvensel's catalogue one specimen in the Royal Museum was taken in 1800 at Uleaborg. Mela also believes that the species occurs in the extreme north of the Gulf of Bothnia.

scribed them. These specimens may thus be ascribed with reason to the said transplantation. However, the Loach does not seem to have continued to multiply in Lake Mälar; SUNDEVALL at all events never succeeded in obtaining the slightest evidence of its occurrence there. On the other hand, it has been found in recent times both in Scania and the south of Halland. In Scania it was discovered in 1864 by Lector HULTMARK in a brook at Trollenäs and by Mr. C. MÖLLER at Gisleberga and Bosarp; in 1869 it was met with by A. NATHORST in the river at Andrarum. In 1888 the Royal Museum received through Mr. TRYBOM, Assistant Inspector of Fisheries, two specimens which had been taken by Mr. F. SVENONIUS in the Laga River at Laholm. It may possibly be found on closer investigation to occur in a few more parts of Sweden; but a fish of this small size may easily escape observation. In Norway it is wanting, to the best of our knowledge; but in Jutland it was found in 1878 by C. E. VARMING in the River Nebels. — It has been met with throughout the rest of Europe as well as the north of Asia. In Germany it is said to be taken at several places in great numbers with nets constructed for the purpose. Its flesh has always been praised as highly delicious and so easy of digestion that even a weak stomach has nothing to fear from it. BLOCH describes at length the method of constructing holes or small pools for the cultivation of this fish.

The Swedish name (*Grönling*), which we have applied to this species, is given by LINNÆUS in his *Fauna Suecica*. It is now unknown with whom the name originated — we are also ignorant of the source from which NILSSON drew his name of *nissöga* (Brownie-eye) for the preceding species — but it is obviously a corruption of the German *Gründling* (Eng. Groundling), a name which has been given to the fish because it keeps close to the bottom. There is nothing green in its coloration. Another Scandinavian name for the Loach is *Smärling*, from the German *Schmerling*.

For the elucidation of the natural relations between our two *Cobitis* species CANESTRINI's numerous measurements afford interesting materials of comparison. Taking into account the measurements given by him we obtain the following results:

Average in	*Cobitis barbatula.* 4 specimens.	*Cobitis barbatula.* 3 specimens	*Cobitis tænia.* 9 specimens.	*Cobitis tænia.* 9 specimens.
Length of the body expressed in millimetres	53.6	92	56.2	85.6
(1) Lateral length of the head in % of the length of the body	18.3	17.3	17.1	15.8
(2) Length of the head to the occiput " " " " " " " "	16.6	15.8	15.2	14.9
(3) Diameter of the eyes " " " " " " " "	4.1	3.4	3.1	2.3
(4) Preorbital length of the head " " " " " " " "	7.9	7.7	7.3	6.8
(5) Breadth of the head " " " " " " " "	9.9	9.1	5.4	5.2
(6) Depth of the body " " " " " " " "	12.0	12.4	13.0	14.3
(7) Length of the dorsal fin " " " " " " " "	9.5	8.5	8.5	8.4
(8) Height " " " " " " " " " " " "	14.3	12.7	14.3	13.5
(9) Length of the pectoral fins " " " " " " " "	16.2	11.2	13.8	11.9
(10) " " " ventral " " " " " " " " "	12.3	12.2	11.6	10.3
(11) " " " anal fin " " " " " " " "	6.2	5.1	6.3	5.9
(12) " " " caudal " " " " " " " " "	16.4	16.2	—	—
(13) " " " head and trunk " " " " " " " "	57.5	60.2	62.4	64.6

The correspondence in the changes of development is here so great — the percentages of the two different ages in both species rise or fall with so great similarity — that we are fully justified in assuming that these two species belong to a common direction of development; and in this direction of development *Cobitis tænia* evidently occupies the more advanced rank.

(SUNDEVALL, SMITT.)

Fam. CYPRINIDÆ.

Air-bladder free (not enclosed in a capsule). Mouth fringed with at most four (or no) barbels.

The family of the Cyprinoids, the largest in the whole class of fishes, contains about 1,000 described species, most of them, however, from Asia and North America, so that only a hundred species occur in Europe, and only a score belong to the Scandinavian fauna. The majority of our fresh-water fishes are comprised, however, in this family. All the Cyprinoids prefer fresh water and are most commonly found in lakes, rivers, ponds, and fens. Still most of our species also occur in the brackish water of the Baltic. Not a single member of the family is a predatory fish properly so called; most of them live chiefly, though not exclusively, on vegetable substances. They may with every reason be called *omnivorous*. In a certain sense they may be regarded as *Ruminants*: the Carp, the Tench, and the Bream are adduced as examples of this; but as a rule food passes rapidly through their intestinal canal: a Goldfish fed with wheat-bread passes after some minutes a white, vermiform mass of excrement, which hangs from the vent. They are sensitive in a high degree to atmospheric influences: but some of them, though they do not properly belong to an Arctic temperature, can in a torpid state survive the process of being frozen[a]. Even in a milder climate they are known in cold weather to collect in dense shoals, which lie still in the deepest parts of the water; and VALENCIENNES[b] states of the Barbel of Southern Europe that he once found a company of this species which during the winter had packed themselves together in the hollow trunk of a tree.

Among the peculiarities in the reproduction of these fishes we shall here remark only one, which is of general interest, but belongs to a species foreign to our fauna, the little *Bitterling* (*Rhodeus amarus*), a form fairly common in Eastern and Central Europe and at most about 9 cm. long. It has long been known that the eggs of some fish are found among the branchial lamellæ of the painter's mussel (*Unio pictorum*): but until 1869 it was a matter of doubt to what species these eggs belonged. Before this time KRAUSS (1858[c]), KESSLER (1860[d]), DYBOWSKI (1862[e]), and SIEBOLD (1863[f]) had described an external oviferous tube, sometimes 30 mm. long, which in the female Bitterling is developed during the spawning-season from the margins of the urogenital opening just behind the vent, and into which the comparatively large, ellipsoidal eggs — sometimes 3 mm. long — force their way and arrange themselves in a single row. NOLL[g] at last discovered that the said eggs in the branchial cavity of the painter's mussel belong to the Bitterling. By observations which he has since completed, he showed that, when the eggs are ripe, the female Bitterling applies the oviferous tube to the inspiratory opening of the painter's mussel, into which the male at the same time emits his seminal fluid. In this way about 40 eggs may be forced one by one into the branchial cavity of the mussel, where they attach themselves to the branchial lamellæ and are developed until the fry have attained a length of about 11 mm. The young of this fish thus lead a kind of parasitic life, a commensalism from which they liberate themselves, when capable of an independent existence, by making their way out through the expiratory tube of the mussel.

The spawning-season of the Cyprinoids occurs in spring and summer, when both sexes assume a brighter and more handsome dress, and the males develop sharp, tubercular excrescences on the scales, which excrescences fall off, however, simultaneously with the fading of the coloration, as soon as the spawning-season is over.

To man these fishes are of no inconsiderable value and utility. Most of them have a soft, white, and palatable flesh, and in Scandinavia, as on the Continent, are the objects of lucrative fisheries. This is not the case in England, where fresh-water fishes in general are little esteemed[h], and the Cyprinoids in particular (with the exception of the Carp) have a bad reputation.

[a] PALLAS (of the Crucian Carp), *Zoogr. Ross. Asiat.*, tom. III. p. 298.

[b] CUV., VAL., *Hist. Nat. Poiss.*, tom. XVI. p. 13.

[c] Jahreshefte d. Ver. f. vaterl. Naturk. in Württemberg, 14 Jahrg., p. 121.

[d] At the Conference of Naturalists at Königsberg, according to SIEBOLD.

[e] *Cyprinoiden Livlands*, p. 87.

[f] *Susswasserfische Mitteleuropas*, p. 118.

[g] *Zoologischer Garten* 1869, p. 257; 1870, p. 237; 1877, pp. 351—362.

[h] DAY lays the blame of this on the English cook's ignorance of the proper method of dressing fresh-water fish for table.

The form of the body is generally regular, showing the compressed, fusiform outline most typical of the Teleosts, whether it extends in a longitudinal direction, as in our Gudgeons and Minnow, or rises vertically, as in our Breams. In the great majority of the fishes of this family[a] the body is covered with dense and firmly-attached, more or less hard, cycloid scales, large or small. The greatest external differences which here, as in the Glanomorphs, afford the most useful characters for the subdivision of the family, consist in the position and dimensions of the fins, especially the dorsal and anal. The back possesses only one fin (adipose fin wanting), situated as a rule at the middle of the trunk, but of a greater or less extent forwards or backwards, in front of or behind the region of the ventral fins, and sometimes set on the tail, above the anal fin, which in its turn shows varying dimensions, greater or less than those of the dorsal fin.

The Cyprinoids in general have a rather small mouth, the position of which may vary from the tip of the snout to the under surface thereof. The lips of some (several East Indian) forms are strongly and singularly developed, sometimes funnel-shaped and fringed, continuous or divided into lobes; but in our forms they are smooth and hardly more fleshy than usual. In a West Asiatic genus, *Chondrostoma*, which also occurs in Southern and Central Europe, a cartilaginous sheath is developed on the lower lip. In a North American genus, *Acrochilus*, a similar sheath appears both on the upper jaw and the lower; and in the genus *Labeo* of the Old World the sheath may appear on either or both of the jaws. In many Cyprinoids the mouth is furnished, as in the preceding family, with barbels, which always belong, however, to the upper jaw and never exceed two pairs; the most common and usually most developed is the barbel at each corner of the mouth. The margin of the upper jaw is formed by the toothless intermaxillary bones, which are generally at least to some extent (sometimes highly) protrusile. This does not depend, however, as usual on any elongation of the nasal processes, which are here comparatively short — though often prolonged upwards by a cartilaginous continuation, which, when the mouth is closed (the upper jaw drawn up), folds into a cavity between the tip of the ethmoid bone and the rostral cartilage[b] — but in most cases only loosely united to the rostral cartilage in front of the ethmoid bone and above the more or less cartilaginous head of the vomer. The intermaxillaries are without erect, lobate process (cf. above, p. 463), a growth which is all the more developed on the maxillary bones behind them. The maxillary bones are besides remarkable in most cases for their detorted form and the short and generally thick head of their articular knob. A distortion of the toothless dental part of the lower jaw that reminds us of the Mugiloids (see above, p. 330), occurs in several Cyprinoids (e. g. in the Bream and Barbel, but not in the Ide), in which the upper dental margin is thus turned outwards. We are also reminded of the Mugiloids by the upright protuberance frequently present at the symphyseal tip of the branches of the lower jaw. The most striking resemblance to the Mugiloids — depending on a similarity of diet — belongs, however, to the palate. The palatal curtains (vela transversa) of the Cyprinoids are well-developed, at least in the upper jaw. The palatal roof is lined with a mucous membrane, thickly covered with papillæ and arranged in longitudinal folds, which is continued backwards, smooth but with large gustatory papillæ, on the tumid, soft, cushion-like mass of muscles and fat — the *Carp's tongue* so highly prized by the epicure — situated under the posterior part of the cranium. Backwards and downwards from the body of the occipital bone runs an osseous (pharyngeal) process[c], pierced at its base for the passage of a blood-vessel (*aorta abdominalis*), the under surface of which process, just at the end of the said cushion, is shod in a depression with a cartilaginous, more or less hard and tumid disk, the so-called *Carp-stone* or *pharyngeal cartilage* (*Karpfenstein*, *la meule*). Against this disk the lower pharyngeal teeth, which are highly characteristic

[a] In a Southern European genus, *Aulopyge*, however, the body is entirely naked. It is also entirely or partially naked in three Asiatic genera.

[b] This cavity sometimes conduces in a remarkable way, even externally, to the singular form of the snout, which in an Indian (*Labeo nukta*, DAY, *Fish. Ind.*, p. 543, pl. CXXVIII, fig. 5) and a Sumatrian species (*Labeo — Schismatorhynchus — heterorynchus*, BLKR, *Atl. Ichth. Ind. Or. Neerl.*, *Cypr.*, p. 50, tab. IV, fig. 4) acquires a monstrous appearance, owing to the presence of a deep, horizontal, transverse hollow in front of the nostrils.

[c] This process was formerly regarded by some as an hypapophysis, by others as an entire hæmal arch; but it arises, as SAGEMEHL (Morphol. Jahrb., Bd. XVI, p. 516) has at least shown to be probable, in a totally different way from these parts of the skeleton, namely by the ossification of connective tissue which SAGEMEHL regards as a remnant (trace) of the ligament (also pierced by the aorta) which in the Characinoids unites the occipital and parasphenoid bones to the air-bladder. This same connexion we shall also find in the Clupeoids.

of the Cyprinoids, work in the mastication or dilaniation of food. The form of the carp-stone, as well as the form, number, and position of the teeth on the lower pharyngeals, afford in most cases the most tenable characters for the definition of the Cyprinoid species and also, to some extent, of the genera, and have been generally employed for this object ever since AGASSIZ[a] and HECKEL[b] directed attention to this point. We shall often return to these structures; here we need only remind the reader that the said teeth on the lower pharyngeals, which latter may be more or less falciform or more like branchial arches[c], are shed or renewed annually, as JURINE[d] and (subsequently) SIEBOLD[e] have pointed out. The upper pharyngeals are small, less remarkable, and toothless. They lie above the sides of the aforesaid cushion in the posterior part of the roof of the pharynx; and in front of and outside them we find, in most cases, but with great irregularity, distinct or covered (glandular) pseudobranchiæ.

The short œsophagus is recognisable internally by the longitudinal folds of the mucous membrane. The stomach is also short and shows very little, if any, expansion. Its mucous membrane lies in zigzag folds or is downy like velvet. These fishes have no distinct pyloric part or pyloric appendages, and the stomach passes gradually into the intestine, the length of which is exceedingly variable, for it sometimes forms only two coils, sometimes five, before it runs back to the vent. The intestine ends in a more or less defined rectum, which is marked by longitudinal folds of the mucous membrane. Often the whole digestive canal lies imbedded in a more or less lobate and subdivided mass of liver and in a thick layer of fat. The variations in the length of the intestinal canal are connected with the diet: a greater proportion of animal food is accompanied by a shorter intestinal canal. HECKEL divided the Cyprinoids[f] on this account into two groups: *Macroentri*, with long intestine — represented in the Scandinavian fauna by *Cyprinus* and *Carassius* — and *Brachyentri*, among which we find all the rest of our Cyprinoids. The gall-bladder lies on the right side of the stomach and sends out a gall-duct into the same; the spleen lies above or to the left of the beginning of the intestine. The largest organ in the abdominal cavity under ordinary circumstances (when the ovaries are not extraordinarily swollen) is the air-bladder. This organ is externally double, but internally continuous, consisting of an anterior, shorter part and a posterior, longer one, tapering behind, which usually follows the curve of the upper wall of the abdominal cavity back to the very end of the cavity, and which communicates in front by means of the pneumatic duct with the œsophagus. The ovaries as well as the testes are paired and closed, their discharging ducts sharing as usual with the urethra a common aperture just behind the mouth of the rectum. The kidneys lie along the under surface of the spinal column and are generally most developed at the contracted part of the air-bladder.

The most remarkable peculiarities of the skeleton are the alterations which the first four abdominal vertebrae undergo in connexion with the development and function of the so-called acoustic bones. The bodies of these vertebrae coalesce, as we have mentioned above, more or less firmly with each other, the boundaries between them being usually marked, however, by distinct sutures, even if the intervertebral cartilage has disappeared. Thus, in the Ide for example, all four are divided from each other with almost equal distinctness; and the intervertebral cartilage is still present between the bodies of at least the third and fourth vertebrae, the neural arches of which, on the other hand, are more firmly united by a suture. In the Chub as well as in the Bream the bodies of the second and third vertebrae are almost perfectly confluent. In the Barbel the body of the first vertebra is confluent with that of the second, and that of the third with that of the fourth.

The body of the first vertebra is always the smallest. Its transverse process, which is also considerably smaller than that of the second vertebra, stands, like the latter, straight out in a horizontal direction and originates from the body, also like the latter, without perceptible suture. The third vertebra is apparently

[a] Mém. Soc. Sc. Nat. Neuchatel, vol. 1 (1836), p. 36.

[b] Abbildungen und Beschreibungen der Fische Syriens nebst einer neuen Classification und Karakteristik sämmtlicher Gattungen der Cyprinen, Stuttgart 1843 (reprinted from RUSSEGGER's Reisen, B. 1, Th. 2).

[c] Cf. above, p. 631, on the lower pharyngeals and teeth of the File-fishes.

[d] Mem. Soc. Phys., d'Hist. Nat., Geneve. Tom. 1 (1821), p. 20. Bloch (*Fische Deutschlands*, Th. 1, p. 47) also suggested the possibility of this.

[e] *Susswasserf. Mitteleur.*, p. 82.

[f] *Russeggers Reisen*, l. c., p. 1001.

without transverse processes; but the fourth, when its body is distinct from that of the third, not only possesses a rib-like transverse process on each side, united by a suture to this side and both set and curved in the same direction as the ribs, only shorter and more terete than they, but also bears on its under surface an inner, lamellar process, set transversely and united to the body of the vertebra and to the transverse processes, pierced at the base (like an hypapophysis), and curved backwards and downwards behind the tip of the large pharyngeal process of the occipital bone. To the posterior surface of this inner process of the fourth vertebra is attached the centre of the anterior end of the air-bladder, and the passage in its base receives the aorta and the anterior end of the kidneys. According to SAGEMEHL[a] this process also belongs to the fourth vertebra in *Hydrocyon* (a Characinoid) and originates from the ventral and partly from the lateral sides of the body of this vertebra[b]. In the Barbel, where, as we have mentioned, the body of the fourth vertebra coalesces with that of the third, we see, however, that the roots of this process lie on the anterior part of this composite body, thus within the limits of the third vertebra. A removal in a backward direction thus seems to have taken place in the rest of our Cyprinoids, an assumption which finds further ground in the insertion of the hindmost so-called acoustic bone (*malleus*) between this process and the true transverse process of the fourth vertebra to join the wall of the air-bladder. Here, as in the Sheatfish (see above, p. 699), we explain the *malleus* on each side as the transformed rib of the third vertebra. In the Cyprinoids it is crescent-shaped or, rather, like the blade of a headsman's axe, and at the inner (concave) margin is set the process whereby it articulates with the side of the body of the third vertebra. Its anterior end, which is united by a ligament to the so-called *stapes*, projects above the base of the transverse process of the second vertebra. This last vertebra sends out to the ligament just mentioned the bone which has been called the *incus*, a bonelet bifid at the base and with one branch articulating in a hole in the body of the second vertebra and the other united by a ligament to the same bone. The *incus* on each side is explained as the transformed rib[c] and neural arch of the second vertebra. The two anterior among the so-called acoustic bones, the *stapes* and *claustrum*, which lie close to each other on the covering membrane of the *atrium sinus imparis* (see above, p. 699), are partly foliate in form, and are explained as representing on each side the otherwise wanting neural arch and spine of the first vertebra. The second vertebra is apparently without neural spine (upper spinous process), but its place is taken by a covering bone above the spinal canal between the occipital bone and the large neural spine of the third vertebra, which spine is usually strengthened by coalescence with the neural spine of the fourth vertebra.

In the structure of the head we shall here remark only the comparatively perfect development of the orbital ring. Not only do the ordinary (here 4—8) suborbital bones surround the eye behind, below, and in front; the eye is also protected above by a supraorbital bone, a covering bone on the frontal bone of each side.

The skeleton of the Cyprinoids, which as a rule contains a moderate number of vertebrae (40[d]—50), is further distinguished by the high and upright, anterior and upper, articular processes (zygapophyses) of the abdominal vertebrae, especially in the forepart of the trunk, where the top of each of these processes meets the base of the neural spine of the vertebra immediately in front or the upper part of the neural arch of this vertebra. The shoulder-girdle is strong. The incurved anterior margin of the clavicle may sometimes, as in *Labeo*[e], be developed into a disk so broad that only a narrow passage is left for the œsophagus. The coracoid bone is also as a rule comparatively broad, and the precoracoid bone ascending from the upper margin thereof, is bifid at the top, one branch meeting the clavicle, the other the scapula. The pelvic bones are elongated, in front bifid, sometimes for the greater part of their length, behind united by cartilage or a suture. From a morphological point of view the articulation of the ventral fins is interesting, as DAVIDOFF has shown[f], on account of its

[a] Morphol. Jahrb., Bd. X (1884), p. 55.

[b] SAGEMEHL explains it as a transformed pair of ribs belonging to this vertebra. SORENSEN, who calls it *os suspensorium*, ascribes it to an ossification of the wall of the air-bladder. Cf. SAGEMEHL's explanation of the pharyngeal process of the occipital bone (see above).

[c] Ligamentous ossification, according to SORENSEN, *Om Forbeninger i Svømmeblæren* etc., Dsk. Vid. Selsk. Skr., 6:te Række, Naturv., Math. Afh., B. 6, No. 2, p. 41 (sep.). The said paper did not reach me, unfortunately, until this sheet was in the press.

[d] In *Barbus maculatus*, according to GÜNTHER, 30.

[e] GÜNTHER, *Cat.*, VII, p. 47.

[f] Morphol. Jahrb., VI (1880), p. 464, taf. XXI, fig. 4.

retention in a cartilaginous form of a row of four basal bones[a] — a point which reminds us of more primitive types (the Ganoids) — the innermost of which even possesses the same form as in *Amia* and *Lepidosteus*. Behind, from the symphysis, each pelvic bone projects on the inner side of the insertion of the ventral fin in a process, directed straight back or curving outward to the side and serving as a point of attachment for a muscle coming from the base of the anal fin. The three branchiostegal rays are as a rule strong, of a broad, ensiform shape; and the urohyoid bone, a triangular, horizontal disk with the point turned forward and with a strong and high osseous ridge, highest behind, on the upper surface, reminds us most strongly of the corresponding bone in the Siluroids.

The systematic arrangement of the Cyprinoids involves many difficulties, partly on account of the great wealth of forms, partly in consequence of the more than usually strong proclivity of these fishes for cross-breeding between different species, even between species belonging to genera recognised as distinct. The Cyprinoids have been named after the island of Cyprus, the ancient sanctuary of Venus[b], and this name has arisen from observations of the fecundity and vivacity of these fishes when spawning. They crowd together in wild tumult to spawn and mingle with each other, seeking the same spawning-places and often having the same spawning-seasons. Cross-breeds between the Carp and the Crucian Carp have long been known. SCHONEVELDE (1624) speaks of such hybrids in the Elbe[c], MARSIGLI (1726) tells us from the Danube that the fishermen of this river, who called these forms *Sittichkarpfen*, explained them as hybrids[d], and according to BÖRNER (1781) the fishermen of Silesia had made the same observation[e], namely that these forms are produced by cross-breeding between the Carp and the Crucian Carp, when Crucian Carp are incautiously allowed to enter the culture-ponds for Carp, and that for this reason the breeders of Carp carefully avoided buying fry from such ponds as were suspected also to contain Crucian Carp. These observations were regarded, however, by zoologists in general merely as surmises — ichthyologists described these hybrids as a distinct species, and HECKEL[f] in 1853 made them the type of a distinct genus — until DYBOWSKI[g] in 1862 and SIEBOLD[h] in 1863 gave the question a different turn. SIEBOLD also showed that there was good reason to regard the *Leiter* of German writers (BLOCH's *Cyprinus Buggenhagii*) — a fish which was said to lead the way for the shoals of Bream, and whose capture was therefore supposed to be a good omen of an abundant take — as a hybrid of two kinds between the Bream genus, *Abramis* (*brama* and *blicca*), on the one hand and the Roach and Rudd genera, *Leuciscus* and *Scardinius*, on the other; and also to interpret the *Hachette* (*Alburnus dolabratus*) of French authors as a hybrid[j] between the Chub (*Leuciscus cephalus*) and the Bleak (*Alburnus lucidus*). JÄCKEL[k] has added several forms from Bavaria to this list of hybrids, one of which, that between the Roach and the Rudd, may possess a special interest for our fauna. As yet, however, to the best of our knowledge, only the first of these hybrids, that between the Carp and the Crucian Carp, has been proved by breeding experiments really to be of a hybrid nature. A great field of investigation is still open here to the pisciculturist, with whom it lies to solve these questions; but we know enough already to prevent any surprise at the uncertainty in the systematic arrangement of the Cyprinoids.

The Scandinavian fauna, it is true, contains only a few of the variations that have ranked as types for the subfamilies and genera hitherto established within the Cyprinoid family. Still, we possess a sufficient number to enable us to see among them the most important extremes in the differentiation of the family. From the most harmonious Roach type the form-series within the Scandinavian fauna proceed in two directions, on the

[a] DAVIDOFF calls these bones *radii*.

[b] *Κύπρις* was also a name of Venus.

[c] *Ichthyol. Slesv. Hols.*, p. 34: "medii Carasi ob id dicti, *halb Karass* vel *Karpfkarass*, quod e Caraso et Carpa compositi videantur.

[d] "Similitudine inter Cyprinum et Carassium mediat, nam ex ovis Cyprini, quantum Piscatores asserunt, et semine, vel lacte Carassi, aut e contra progeneratur." *Danubius Pannonico-mysicus*, tom. VI, p. 61.

[e] *Zoologia Silesiacæ Prodromus*, p. 205.

[f] Verh. zool. bot. Ver. Wien, Bd. II, p. 29.

[g] *Vers. Monogr. Cypriniden Livlands*, p. 55.

[h] *Süsswasserf. Mitteleur.*, p. 94.

[i] L. c., pp. 145—152.

[j] SIEB., l. c., p. 167.

[k] Abh. zool. mineral. Ver. Regensb. 1864 and 1865; Zool. Garten 1866; *Fische Bayerns*.

one hand to an elongation of the base of the dorsal fin, but with this base more and more reduced the nearer the series approaches to *Leuciscus*, on the other hand to almost as great an elongation of the base of the anal fin. By combining the expressions of these changes we find one division, the subfamily of the Carps, corresponding to KLEIN'S[a] genus *Cyprinus*, in all the forms of which the dorsal fin is at least $^1/_3$ (up to $1^1/_2$ times) longer than the anal, another division, within which the base of the dorsal fin measures at most about 130 %[b], but sometimes no more than 70 % of the length of the base of the anal fin, and a third division, within which this percentage lies between 60 and 23. The last two divisions, which comprise the majority of our Cyprinoids, may also be defined by a comparison between the lengths of the lower jaw and of the base of the anal fin. In the former group, the subfamily of the Roaches, KLEIN'S[c] genus *Leuciscus*, the length of the lower jaw measures as a rule perceptibly more than half of the base of the anal fin; but the proportion is subject to a change of growth[d] which approximates this group to the latter one, essentially corresponding to KLEIN'S[e] genus *Brama*, the subfamily of the Bleaks and Breams, within which division the length of the lower jaw may indeed sink to about $^1/_3$ of the base of the anal fin, but may also rise at least to 48 % thereof[f]. On these grounds we therefore distinguish among all the forms that in this respect have attained a fixed character[g] — which is the case in all the Scandinavian species — three subfamilies:

A: Dorsal fin considerably longer than the anal, length of the base of the latter at most 75 % (sometimes only 24 %) of that of the base of the former. Subfamily *Cyprininæ*.

B: Dorsal and anal fins of fairly equal length, minimum length of the base of the latter at least 77 % of that of the base of the former, minimum length of the base of the former at least 70 % of that of the base of the latter. Subfamily *Leuciscinæ*.

C: Anal fin considerably longer than the dorsal, length of the base of the latter at most 60 %, (sometimes only 23 %) of that of the base of the former. Subfamily *Abramidinæ*.

The knowledge of the Scandinavian Cyprinoids has been of fundamental service in the determination of the other European forms of this family, and the first edition of *Scandinavian Fishes* was of great importance from this point of view. FRIES and EKSTRÖM there prefaced their diagnosis by a general summary of what their predecessors, from ARTEDI, had accomplished to the same end, and this summary is even now not without interest.

ARTEDI, they wrote, who described with an accuracy unparalleled in his time all the indigenous piscine species which he had the opportunity of seeing and observing in nature, adopted[h] sixteen Swedish species of the genus *Cyprinus*:

Iden (the "Ide"),	in modern times	*Leuciscus idus*,
Sarfven (the Rudd),	,, ,, ,,	*Scardinius erythrophthalmus*,
Mörten (the Roach),	,, ,, ,,	*Leuciscus rutilus*,
Stämmen (the Dace),	,, ,, ,,	*Leuciscus grislagine*,
Sandkryparen (the Gudgeon),	,, ,, ,,	*Gobio fluviatilis*,
Aspen (the "Asp"),	,, ,, ,,	*Aspius rapax*,
Löjan (the Bleak),	,, ,, ,,	*Alburnus lucidus*,
Vimban (the "Zärthe"),	,, ,, ,,	*Abramis vimba*,
Björknan (the White Bream),	,, ,, ,,	*Abramis blicca*,
Braxen (the Bream),	,, ,, ,,	*Abramis brama*,
Fliran (the "Zope"),	,, ,, ,,	*Abramis ballerus*,
Faren, which has proved to be merely a nominal species,		
Karpen (the Carp),	in modern times	*Cyprinus carpio*,
Sutaren (the Tench),	,, ,, ,,	*Tinca vulgaris*,
Rudan (the Crucian Carp),	,, ,, ,,	*Cyprinus carassius*,
Elritsan (the Minnow),	,, ,, ,,	*Phoxinus aphya*.

[a] *Hist. Pisc. Nat.*, Miss. V, p. 58.

[b] According to our measurements at most 123 %; but KROYER mentions a Roach in which the base of the dorsal fin measured 129 % of that of the anal.

[c] L. c., p. 64, with the exclusion, however, of the Bleaks.

[d] In large Rudd the percentage may sink to 51.

[e] L. c., p. 61, with the exclusion, however, of the Rudd and Tench.

[f] In the above-mentioned hybrid, the German *Leiter*, which also occurs in Scandinavia, the length of the lower jaw is sometimes rather more, sometimes less than half the length of the base of the anal fin.

[g] In genera which presumably stand nearer the original forms of the family, this character has not acquired the same degree of constancy as in those which have advanced further in the differentiation of form. So, for example, the above taxonomic relation seems to give a sexual difference in the *Bitterling* (*Rhodeus amarus*), to judge by the 6 specimens which the Royal Museum has received through Professor SIEBOLD from the River Ill at Strasburg. In the four females among these specimens the length of the base of the anal fin is at most 75 % (70—75 %) of that of the base of the dorsal fin, while in the two males this percentage is respectively 77 and 81 %.

[h] *Descr. Spec. Pisc.*, pp. 6—31. Together with the excellent descriptions the Swedish names may serve in the first place to determine these species.

All these forms had retained their position of recognised species until the time when the first edition of *Scandinavian Fishes* appeared. FRIES and EKSTRÖM then advanced the opinion that the so-called *Faren* was a young Bream[a] to which ARTEDI had applied a Swedish name that is used throughout the Södermanland coast of Lake Mälar for the "Zope".

In the second edition of his *Fauna Suecica* LINNÆUS adopted as Swedish all ARTEDI's species with the exception of the Gudgeon, and added only one new, but very characteristic species, the *Skärbraxen*, *Cyprinus* (now *Pelecus*) *cultratus*. We must not suppose, however, that LINNÆUS understood by his *Cyprinus Biorkna* the same species as ARTEDI: — this Linnæan form, as FRIES and EKSTRÖM have shown, is a nominal species made up of the White Bream and the Zope. LINNÆUS is also the originator of another nominal species, briefly alluded to in the *Systema Naturæ*[b] under the name of *Cyprinus Idbarus*, as occurring in the Swedish lakes, and subsequently introduced by RETZIUS into the Scandinavian fauna. From the short diagnosis given by LINNÆUS it is hardly possible to decide with absolute certainty whether this nominal species is identical with the Ide or the Roach, though it is most probably the same as the former.

In the third edition, begun by RETZIUS in 1800, of the *Fauna Suecica*, 20 species of the Carp genus are adopted, namely the same 16 as in the second edition (the *Bjorkna* and *Faren* thus in their Linnæan signification, and not as in ARTEDI), together with ARTEDI's *Sandkrypare* (*Cyprinus Gobio*), and three new species are added:

Cyprinus Dobula,
„ *Idbarus*,
„ *Phoxinus*.

Among these three FRIES and EKSTRÖM recognised the specific rank of the first alone; of *Idbarus* they had already declared their opinion, and with regard to *Phoxinus* they pointed out that the specific character assigned to it did not justify its recognition as a distinct species from LINNÆUS's *Cyprinus Aphya*.

In 1832 NILSSON gave in his *Prodromus Ichthyologiæ Scandinavicæ* a scheme of a Scandinavian piscine fauna, which possesses the merit, in addition to several others, of having established the definitions of the species on more trustworthy diagnostic grounds. Within the Carp genus (*Cyprinus*) the said author includes 20 species, namely the original 16 of ARTEDI, which we there find restored to their first signification and more fully diagnosed than before; furthermore *C. cultratus*, *Dobula*, *Phoxinus*, and a species now introduced for the first time into the Scandinavian fauna, BLOCH's *Cyprinus Gibelio*. The last-mentioned species was, however, shown by EKSTRÖM to be merely a variety of the Crucian Carp.

In the description published by EKSTRÖM of the piscine species of *Mörkö* there also occurred a mistake which he hastened to correct in *Scandinavian Fishes*, as it had given rise to another nominal species, *Cyprinus microlepidotus*. On continued observation of the growth of the Cyprinoids he had convinced himself that this fish, though very different both in form and coloration, was nothing more than the Ide at an early stage of growth.

The first edition of *Scandinavian Fishes* thus contained 17 Scandinavian species, determined with certainty, within the Cyprinoid family. In KRÖYER's meritorious *Danmark's Fiske* (vol. 3, pp. 289 etc.) and in NILSSON's *Skandinavisk Fauna* (*Fiskarna*, pp. 281 etc.) the number of species is the same. This number was first increased in 1871 by a new addition to our fauna, when LILLJEBORG[c] described Swedish specimens of *Leucaspius delineatus*, specimens to which his attention had been called by Mr. AHLBOM, Collector of Customs at Landskrona. In 1877 Doctor FEDDERSEN found in Jutland a species new to Denmark, *Abramis bipunctatus*. We thus know at present 19 or — as the Goldfish may claim a place in the character of a domesticated species — 20 Scandinavian species of Cyprinoids, together with the above-mentioned hybrids.

[a] As we shall show later on, ARTEDI (l. c., p. 23) has really described an *Abramis ballerus* or "Zope" under the Swedish name of "*Faren*".

[b] Ed. X, tom. I, p. 324.

[c] Öfvers. Vet. Akad. Förh. 1871, No. 7, p. 815, tab. XVII A.

Subfamily CYPRININÆ.

Dorsal fin much longer than the anal (length of the latter at most $^3/_4$ of that of the former), its distance from the tip of the snout as a rule less than (sometimes about equal to) twice the length of the head. Among the simple rays at the anterior margin both of the dorsal fin (3 or 4) and the anal (2 or 3) the hindmost is generally hard as bone and spiniferous at the hind margin. Lateral line on the tail occupying the middle of the depth of the body. Ventral margin terete. Mouth as a rule furnished with barbels. Pharyngeal cartilage as a rule triangular, with the anterior margin straight or slightly concex. Length of the intestinal canal (including the stomach and œsophagus) as a rule several times greater than the length of the body.

We have given the first place among these characters to the one which seems to us to be the most distinct external token of the direction of development followed by the subfamily: a long dorsal fin, developed especially in front, as opposed to a short anal fin. In the Scandinavian fauna this character is not impaired by a single exception; but in consequence of another developmental change, by which the relative length of the head decreases with age, it sometimes happens that, in large Crucian Carp for example, the length of the head is somewhat less than half the distance between the dorsal fin and the tip of the snout, while the Tench also resembles, as a rule, in this respect the following subfamily. The systematic significance of the barbels we have already seen within the families both of the Sheatfish and the Loach; but here it sometimes happens that one species of a genus (*Cyprinus*) possesses them, while others are without them: — and yet these species interbreed with each other so freely that it seems far too artificial to separate them into distinct genera. With its present definition, however, the subfamily includes all the Scandinavian Cyprinoids that are furnished with barbels. The same irregularity affects another character, the serration of the last undivided and osseous ray in the dorsal and anal fins: this may be present in some species of a genus (*Barbus*), but wanting in others, while in the Scandinavian fauna it is wanting in two genera of this subfamily (*Gobio* and *Tinca*), which in other respects as well (the form of the pharyngeal cartilage and the length of the intestinal canal) show signs of a transition to the following subfamily.

The genera that occur within the limits of the Scandinavian fauna, may be distinguished as follows:

A: Length of the dorsal fin more than twice that of the anal .... Genus *Cyprinus*.

B: Length of the dorsal fin less than twice that of the anal.

- *a:* Least depth of the tail less than $^2/_5$ of the length of the head .... Genus *Gobio*.
- *b:* Least depth of the tail more than $^2/_5$ of the length of the head .... Genus *Tinca*.

Genus CYPRINUS.

Base of the dorsal fin more than twice that of the anal fin. Branched rays in the dorsal fin at least 17 (exceptionally 16), in the anal fin at most 7 (exceptionally 8). Both these fins with one of the anterior rays strongly osseous and behind spiniferous. Scales large — their number in the lateral line less than 40 — thick and hard.

As Günther[a] has remarked, we are fully justified in retaining the generic name of *Cyprinus* in its original signification — in the first place as a name for the Carp —, in spite of the fact that neither Artedi nor Linnæus has always been so exact in his systematic enumeration of the Cyprinoids as to range the

[a] *Cat. Brit. Mus., Fish.*, vol. VII, p. 25, note.

Carp first. BLEEKER's objection to this course[a] — that the *Cyprinus* of ARTEDI and LINNÆUS was strictly a synonym of the *Leuciscus* of modern writers — has not gained any adherents among ichthyologists.

The genus, which is indigenous to Asia and Europe, but has been transported by human agency throughout the civilised world, is by no means rich in forms — GÜNTHER recognises only five species — but these species have been transformed by domestication into a multitude of varieties and often possess monstrously developed organs. NILSSON established[b] for the Crucian Carp a subgenus, *Carassius* (without barbels), formed on the principle resorted to by CUVIER of misusing for this purpose the Linnæan specific names. But this subdivision of the genus is of far too little importance — in spite of the fact that in some authors *Carassius* has been recognised as a distinct genus — partly in consideration of the intermediate position in form of body occupied by the Goldfish, partly on account of the ease with which the Crucian Carp and the Carp together beget progeny capable themselves of reproduction.

The forms belonging to the Scandinavian fauna may be distinguished by the following external differences:

A: Four barbels, two on each side of the mouth.
- *a:* Length of the postabdominal part of the body about equal to the greatest depth of the body — greater than it or at least more than $^4/_5$ thereof ... *Cyprinus carpio.*
- *b:* Length of the postabdominal part of the body less than or equal to $^3/_4$ of the greatest depth of the body ... (Hybrid *Carpio Kollarii*).

B: Mouth without barbels.
- *a:* 5 or 6 scales in an oblique transverse row between the lateral line and the anterior part of the base of the dorsal fin ... *Cyprinus auratus.*
- *b:* 7 or 8 scales in an oblique transverse row between the lateral line and the anterior part of the base of the dorsal fin ... *Cyprinus carassius.*

THE CARP (SW. KARPEN).

CYPRINUS CARPIO.

Plate XXXI, fig. 1.

Two pairs of barbels, one (small) at each upper corner of the snout, one (larger) just behind each corner of the mouth. Pharyngeal teeth blunt (molars), more or less cylindrical, with a more or less multistriate grinding surface on the top: 1, 1, 3—3, 1, 1. Greatest depth of the body about $^1/_4$ of its length; distance between the foremost point of the insertion of the ventral fins and the beginning of the anal fin greater than the said depth or at least than $^4/_5$ thereof.

Fig. 178. Pharyngeal bones and pharyngeal cartilage of *Cyprinus carpio*; natural size: *a*, left pharyngeal seen from above; *b*, the same seen from outside (the left); *c*, pharyngeal cartilage seen from in front and below, the lower (posterior) end pointing upward.

R. br. 3 (4); *D.* $\frac{3-4}{17-22}$; *A.* $\frac{2-3}{5-6}$; *P.* $\frac{1}{14-17}$; *V.* $\frac{2}{6-8(9)}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* (34)36—39; *Lin. tr.* $\frac{5-6(7)}{(4)5-6(7)}$ 1; *Vert.* 36—37.

Syn. **Κυπρῖνος** et **Κυπρινός**, ARISTOT., ATHEN., cett. vide RONDELET. (*Cyprinus*) *Univ. Aquat. Hist.*, part. II, p. 150. *La carpe*, BELON, *Nat., Divers. Poiss.*, p. 267. *Cyprinus*, No. 1, ART. *Syn. Pisc.*, p. 3; No. 13, *Spec. Pisc.*, p. 25.

[a] *Atl. Ichth. Ind. Or. Néerl.*, tom. III, p. 73.
[b] *Prodr. Ichth. Scand.*, p. 32.

Cyprinus Carpio, LIN., *Syst. Nat.*, ed. X, tom. I, p. 320; BL., *Naturg. Fisch. Deutschl.*, part I, p. 92, tab. XVI et XVII; RETZ., *Fn. Suec. Lin.*, p. 354; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 289; NILSS., *Prodr. Ichth. Scand.*, p. 33; SCHAGERSTR., Physiogr. Sällsk. Tidskr., p. 295; CUV., VAL., *Hist. Nat. Poiss.*, tom. XVI, p. 23; HCKL, *Russegg. Reis.*, part. II, p. 1013; KR., *Danm. Fisk.*, vol. III, p. 290; NILSS., *Skand. Fn., Fisk.*, p. 284; HCKL, KN., *Süsswasserf. Österr. Mon.*, p. 54; SIEB., *Süsswasserf. Mitteleur.*, p. 84; CANESTR., Archiv. Zool., Anat., Fisiol., vol. IV (1866), p. 64; GTHR, *Brit. Mus. Cat., Fish.*, vol. VII, p. 25; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 179; HESSEL, U. S. Comm. Fish., Rep. 1875—76, p. 865; FEDDERS., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 82; BNCKE, *Fisch. Fischer., Fischz. O., W. Preuss.*, p. 106; *Handb. Fischz., Fischer.* (M. V. D. BORNE), p. 117; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 368; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 158, tab. CXXIX, fig. 2; MOB., HCKE, *Fisch. Ostsee*, p. 105; LILLJ., *Sv., Norg. Fn., Fisk.*, vol. III, p. 129; FATIO, *Fn. Vert. Suisse*, vol. IV, part. I, p. 171.

Rex Cyprinorum + *Cyprinus nudus (alepidotus)*, BL., l. c., part. III, pp. 131 et 178.

Cyprinus carpio + *C. coriaceus* + *C. specularis* + *C. rubrofuscus* + *C. nigroauratus* + *C. viridi-violaceus*, LACEP., *Hist. Nat. Poiss.*, tom. V, pp. 504, 528, 530, 547.

Cyprinus carpio + *C. regina* + *C. elatus*, BONAP., *Fn. Ital.*, *Pesc.* tab. 108.

Cyprinus hungaricus, HCKL, Ann. Wien. Mus. vol. I, part. 2, p. 222, tab. 19, fig. 1, *C. acuminatus*, HCKL, KR., l. c., p. 58.

Cyprinus Nordmanni + *C. flavipinnis* (ex KUHL et V. HASS.) + *C. vittatus*, CUV., VAL., l. c., pp. 66, 71, 72.

Cyprinus bithynicus, RICHARDS., Proc. Zool. Soc. 1856, p. 372 (vide GTHR).

Cyprinus atrovirens + *C. flammans* + *C. sculponeatus* + *C. hybiscoides*, RICHARDS., *Ichthyol. China*, Rep. Brit. Assoc. 1845, p. 287, cett.

Cyprinus hæmatopterus + *C. melanotus* + *C. conirostris*, SCHLEG. *Fn. Japon., Pisc.*, pp. 189—191, tab. XCVI et XCVII.

Cyprinus chinensis + *C. obesus*, BASIL., Nouv. Mém. Soc. Nat. Mosc., tom. X, pp. 227 et 228, tab. I, fig. 2, tab. II, fig. 3.

All these numerous names — and still more, which we have refrained from giving, as we were unable to verify the quotations — have been applied in descriptions to the Carp with its many varieties. It has been treated from time immemorial, we may almost say, as a domestic animal, and this treatment has affected its external form. Several of the above synonyms probably denote hybrid forms, though it is difficult to give a positive opinion on this head, as the dentition of the pharyngeal bones has not been specially described.

In Germany and Eastern Europe the Carp attains a length of about $1^1/_4$ (HECKEL and KNER) or $1^1/_2$ (BENECKE) metres and a weight of about 30—33 kgm. (PALLAS and HESSEL). In Scandinavia it has never been known to attain a size at all approaching this, and even the account given by ASTRÖM[a] of three Carp respectively 23, 24, and 27 Swedish pounds (10—$11^1/_2$ kgm.) in weight, which were said to have been caught "about" 1850 in the Höje River at Lomma, is evidently based on hearsay, though it cannot be considered to involve any impossibility. These Carp would at that weight have been probably 80—88 cm. long.

The body is fairly elongated and thick, the greatest depth, which lies at the beginning of the dorsal fin, measuring (in specimens 4—$4^1/_2$ dm. long) about 25—27 % of the length, and the greatest thickness (just behind the head) about half the depth or a little more. Young specimens are in general somewhat deeper[b], but thinner: the thickness increases with age more than the depth. The dorsal and ventral profiles are fairly regularly arcuate, the former, however, more so, especially in front. The dorsal edge is somewhat sharpened just in front of the beginning of the dorsal fin; the ventral edge, on the other hand, is more terete or even somewhat flattened. The contour of the tail shows at the ventral margin a slight break to receive the base of the anal fin. The least depth of the tail measures about 12—11 % of the length of the body and is as a rule more than $^1/_3$ greater than the length of the base of the anal fin or about $^1/_2$ (52—47 %) of the length of the head.

The length of the head varies in adult Carp (3—5 dm. long) between about $23^1/_2$ and $22^1/_2$ % of that of the body[c]; in young specimens it is comparatively somewhat greater, and it seems generally to be less in the females than in the males. The head is of a compressed conical form, with sharply rounded snout, and quite strongly reminds us of a pig's head. The forehead is fairly broad and somewhat convex (the breadth of the interorbital space equal to or somewhat greater than the length of the snout), but shows between the eyes a depression, bounded within the convex supraorbital regions by two shallow grooves, which converge

[a] *Några iakttagelser rörande de vertebrerade djur, som förekomma i trakten af Lomma*, disp. Lund 1859, p. 26.

[b] According to CANESTRINI'S measurements the depth of the body measures 27—30 % of its length (including the entire caudal fin), while this length increases from 128 to 200 mm.

[c] When the length of the body is measured, as usual in this work, to the end of the middle caudal rays. If we take into account the entire length of the caudal fin, the above percentages become respectively $21^1/_2$ and 20.

in front towards the snout. This depression is most distinct in old specimens, in which the externally bare hind parts of the frontal bones too are more distinctly marked with radiating striae. The eyes are round (with the longitudinal diameter slightly greater than the vertical) and are set rather high, by far the greater part of them lying above a horizontal line from the tip of the snout to the middle of the caudal fin. In specimens between 3 and 5 dm. long their longitudinal diameter measures about 15—14 % of the length of the head; in younger Carp they are as usual comparatively larger, their longitudinal diameter, when the body is 2 dm. long, being about $^{1}/_{5}$ of the length of the head, when the body is $^{3}/_{4}$ dm. long, about $^{1}/_{4}$ of the same. The nasal cavities lie just in front of the upper anterior corners of the orbits. The two nostrils on each side are fairly large and round, the diameter of the posterior being about equal to its distance from the orbit. They are set close to each other, the anterior obliquely on the inner side of the posterior; and the margin of the anterior nostril is raised behind in an obliquely cut, canaliculate form, so as to compose a lid with which the aperture may be closed. The distance between the two anterior nostrils is somewhat less than their distance from the middle of the tip of the snout, but about equal to half the breadth of the interorbital space above the centre of the eyes. The length of the snout varies, however, quite considerably, from $^{1}/_{3}$ of the length of the head in young Carp to about 39 % thereof in old. The mouth is fully terminal, the cleft, when the mouth is closed, slightly ascending, and the gape, when protruded and wide open, of a rounded quadrangular form. The lips are fleshy; the upper lip is double, the maxillary bone being also furnished with a dermal fold, in which the two pairs of barbels have their origin; the lower lip hangs down along the sides of the lower jaw in front of the corners of the mouth. The barbels are flattened at the base and vary considerably in length; the lower (at the corners of the mouth) may be half as long again, according to FATIO, as the diameter of the eye, but are usually shorter and in young Carp much shorter than the diameter of the eye; the upper (anterior), which are set about half way along the maxillary bones or a little higher, are only half or one-third as long as the lower; but we must not forget that during life these barbels are capable of extension and contraction. The length of the upper jaw, measured from the middle of the tip of the snout to the hind extremity of the maxillary bones, is in adult Carp about 27 or 28 %, and the length of the lower jaw 34—36 % of the length of the head. The gill-openings extend from the upper posterior corner of the operculum to the isthmus, about to the perpendicular from the articular knob (upper anterior corner) of the operculum. The branchiostegal membranes are below united to the isthmus at a distance from each other which in old specimens is equal to the longitudinal diameter of the eyes. The branchiostegal rays are 3 in number, in accordance with the general rule within the family; but FATIO on one occasion found 4 rays in each membrane. The operculum is obliquely quadrangular (rhomboidal), with the lower posterior angle rounded and obtuse. The anterior margin is the longest, being about equal in length to the postorbital part of the head, or to about half the entire length of the head. The lower margin is slightly indented in a very elongated S-shape or even straight. The surface of the operculum is striated by granulated ridges with interjacent grooves, radiating backwards and downwards from the articular knob. The crescent-shaped suboperculum, which coasts the inferior margin of the operculum, is distinctly (about $^{1}/_{3}$) longer than the lower jaw. The triangular interoperculum, pointed at the top, fills the angle between the two bones just mentioned and the lower part of the preoperculum, and coasts the inside of the horizontal (lower) arm of this last bone forward to the point of union with the articulation of the lower jaw. The hind angle of the preoperculum is obtuse and rounded. The cheeks are soft; but the space between the eye and the uppermost part of the preoperculum is filled by the posterior bones of the orbital ring. The suborbital bones are also thick and firm, striated like the operculum. The gill-rakers are short and rather scattered (18—20 in the outer row on the first branchial arch), consisting of pointed triangular disks with dermal papillae on the inner margin. The lower pharyngeals (fig. 178), the mucous membrane of which is fringed at the outer superior margin with similar, but smaller gill-rakers, 22 in number, are furnished within this margin as a rule with five teeth each; but while the teeth are being shed, one or two of these may be wanting or may lie hidden or loose in the mucous membrane. The largest teeth are 3 in number, set in an inner row. The first of them is bluntly conical, with a greater or less degree of lateral compression, and never shows signs of wear by grinding, but bears at the top a small annular protuberance; the middle tooth, the largest one, is transversely (from behind and in front) compressed and striated in the same direction, with four bent furrows on its worn masticatory surface; the hindmost tooth, as a rule the smallest one, has the same transversely compressed form and similar markings, but is furnished with only three furrows. The other two teeth are set beside each other at right angles to the inner row, in an outward direction from the middle tooth thereof, and have a more rounded masticatory surface, which at least on the inner (larger) one is marked with striæ. The pharyngeal cartilage is deciduous and in form resembles a more or less equilateral triangle, with the anterior (upper) side almost straight or slightly convex.

The dorsal fin begins in old Carp at a distance from the tip of the snout that measures about 42 % of the length of the body; but in young Carp its beginning lies farther back. Its posterior part is of fairly uniform height, but in front it is elevated in a somewhat pointed form, the upper margin being thus more or less concave. The length of its base measures in old Carp about 38—35 % of that of the body, and its greatest height (the length of the first branched ray) about 13—12 % of the length of the body, the length of the base of the fin being thus about three times its height; but in young specimens — up to a length of about 2 dm. — the fin is comparatively much shorter, its height sometimes measuring as much as half its length[a].

The anal fin begins in old Carp at about the end of the second third of the length of the body, and its base measures about $^1/_{12}$ or $^1/_{13}$ of the same length. Its height (the length of the first branched ray), on the other hand, measures about $^1/_9$—$^1/_7$ of the length of the body and may thus even exceed the greatest height of the dorsal fin. The form of the anal fin is an oblique trapezoid, with the outer (lower) margin straight or slightly convex.

The caudal fin is deeply forked, the length of the middle rays (about $^1/_{12}$ of the length of the body) being scarcely half that of the lobes; but the lobes vary in form, being sometimes somewhat pointed, sometimes rounded. Here, as in the generality of the Cyprinoids, the caudal fin consists of 17 branched rays, one long, simple ray at each margin (above and below), and at the base of this ray a varying number of short supporting rays.

The pectoral fins, which with their fleshy base are set low and obliquely, just behind the lower third of the gill-openings, are oval and obliquely rounded, the third branched ray being the longest. The entire length of the fins is about 16 or 17 % of the length of the body[b], and the distance between the foremost points in the insertions of these fins and in those of the ventral fins (the length of the preabdominal region) measures in old Carp about 24 or 22 % of the length of the body.

The ventral fins are of a more trapezoidal form, with rounded hind margin. They are also of different structure, the simple ray at the anterior margin being furnished at its base with a short, simple, supporting ray, which, though it is often difficult to distinguish, appears as a rule in the ventral fins of all the Cyprinoids. The length of these fins is generally greater in the males than in the females and varies in old Carp between about 16 and 14 % of that of the body. The distance between the foremost points in the insertions of these fins and in that of the anal fin measures about 27 % of the length of the body.

The covering of scales is subject in the Carp to the most singular variations. The whole body (except the head and fins) may be clothed with scales from the very occiput, where the boundary of the scales lies at a distance from the tip of the snout which is comparatively greater in young Carp than in old, measures about 83—79 % of the length of the head, and generally, even in old specimens, is about equal to the depth of the body at the occiput. Throughout their extent over the body the scales are rather large (see above, *Lin. lat.* and *Lin. tr.*), of a rounded quadrangular shape, and so closely imbricated that each scale covers nearly two-thirds of the adjoining scale behind it. The anterior (covered) part of the scale is marked with extremely fine, numerous, concentric striæ; but the radiating grooves are only slightly traced and irregular, and the anterior margin of the scale is only slightly and unevenly indented. On the hind (exposed) part of the scale, however, both the concentric striæ and the radiating grooves are coarser, and the surface is here

[a] According to CANESTRINI's measurements the length of the dorsal fin in a Carp 74 mm. long was only 27 % of that of the body (including the whole of the caudal fin), and its height 13·5 % of the same length.

[b] According to CANESTRINI's measurements the length of the pectoral fins — which in general shows even relative increase with age — in Carp 74—354 mm. long (including the whole of the caudal fin) is 14 or 15 % of that of the body.

rough (granulated), furnished with a great number of small, verrucose protuberances (thickened parts). The lateral line descends from the temporal region in a slight, but regular curve down to the middle of the depth of the body at about the tip of the pectoral fins, from which point it advances, straight and uninterrupted, to the middle of the base of the caudal fin. The duct in each scale is short, and pierces only about the middle third of the length of the scale. It has long been known, however, that, in addition to the ordinary Carp, there occur varieties (see our figure) which are distinguished by the absence of scales and the greater thickness of the skin on a greater or less part of the body, the scales on the other parts being considerably, even monstrously enlarged. One of these varieties is represented in our figure. The largest scales lie in the lateral line, in a continuous or an interrupted row. One or two rows of rather large scales generally coast the dorsal margin of this variety. The belly is clothed with ordinary scales. As the large scales on the sides of the body most often possess an iridescent or a vitreous lustre, this variety has been named *spegelkarp* (Mirror Carp). Another variety, which is entirely without scales, but has a still thicker skin, is known as the Leather Carp (*läderkarpen*).

There is hardly any external difference between the sexes, except during the spawning-season, at which time the males are marked by a dermal eruption, consisting of small, white tubercles, on the cheeks and gill-covers.

The usual coloration is olive green, on the back darker, sometimes blackish brown, on the belly lighter, sometimes yellowish white, on the sides with a coppery or brassy lustre. It is, however, subject to considerable variations, shading on the back into blue or red, on the sides still oftener into red, a colour especially characteristic of the so-called Leather Carp. This ground-colour is diversified by the black edges and centre of each separate scale. The dorsal and caudal fins shade most often into gray, the paired fins and the anal fin into red. In the reddish varieties, however, all the fins share in the general tone of colour. The iris is yellow, with a bright golden margin round the pupil. In captivity albinos sometimes occur.

The natural range of the Carp extends from Japan and China through Central Asia to Eastern Europe. It is difficult to fix the limit of the Carp's natural range in Central Europe; but it has been introduced in a state of domestication throughout the rest of Europe, except the extreme north, and has also been transported to the East Indian Archipelago, Australia, and North America. In India it is unknown. Subsequent to its introduction it has spread to the lakes and rivers of these regions, where it now lives even in a state of freedom. KRÖYER assumes, with great probability, that it was during the Roman Catholic times, when fish was the only animal food permitted during Lent, that the Carp was introduced by the monks into Denmark and the south of Sweden, and began to be cultivated in ponds at the convents. We have no positive information, however, on this point. An old tradition, on the other hand, quoted from PONTOPPIDAN[a] by BLOCH, KRÖYER, and NILSSON, but also in need of confirmation, ascribes the introduction to a later date, when PEDER OXE (1567—1575) was Lord Steward of Denmark and owned large estates in Scania. In England Carp existed, though their number was small, in 1496, according to Dame JULIANA BERNER'S Boke of St. Albans[b]; and at the present day the Carp is very common in that country.

The Carp, like the other Cyprinoids, is by nature a fresh-water fish, but it can also endure salt water. In the Caspian Sea, according to PALLAS, the Carp lives in water so salt that hardly any other fish can sustain life there. In brackish water it occurs, according to MÖBIUS and HEINCKE, in the Schlei at Schleswig. In Sweden it has spread from the ponds to the lakes and rivers, principally in Scania. It has also been cultivated, without doubt, on the estates of Central Sweden, for it occurs, though extremely rare, in Lake Mälar, where in June, 1888 a fisherman from Sundbyholm (Södermanland) caught the female Mirror Carp represented in our figure ($^1/_3$ of the natural size). Neither he nor his acquaintances had ever seen one of these fishes before.

In a state of nature the Carp haunts places with a luxuriant vegetation, being by no means averse to a muddy bottom, but requiring clear water and free access to the sunlight. Distinction has long been made between *River Carp*, *Lake Carp*, and *Pond Carp*, which generally differ not only in their coloration, which adapts itself to the bottom and the water, but also in their flavour, which is best in the first-mentioned forms, worst in the last-mentioned, unless the pond has been

[a] *Den Danske Atlas*, p. 653.

[b] See YARRELL, *Brit. Fish.*, ed. 2, vol. I, p. 350 and DAY, l. c., p. 163.

supplied with a continual flow of fresh water. In summer, so long as the water is not too warm, Carp frequent shallow and sunny spots; in winter they flock together in deep pools.

The adult Carp is sluggish and peaceable in disposition, though frequently migratory in its habits, especially during the spawning-season. It is highly sensitive to heat and cold: during the colder part of the year it abstains from food. Still it is very tenacious of life, and may be transported long distances alive. It may also be transferred from its native haunts to some artificial receptacle, where it may be kept alive for a long time, and better seen to and fattened. This is an old custom, resorted to especially for the purpose of freeing Pond Carp from their muddy flavour. Packed in damp moss or ice, and with a bit of bread dipped in spirits in the mouth, the Carp can live at least twenty-four hours or more. The above-mentioned Mirror Carp from Sundbyholm was sent to the Royal Museum alive in a bucket, and was kept alive in a tub for some days. One morning it was found to have leapt out of the tub, and lay on its side apparently dead. It was restored to the water, but floated belly upwards and did not move a limb. It was then given a dessert-spoonful of spirits, and began after some minutes faintly to move its pectoral fins. After a quarter of an hour the dose was repeated, and within an hour the fish moved about with ease, as if nothing had happened. During the warm season, however, the Carp soon dies of suffocation, if prevented from coming up to the surface to breathe. BUCKLAND tells[a] an amusing anecdote of its habit of breathing air. In an Irish lake fairies were seen dancing on the water during calm, moonlight nights — the fairies being large Carp that made rings at the surface by smacking their lips as they breathed.

The food of the Carp is both animal and vegetable, consisting of seeds, fish-roe, and insects; but it never, or extremely seldom, bites at a fly. Its favourite nourishment is composed of decomposing vegetable substances, worms, *Entomostraca*, and the larvæ of insects. The mud swallowed by it can hardly be included among its food, but seems necessary to its digestion and general health.

The spawning-season occurs in May or June, but may sometimes be protracted till the month of August, being often interrupted during unfavourable weather. At this time the Carp is exceedingly restless and bold, darting wildly about, jumping out of the water, and leaping high, if necessary, to reach a suitable spawning place. Here the eggs, which are small (about $1\frac{1}{2}$ mm. in diameter) and light yellow or yellowish green, are deposited in shallow water, and attach themselves in lumps to the water-plants, especially *Utricularia*, *Nymphæa*, *Alisma*, and *Glyceria*[b]. The males — two or three to every female — swim at the surface above the females, as far as the depth of the water permits. The number of the eggs varies according to the age and size of the females, but is also different in individuals of the same size. In a female 3 lbs. ($1\frac{2}{5}$ kgm.) in weight BLOCH[c] counted 237,000 eggs, and in a female $16\frac{1}{2}$ lbs. ($7\frac{1}{2}$ kgm.) in weight, the ovaries of which weighed $5\frac{1}{2}$ lbs. ($2\frac{1}{2}$ kgm.), BUCKLAND[d] estimated the number of the eggs at 2,059,750; but another female, $21\frac{1}{2}$ lbs. ($9\frac{3}{4}$ kgm.) in weight, contained only 1,310,750 eggs. Sterile Carp are not uncommon, and have always been highly esteemed for their fat, delicate flesh. An English fisherman of the name of TULL discovered[e] a method of castrating Carp in order to fatten them with better success.

In a suitable temperature the ova develop so rapidly that the eyes of the embryo appear on the fifth or sixth day, and the egg is hatched between the twelfth and sixteenth days, according to DAY, or as early as the eighth day, according to BENECKE. Of the growth of the fish CANESTRINI[f] tells us that at the age of one year it weighs 8 gm., at the age of two 32 gm., at the age of three 500 gm., at the age of four 1 kgm., at the age of five 2—4 kgm., at the age of six 4—5 kgm., at the age of seven 7—8 kgm., and at the age of eight 9—10 kgm. These weights vary of course according to the abundance of food. The Carp may reach maturity in the third year.

[a] *Nat. Hist. Brit. Fish.*, p. 40.

[b] The seeds of *Glyceria fluitans* are also an agreeable food for the Carp.

[c] L. c., p. 97.

[d] L. c., p. 38.

[e] See WATSON, *An Account of Mr. Samuel Tull's Method of Castrating Fish.*, Philos. Trans., vol. XLVIII, art. CVI, p. 870 (Dec. 1751).

[f] *Fauna D'Italia*, part. III, *Pesci*, p. 10.

In Sweden the Carp-fishery is of little importance, the occurrence of this fish in a natural state and in any quantity being confined to a few lakes in Scania — Vombsjön and Ringsjön, according to NILSSON — with the streams that feed and drain them. The Carp is taken with the tackle ordinarily employed in fresh-water fishing, but principally in different kinds of traps. It is generally too cunning for the net and seine, avoiding the former and swimming under or leaping over the latter — a ruse which even the ancient Greeks and Romans knew it to practise. Sometimes it is caught with rod and line or on nightlines, a method of fishing extensively employed in France both as an amusement and a source of profit. The bait consists of lobworms, a piece of old Gruyère, or a bit of dough kneaded with a little honey. The hook must be allowed to sink to the bottom, and the bait should not be too large, for the Carp must gulp it down at once — if it begins to nibble at the bait and feels the hook, it cautiously spits out both of them. The angler may choose a spot quite near land, for the Carp resorts freely to the shore for food, and may be enticed thither without difficulty by now and then throwing some breadcrumbs into the water. The best time for angling is the evening.

Large, or at least middle-sized Carp, 3—5 kgm. in weight, are good eating when well cooked, especially when boiled in wine or stewed with spices. It was therefore quite natural that, even in olden times, attempts should be made to utilise this fish in the most convenient and most profitable manner. Hence the origin of the cultivation of the Carp, an industry which has made great strides in some countries, especially in Germany and Austria, and which even in Sweden has been carried on with success. In his *Skånska Resa* LINNÆUS described the condition of this industry in Scania in 1749, and his opinion was that "the ground occupied by a fishpond is far more valuable to its possessor than the finest tilth" (p. 378). In an academical thesis (Lund, 1766) CEDERLÖF has left us *some economic remarks on the Scanian Carp-ponds*. But this interest flagged, and it was not until the present day that the cultivation of the Carp was resumed as an industry. This has been done by the instrumentality of Mr. WENDT, a German landowner who removed to Sweden, and in 1879, at Gustafsborg near Perstorp, a railway station in the District of Christianstad, constructed a Carp-breeding establishment. In 1883 he sold 30,000 Swedish pounds (12,752 kgm.) of fish, and in 1884 half as much again (19,128 kgm.), most of this quantity being exported to Germany [a]. At Langbanshytta in Wermland another establishment for the breeding of Carp has lately been opened [b].

These Carp-ponds are dug, or still better — if their site admits of this — formed by damming, beside a river or brook. They should be some feet deep and at least two in number, so constructed that one or more of them may be emptied at the same time and thoroughly drained. In a complete establishment the ponds must be of two kinds, breeding-ponds (Germ. *Streichteiche*, where the Carp may spawn, *sich streichen*) and growing-ponds (Germ. *Streckteiche*, where the Carp may grow, *sich strecken*, from the beginning of the second year). In some places a third kind of pond may be seen, the stew (Germ. *Fettteich*, *Setzteich*, *Abwachsteich*, *Kammerteich*), where the Carp that have reached the age of three years or more, are kept ready for use or sale. The size of the ponds depends on circumstances; but the breeding-ponds, which may be most reduced in size, should measure at least 10—12 *ares* (about 1 rood), and to each *are* 5 females and 3 males may be allowed. These ponds, in which the fish are to spawn, must also contain a shallow part, where the water may be heated by the sun, as early in the year as possible, to a temperature of about + 17° or + 18° C. (about 63° Fahr.), for at a lower temperature the Carp will not readily spawn. The growing-ponds as well as the stews, on the other hand, must contain a deeper part, at least about 5 ft. in depth, where the Carp may assemble in winter without danger of the bottom freezing. The entrance and outlet must of course be constructed, in the first place, so as to avoid the possibility of inundation; and precautions should be taken by means of suitable filters to prevent the Carp from escaping and to keep out other fishes and noxious animals. One or two Pike, to cut off the weaklings and to keep the older Carp in active motion, do no harm in the ponds, for the survivors thrive and grow all the better for their company; and Perch and

[a] See TRYBOM, *Om karpodling i allmänhet och särskildt om den vid Gustafsborg i Kristianstads län*, Landtbruks-Akademiens Handlingar och Tidskrift för år 1885.

[b] See LILLEBORG, *Sv., Norg. Fisk.*, vol. III, p. 794. When this sheet was in the press, the second number of the '*Svensk Fiskeri-Tidskrift*' appeared, containing a paper by H. V. TIBERG on the cultivation of the Carp at Langbanshytta.

Pike-perch are also of service, though not in exactly the same degree. But large numbers of other fishes, especially of the Carp's own family, such as Roach, Rudd, or Crucian Carp, only do mischief. The most practical method of keeping the ponds clean, a method which at the same time renders their bottom better capable of developing food for the Carp, is to drain them in turn and leave them dry for a year, during which period they may be ploughed and sown, in most cases with good results. They must also be emptied to facilitate the transfer of the fish from one pond to the other, an operation which should be performed during the cool season, in autumn or spring, the heat of summer being at best disagreeable to the Carp on dry land. It is obvious that the ponds should also be protected from the inroads of poachers, otters, herons, and other enemies of the Carp; but ducks do no damage. The reader who desires fuller information on this head, will find what he needs either in NORBÄCK'S *Handledning i Fiskevård och Fiskafvel* (p. 257) or in the numerous German manuals on the subject, e. g. MAX V. D. BORNE, *Handbuch der Fischzucht und Fischerei*, Berlin 1886, p. 261.

Among Carp as among other domesticated fishes we frequently meet with deformed individuals. One of these examples, not uncommon in its occurrence, with the snout apparently reduced, is described by VALENCIENNES[a]. The reduction, however, does not really affect the snout or the jaws, which parts are developed as usual, or only distorted, the frontal bones, on the other hand, being anteriorly depressed, and the basisphenoid and parasphenoid bones reduced.

In the pond the Carp is a victim to all kinds of diseases. We sometimes hear of Carp being so old that moss has begun to grow on their bodies, this moss being really a mould fungus, *Saprolegnia*, of the same genus as the scourge of the Salmonoids. The best remedy for this is a little salt in the pond or a change of water. By unsuitable food the whole stock of a pond may be poisoned. Carp may be fed and fattened on ordinary kitchen-refuse, brewer's grains, boiled and mashed potatoes, chopped cabbage, guano, or the dung of the horse, pig, or sheep. But experience, according to M. V. D. BORNE and others, shows the necessity of great caution, and the economical results of fattening have not been satisfactory. Carp are often troubled by the male frogs, which under the influence of sexual excitement attach themselves firmly to the head of the sluggish Carp, and with their forefeet press the eyes of the fish so hard as to produce blindness.

For all this the Carp is an easily fed and easily managed domestic animal; but without expensive preparation for table its culinary value is even less than that of the Pike. In the south of Europe its roe is made into caviare, consumed principally by the Jews, who are forbidden by law to eat genuine caviare, the Sturgeon being destitute of ordinary scales.

The age attained by the Carp is not yet ascertained. BUFFON mentioned Carp 150 years old as existing in the moats at Pontchartrain, and LEBEL stated that the ponds at Lausitz[b] contained Carp 200 years of age. It is difficult, however, to test the truth of these old statements, and the same difficulty applies to BLOCH'S account[c] of the capture in 1711, at Bischofhausen near Frankfurt-on-the-Oder, of a Carp 6 feet long, $2^1/_5$ feet deep, with scales as large as an 8-groschen piece, and 70 lbs. in weight. In a state of freedom, according to HECKEL and KNER (l. c., p. 57), the Carp only attains the age of about 12 or 15 years.

As we have mentioned above, many cultivators of the Carp are unfortunate enough to have their breed of fish spoilt by crossing with the Crucian Carp. The hybrid produced by this cross-breeding has generally been known among modern ichthyologists by the name of

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[a] CUV., VAL., *Hist. Nat. Poiss.*, vol. XVI, p. 57.

[b] See LACEPÈDE, *Hist. Nat. Poiss.*, tome V, p. 510 and BLOCH, *Naturg. Deutschl. Fish.*, part. I, p. 95.

[c] Cited from BECKMANNS *Gesch. der Chur.*, Th. I. p. 574.

CARPIO KOLLARII

Fig. 179.

Two pairs of barbels, but these more or less reduced, the anterior pair or even one of the posterior barbels (at the corners of the mouth) being often rudimentary. Most of the pharyngeal teeth transversely compressed (in front and behind), with the masticatory surface furnished with one groove, usually: 1, 4—4, 1 (sometimes: 3—3, sometimes: 1, 1, 4—4, 1, 1). Greatest depth of the body about 1/3 *of its length; distance from the foremost point in the insertions of the ventral fins to the beginning of the anal fin less than* 1/3 *of the said depth.*

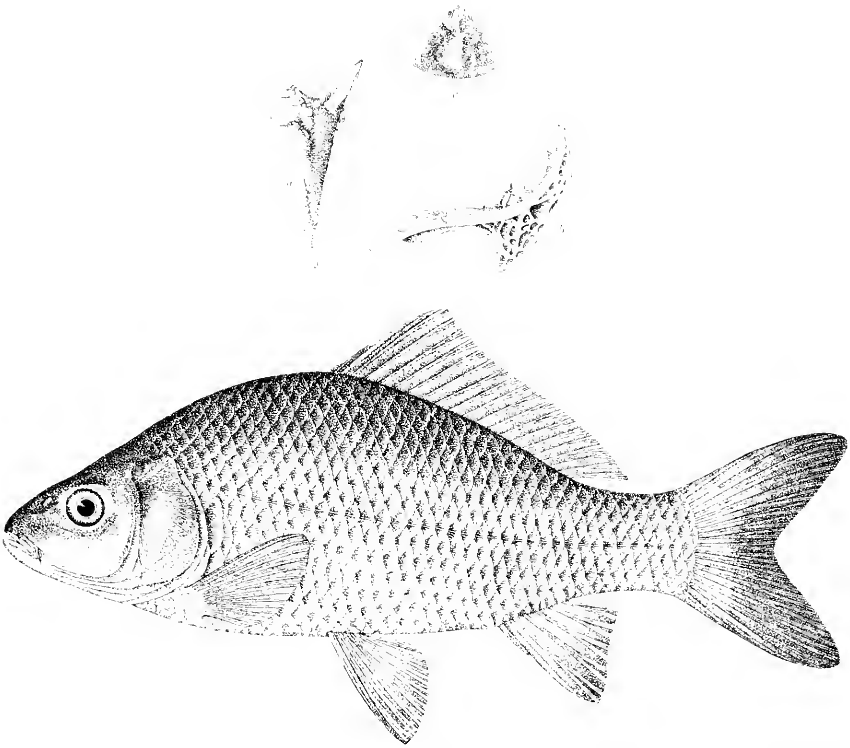


Fig. 179. *Carpio Kollarii*, natural size, from Rydgård (Scania), taken on the 28th of October, 1858, and its pharyngeal bone (left) and pharyngeal cartilage magn. 3 diam. *a*, *b*, and *c* as in the preceding figure.

R. br. 3; *D.* $\frac{3-4}{19^{a}-21}$; *A.* $\frac{3}{6^{b}-7}$; *P.* $\frac{1}{15-16^{a}}$; *V.* $\frac{2}{8-9}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* 36—37; *L. tr.* $\frac{(6)7}{(6)7}$ 1; *Vert.* 36.

Syn. *Cyprinus Kollarii*, Heck., Ann. Wien Mus., vol. I, p. 223, tab. 19, fig. 2; Id. (*Carpio*), *Russeggers Reisen*, part. II, p. 1014; Cuv., Val. (*Cyprinus*), *Hist. Nat. P[oiss]*., vol. XVI, p. 76, tab. 458; Heck., Kn. (*Carpio*), S[...]

[a] Sometimes 17, according to Siebold.
[b] " 5, " " "

[illegible] *Oest. M*[illegible], p. 64. SIEBOLD, *Süssw. fisch. Mitteleur.*, p. 91.
Cyprinus striatus, HECKEL [illegible] *Fi. d.* [illegible] *M*[illegible], p. 242.
Carpio Sieboldii, JAECKEL, *Fish. Bay.*, Abh. zool. mineral. Ver. Regensburg, vol. 9 (1864), H. p. 21.
Carasso-Cyprinus vulgo-Carpio, FATIO, *Fn. Vert. Suisse*, vol. IV, part. I, p. 198.

Carpio Kollarii (Sw. *Karprudan*) in its Swedish forms is even externally an intermediate type between the Carp and the Crucian Carp. The depth of the body is greater, and the base of the dorsal fin is shorter than in the Carp, both measuring on an average $^1/_3$ (31—34 %) of the length of the body. The changes of growth and the individual variations both in the Carp and the Crucian Carp, however, render these characters of little constancy, though they are generally sufficient to enable us to recognise a *Carpio Kollarii*. The same may be said of the texture of the scales, which in this hybrid usually show more distinct and more regular radiating grooves on the anterior (covered) part of the scale and notches in the anterior margin thereof. The most important expression of the hybrid nature of *Carpio Kollarii* is afforded by the form of the pharyngeal teeth and the inconstancy of their number, which is often different even on the right and left pharyngeals.

The first Swede to describe *Carpio Kollarii* as an actual hybrid between the Carp and the Crucian Carp, was SCHAGERSTRÖM (in the "Physiografiska Sällskapets Tidskrift" 1838, p. 295), and LILLJEBORG has subsequently described (in *Sveriges och Norges Fiskar*, vol. III, p. 137) at greater length one of the specimens on which SCHAGERSTRÖM based his opinion, and which were taken in a Carp-pond on the manor of Krapperup in Scania. This specimen was 3 dm. long. Baron G. C. CEDERSTRÖM found this hybrid to be plentiful among the Carp and Crucian Carp in a pond at Rydgård. The largest of the specimens he presented to the Royal Museum from this locality, has served as the original of the figure given above in the natural size.

That *Carpio Kollarii* is really a hybrid, has been proved by the experiments of HESSEL. "In order to determine this question," he writes[a], "I myself managed to bring about such crosses by placing (1) female common carp with male crucian carp, and (2) female crucian carp with male common carp, in small tanks, constructed with this end in view; (3) I also put together female *Carpio kollarii* with male common carp; this for the sole purpose of testing the capability of propagation of the *C. kollarii*, which had been doubted. In the two former cases I obtained forms analogous to *Carpio kollarii*, sometimes approaching in appearance the true carp, at others the crucian carp. In the third case, however, having placed ripe *Carpio kollarii* together with *Cyprinus carpio*, I obtained a product with difficulty to be distinguished from the genuine Carp. I took the trouble to feed them for three years, in order to try their fitness for the table, but their flesh was exceedingly poor and very bony and could not be compared by any means to that of the common carp."

[a] Rep. U. S. Comm. Fish and Fisheries 1875—76, p. 868.

THE GOLDFISH (SW. GULDFISKEN).

CYPRINUS AURATUS.

Plate XXXI, fig. 2

No barbels. Preabdominal length (distance between the foremost (uppermost) points in the insertions of the pectoral and ventral fins) less than $^{3}/_{5}$ of the length of the base of the dorsal fin. Length of the lower jaw more than $^{3}/_{5}$ of the preabdominal length. 5 or 6 scales in an oblique transverse row between the lateral line and the anterior part of the base of the dorsal fin. Pharyngeal teeth set in one row, transversely (in front and behind) compressed, and with one groove in the masticatory surface: 4—4.

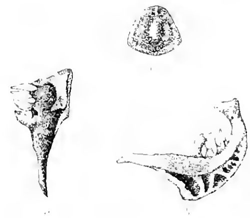


Fig. 180. Pharyngeal bone (left) and pharyngeal cartilage of *Cyprinus auratus*, magn. 3 diam. *a*, *b*, and *c* as in the preceding figure.

B. br. 3; *D.* $\frac{3(4)}{18[a]—20}$; *A.* $\frac{2—3}{5—7}$; *P.* $\frac{1}{15[b]}$; *V.* $\frac{(1)2}{8}$; *C.* x + 1 + 17 + 1 + x; *Lin. lat.* 29[c]—30[d]; *Lin. tr.* $\frac{5—6}{7}$ 1;
Vert. 30—31.

Syn. *Cyprinus* pinna ani duplici, caudæ trifurca, LIN. Vet. Akad. Handl. 1740, p. 403, tab. I, figg. 1—8; *Fn. Suec.*, ed. I, p. 125, tab. II, fig. ad. num. 331.

Cyprinus auratus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 322; BASTER, *Opusc. subseciva*, tom. II, lib. II, p. 78, tab. IX; BL., *Fisch. Deutschl.*, part. III, p. 132, tab. XCIII et XCIV (+ *Cypr. macrophthalmus*, *Ausl. Fisch.*, part. IX, p. 51, tab. CCCCX); LACEP. (*Cypr. auratus* + *C. argenteus* + *C. telescopus* + *C. macrophthalmus* + *C. quadrilobatus*) *Hist. Nat. Poiss.*, tom. V, p. 553; YARR, *Brit. Fish.* ed. I, vol. I, p. 315; CUV., VAL. (*Cypr. lineatus* — obs. tamen *D*: $\frac{4}{23}$; *Lin. lat.* 33; *Lin. tr.* 11 — + *C. thoracatus* + *C. Langsdorfii* + *C. auratus*) *Hist. Nat. Poiss.*, vol. XVI, p. 96, cett.; RICHARDS. (*Cypr. lineatus* + *C. carassioides* (ex GRAY) + *C. Burgeri* + *C. gibelioides* (ex CANT.) + *C. Cuvieri* + *C. Langsdorfii* + *C. thoracatus* + *C. abbreviatus* + *C. auratus*) Rep. Brit. Assoc. 1845, p. 291, cett.; BASIL. (*Carassius Pekinensis* + *Car. coeruleus* + *Car. discolor* + *Cyprinus auratus* + *Cypr. macrophthalmus* + *Cypr. quadrilobatus*) Nouv. Mém. Soc. Natur. Mosc., tom. X (1855), p. 229, cett., tab. III, fig. 3, tab. V, figg. 1—5, tab. IX, fig. 2; BLANCH. (*Cyprinopsis*, ex FITZ.) *Poiss. d. eaux douces Fr.*, p. 343; GTHR (*Carassius*) *Brit. Mus. Cat., Fish.*, vol. VII, p. 32; FEDDERS., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 83; FATIO, *Fn. Vert. Suisse*, vol. IV, part. I, p. 205; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 166, tab. CXXX, fig. 2; LILLJ. (*Cyprinus*) *Sv., Norg. Fn., Fisk.*, vol. III, p. 158.

Carassius Langsdorfii + *Car. Burgeri* + *Car. Cuvieri* + *Car. grandoculis*, SCHLEG. (SIEB.) *Fn. Japon. Pisc.* p. 192, cett. tab. XCVIII.

The Goldfish is everywhere so well known that any special description of it seems unnecessary. In its normal type it is an intermediate form between the Carp and Crucian Carp, with a more shallow and more terete body and longer dorsal fin than the latter. During youth, however, the Crucian Carp and the Goldfish may be almost exactly similar in these respects, especially as the Goldfish undergoes exceedingly great variations in a domesticated state. The rule is that the latter generally has comparatively larger fins and shorter preabdominal region than either the Carp or the Crucian Carp, the young Goldfish being thus most easily recognised — where the coloration does not decide the question — by the fact that the tips of the pectoral fins extend behind the perpendicular from the insertions of the ventral fins.

The Goldfish, the *kin-ju* of the Chinese, has its original home "in a small lake, Tschekiang[1], near the

[a] Sometimes 15, according to FATIO and CANESTRINI.
[b] " 14, " " FATIO.
[c] " 9, " " FATIO.
[d] " 25, " " FATIO and CANESTRINI.
[1] In modern maps Tschekiang is the name given to one of the eastern provinces of China, on the coast, between 27° —31° N. lat.

town of Tschangwahyen in the province of Hiantschewfu, at the foot of the mountain Tsienking"[a]. From this locality it was first transported to the northern provinces of China and to Japan, long before it became a luxury in Europe at the middle of the last century. The assumption has indeed been made that it had been introduced at an earlier date into Europe by the Portuguese, after they had discovered the route to India round the Cape of Good Hope; and at the present day it is said to be a common fish in the streams of Portugal. But it was not until the eighteenth century that the cultivation of the Goldfish was begun in Europe. The French East Indian Company then presented some Goldfish to Madame POMPADOUR, and about 1730 the species was naturalised in England. From that country it subsequently spread over the whole of Europe; and at present the breeding of Goldfish is practised on the largest scale in Germany. The neighbourhood of Havre in France also supplies the market with considerable quantities of Goldfish.

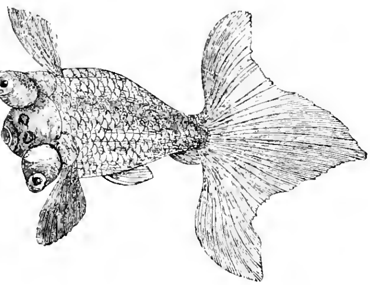


Fig. 181. The Telescope-fish, a variety of the Goldfish. After GÜNTHER.

In its original state the Goldfish is olive green, darker — sometimes blackish brown — on the back and lighter — sometimes whitish — on the belly, with a golden (brassy) or silvery lustre, and has the form shown, with only slight deviations from the natural type, in our figure (Plate XXXI, fig. 2). Cultivation and selection[b] are the causes of the well-known alterations both in colour and form[c]. The colour shades 1) into blood-red or orange, ending in the lustrous gold of the typical Goldfish, 2) into paler yellow or white, a transformation which gives the Silverfish its name, or 3) into brown, blue, or nearly pure black. These tints either become predominant both on the body and the fins, or in the light varieties, leave patches and traces of the original colour. The changes of form tend not only to a more terete shape of body, but also to the most grotesque modifications of the fins. The dorsal fin is reduced more and more, until it finally disappears, or it may also be divided into an anterior and a posterior part. The caudal and anal fins are doubled; and when these changes are accompanied by the protrusion of the eyes, they culminate in the variety described by LINNÆUS in 1740, the Telescope-fish (fig. 181). The internal organs also undergo monstrous alterations. The development of the air-bladder may suffer such distortion as to leave the fish a helpless cripple.

In this manner the Goldfish has been cultivated and deformed for the amusement of people of rank ('in Magnatum oblectamentum', LINNÆUS), above all at the imperial court of China, where officials have been especially appointed to take charge of the Goldfish, and where, as LACEPÈDE remarks, the women may well require this diversion to break the monotony of their idle existence. Among these ladies it has been a shifting fashion to keep one variety or another, and an interesting observation of nature to watch the amatory passages of the Goldfish, as the male caresses the gravid female, rubbing his body against hers. The peaceful and sociable life of these fish and the ease with which they may be bred, without the need of any troublesome attendance, have rendered them agreeable and cheap pets. By ringing a bell — the Chinese always have one hanging beside the ponds — each time the fish are fed, they may be trained even in large pools to obey this summons and to come up to the shore, when the bell is sounded, to show themselves. By means of warmth and abundant food Goldfish may be induced, in suitable aquaria or in fish-ponds, to breed three or four times in the course of the summer. The Goldfish hatched in spring are 3—7 cm. long by autumn, the largest being now ready for sale, as they have generally acquired by this time the proper

[a] According to the Jesuit missionary LE COMTE, who wrote an account of his travels at the end of the seventeenth century. See BASTER, l. c., p. 80. At the same period KAMFER, one of OLAUS RUDBECK's followers, published a book of travels and a history of Japan, where he mentions the Goldfish, the *king-jo* of the Japanese.

[b] *Land and Water*, May 3rd 1879 and C. WAGNER, *Wasser-Cultur*, Bremen 1881.

[c] Cf. BASTER, l. c., tab. IX.

coloration. In its earliest youth, the duration of which may, however, be shortened by cultivation, the Goldfish wears its original colour. Traces thereof appear in our figure on the lips and the pectoral and ventral fins.

In many parts of Southern and Central Europe the Goldfish has become completely naturalised. In Sweden there can hardly be any locality where the natural temperature is high enough fully to satisfy the climatic requirements of the Goldfish; but in Denmark it is kept in ponds at several places, and even in Sweden it can live and multiply in the open, as shown by an experiment made at Helsingborg. In 1888 five handsome Goldfish were put into a fountain in the Park of that town, and left to find their own support among the algæ growing on the bottom of the basin, and among the insects they might capture at the surface of the water. Here they survived a severe winter, and seemed to thrive excellently, having gained both in weight and size by the following summer. They also considerable increased in number, the parent stock being now surrounded by a numerous progeny"[a].

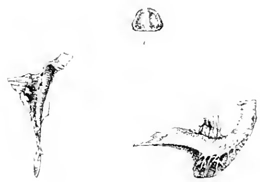
The flesh of the Goldfish was tasted and commended long ago by BASTER (1765). It is said to be excellent, whether boiled or fried, and superior to that of the Carp. The Goldfish of commerce yields most profit, however, by its sale as stock for ornamental waters.

THE CRUCIAN CARP (SW. RUDAN).

CYPRINUS CARASSIUS.

Plate XXX, figs. 2 and 3.

Mouth without barbels. Preabdominal length more than $^2/_5$ of the base of the dorsal fin. Length of the lower jaw less than $^2/_5$ of the preabdominal length. 7 or 8 scales in an oblique transverse row between the lateral line and the anterior part of the base of the dorsal fin. Pharyngeal teeth set in one row, for the most part transversely compressed, with simple or one-grooved masticatory surface: 4—4.



a b

Fig. 182. Pharyngeal bones and pharyngeal cartilage of *Cyprinus carassius*. Nat. size. *a*, *b*, and *c* as in the preceding figure.

R. br. 3: *D.* $\frac{3-4}{16-19}$; *A.* $\frac{3}{6-7}$; *P.* $\frac{1}{13-16}$; *V.* $\frac{2}{7-9}$;

C. $x+1+17+1+x$: *Lin. lat.* (31)33—35: *Lin. tr.* $\frac{7-8}{6}$ 1: *Vert.* 32.

Syn. *Karas* (Karass) et *Giblichen*, GESN. *De Aquat.*, *Paralip.*, p. 16; *Cyprinus brevis*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 33; *Cyprinus* pinna dorsi ossiculorum viginti, linea laterali recta, ART., *Ichthyol.*, *Gen. Pisc.*, p. 4; *Syn. Pisc.*, p. 5; *Descr. Spec. Pisc.*, p. 29: LIN. *Fn. Suec.*, ed. 1, p. 122 (pinna *ani* err.); *Cyprinus* Hamburger dictus, GRONOV., Act. Upsal. 1741, p. 75; *Cyprinus*, No. 4, KLEIN, *Hist. Pisc. Natur. Miss.* V, p. 59, tab. XI, figg. 1 et 2.

Cyprinus Carassius, LIN., *Syst. Nat.*, ed. X, tom. 1, p. 321; PENN., *Brit. Zool.* (ed. 1776), vol. III, p. 319; BL., *Fisch. Deutschl.*, part. I, p. 69, tab. XI; RETZ., *Fn. Suec. Lin.*, p. 355; SWARTZ, *Sv. Zool.*, vol. I, tab. No. 10; EKSTR., Vet.-Akad. Handl. 1830, p. 192; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 297; NILSS., *Prodr. Ichth. Scand.*, p. 32; EKSTR., Vet.-Akad. Handl. 1838, p. 213; ID., *Skand. Fisk.*, ed. 1, p. 140, v. WR., tab. 31 et 32; YARR., *Brit. Fish.*, ed. 2, vol. I, p. 355; CUV., VAL., *Hist. Nat. Poiss.*, vol. XVI, p. 82, tab. 459; NILSS., *Skand. Fn.*, *Fisk.*, p. 290; BLANCH. (*Cyprinopsis*) *Poiss. d. eaux douces Fr.*, p. 336; LINDSTR. Gotl. L. Hush. Sällsk. Årsber. 1866, p. 16 (sep.); MELA *Vert. Fenn.*, p. 317; tab. X; LILLJ., (*Cyprinus*) *Sv.*, *Norg. Fn.*, *Fisk.*, vol. III, p. 147.

Cyprinus Gibelio, BL., l. c., p. 71, tab. XII; EKSTR. 1830, l. c., p. 196; NILSS., *Prodr.*, p. 33; YARR., l. c., p. 358; CUV., VAL., l. c., p. 90; HECK., KN. (*Carassius*) *Süsswasserf. Oestr. Mon.*, p. 70; COLL., Forh. Vid. Selsk. Chrnia 1874 Tillægsh., p. 180; BLANCH. (*Cyprinopsis*) l. c., p. 340; NORDM. (*Carassius*) *Handl. Fisker.*, *Fiskafr.*, p. 417, tab. XLVIII, fig. 130.

Carassius vulgaris, NORDM., *Voy. Russ. Mer.* (DEMIDOFF), tom. III, p. 479; KR., *Danm. Fisk.*, vol. III, p. 294; HECK., KN.,

[a] See the *Svenska Dagblad* for the 22nd of August, 1889.

I, p. 67; DYBOWSKI, *Vers. Monogr. Cypr. Livl.*, p. 41; SIEB., *Susswasserf. Mitteleur.*, p. 98; MGRN, *Fnl. Fiskfn.* (disp. Helsingf. 1863), p. 37; CANESTR., Arch. Zool., Anat., Fisiol., vol. IV, fasc. 1 (1866), p. 66; GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 29; FEDDERS., Nat. Tidskr. Kbhvn., ser. 3, vol. XII, p. 82; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 109; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 374; MOR., BKE, *Fisch. Osts.*, p. 106; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 164; BNCKE, *Handb. Fischz., Fischer.* (M. V. D. BORNE), p. 119.

Cyprinus moles, AGASS., Mem. Soc. Sc. Nat. Neuchat., tom. 1 (1836), p. 37.

Cyprinus humilis + (?) *C. bucephalus*, HCKL, Ann. Wien., Mus. vol. II, pp. 156, 157, tab. 9, fig. 4.

Cyprinus Linnæi, BP., *Cat. Met. Pesc. Eur.*, p. 27; MALM (*Carassius*) *Gbgs, Boh. Fn.*, p. 556.

Cyprinus oblongus, HCKL, KN., *Susswasserf. Oestr. Mon.*, p. 73.

A: *The Lake Crucian Carp* (*Cyprinus carassius*, auctt.) — Plate XXX, fig. 2.

The size of the Crucian Carp is very variable, being influenced by the water in which the fish lives, and by the supply of food. Most specimens are small, but sometimes the species attains a length of 4 dm. or more. The largest specimen EKSTRÖM saw measured 35 cm. to the base of the caudal fin, i. e. 42 cm. to the end of the caudal lobes. LILLJEBORG mentions several specimens 45 cm. long from Upland, and he once saw a still larger Crucian Carp, which was taken in Lake Hedervik (Upland) and weighed nearly $3^1/_2$ kgm.

The body is rather thick, but compressed and very deep, the greatest depth[a], which coincides with the perpendicular from the beginning of the dorsal fin to the bases of the ventral fins, measuring half the length of the body to the base of the caudal fin or even to a point half-way along the said fin. The greatest thickness, which lies almost in the same perpendicular, measures more than $^1/_3$ (about $^2/_5$) of the greatest depth. The back is broad and convex at the occiput, gradually decreasing in breadth towards the dorsal fin, at the base of which it is strongly compressed and thin. From the end of the dorsal fin to the caudal fin the back resumes its broad, convex shape. Forming a more or less obtuse angle at the beginning of the dorsal fin, the entire dorsal profile runs in a high arch to the end of the said fin, where a depression begins and extends to the caudal fin. The belly is flat in front of the ventral fins, between these fins and the anal fin convex, with a low carina along the median line. The curve of the ventral profile, less marked than that of the dorsal, is regular to the beginning of the anal fin, from which point it rises more abruptly to the peduncle of the tail. This finless part of the tail is deep[b] and very short, the distance between the anal and caudal fins measuring half the depth of the tail at the termination of the former fin.

The head, which is not very large, occupies in adult specimens about 22 % of the length of the body, or rather more than $^1/_4$ of the length to the base of the caudal fin, while in young specimens its relative length is somewhat greater. The breadth measured across the gill-covers is about equal in adult specimens to the distance from the tip of the snout to the hind margin of the preoperculum, in young specimens to that of the orbit. The forehead is broad and convex, its breadth at the middle of the eyes measuring in adult specimens about 38—41 % of the length of the head. The profile is straight from the snout to the occiput, where a slight break generally interrupts its continuity. The snout is blunt. Its length in adult specimens is about $^1/_3$ of that of the head. It projects slightly in front of the mouth, which is small, protrusile, and turned slightly upwards. The lips of young specimens are fairly thick, especially the underlip; but in old specimens they shrink, and sometimes leave the sharp inferior edge of the intermaxillary bones to form the very margin of the upper jaw. The upper jaw projects somewhat, though only slightly, beyond the lower; but the length of the latter is generally somewhat greater than that of either the snout or the operculum. The eyes are circular and middle-sized, being comparatively larger as usual during youth, and varying in longitudinal diameter between about 70 and 40 % of the breadth of the interorbital space. They are set so high that an horizontal line drawn from the middle of the margin of the upper jaw touches the lower edge of the iris or of the pupil. The nostrils resemble those of the Carp; but the two anterior nostrils lie at a somewhat greater distance from each other than from the tip of the snout. The operculum is flat, without any marked convexity, and rendered rough to the touch by rows of tubercles radiating towards the inferior margin. Its upper margin is united by the skin to the side of the body. In this species also the

[a] About 41—43 % of the length of the body to the end of the middle caudal margin.

[b] Least depth of the tail about 13 % of the length of the body.

branchiostegal membranes coalesce with the sides of the isthmus, at a distance from each other which is equal in old specimens to the longitudinal diameter of the eye. The size of the gill-openings is consequently not very considerable, though greater than in the Carp, the head being much deeper. The branchiostegal membrane forms a broad, membranous rim, usually broader than in the Carp, along the margins of the operculum and suboperculum. The gill-rakers are of the same soft structure as in the Carp, but more numerous, the outer row on the front of the first branchial arch containing about 26—30. The lower pharyngeals are furnished at the outer margin with about 19 similar but shorter spines. At the inner margin they have a short row of four teeth (fig. 182), the first of which pretty closely resembles the corresponding tooth in the Carp, being terete, or even somewhat compressed at the sides, but with hooked tip and obliquely cut crown. The three posterior teeth, on the other hand, are strongly compressed in a transversal direction (in front and behind), and their crowns are bent close to each other. The pharyngeal cartilage has about the same triangular shape as in the Carp.

The body is covered with large, imbricated, and striated scales, resembling in essential respects those of the Carp, but with the radiating grooves on the covered (anterior) part of each scale more distinct and opening in sharp sinuses at the anterior margin of the scale. As a rule six (4—8) grooves appear at this margin. Another groove usually runs straight or obliquely across the scale, and from the middle of this groove (the indistinct nucleus of the scale) two or three similar grooves extend obliquely backwards along the free (posterior) part of the scale, where the concentric striæ show undulating breaks. The hind margin of the scale thus displays numerous and fine, but irregular notches. The lateral line is straight or slightly sloping, and lies somewhat nearer to the ventral edge than to the dorsal. It is covered by 33 (31—35) scales. It terminates sometimes at the middle of the body, more frequently above the vent; and is seldom complete all the way to the caudal fin. The perforating ducts of the lateral line are still shorter than in the Carp. In most cases we find 7 rows of scales above the lateral line and 6 below it. Sometimes there are 8 rows above and 7 below, in which case the top and bottom rows consist of smaller scales. The vent lies somewhat behind the beginning of the hindmost third of the body.

The dorsal fin is long, but shorter than in the Carp, though its length undergoes even relative increase with age, varying between about 26 and 32 % of that of the body. Its height, on the other hand, is generally greater than in the Carp, being apparently subject to greater individual variation (about 11—18 % of the length of the body). It begins as far from the tip of the snout as from the base of the caudal fin, or a little nearer the latter, exactly above the bases of the ventral fins, or a little farther forward, and ends in most cases above the middle or the termination of the anal fin. Its height is almost uniform, or slightly greater in the anterior half; and its margin is arcuate in adult specimens, straighter in the young. The rays vary in number between 20 and 23. The first four rays are simple, the first of all being an almost imperceptible spine, most often hidden in the skin, the second somewhat longer, the third more than twice as long as the second, and the fourth dentated behind on both sides, soft at the tip, and nearly as long as the first branched ray. The last ray is cloven to the base, and may easily be counted twice over.

The anal fin is short but fairly high, with rounded margin. Its length is about 10 or 11 %, its height about 12 or 13 % of the length of the body. It contains 9 or 10 rays, the first three simple. The first is a rather small spine, the second twice as long as the first, the third thick and hard, with soft and jointed tip, dentated behind on both sides, and somewhat shorter than the first branched ray. The last branched ray is cloven to the base.

The pectoral fins are obliquely rounded at the tip, and contain 1 simple and (in most cases) 14 branched rays. Their length may rise from 14 to 18 % of that of the body. The ventral fins are both broader and longer, being more obliquely rounded at the tip. Their length varies between 16 and 19 % of that of the body. Here, as in the preceding forms, the first ray is short and set very close to the second, which is thick and hard, with soft tip, and nearly as long as the first branched rays. Both pectoral and ventral fins are generally longer in the males than in the females.

The caudal fin is broad, when folded somewhat forked, almost truncate when expanded. The middle rays occupy 13—18 % of the length of the body, and in adult specimens are $^2/_3$ as long as the longest lateral rays.

The colouring of the Lake Crucian Carp is very variable, and is closely connected with the nature of the water inhabited by the fish. It is purest and most handsome in lakes with clear water and weedy bottom. In such cases the back is olive green, the sides are lighter and suffused with brassy yellow, growing still lighter towards the belly, which is whitish yellow. The top of the head is of a darker olive green than the back; its sides are coloured with a handsome brassy yellow. In muddy lakes with turbid water the coloration is darker, the back and the top of the head being dark green, the suffused colour on the sides hardly visible, and the belly dark yellow. The iris is yellow in specimens that live in clear water; but the darker the colour of the body, the greater the density of the dark dots with which the iris is punctated, and which in these specimens give it a brownish or pure brown appearance. The colour of the fins is no less variable. It conforms to that of the body, and thus becomes darker or lighter. The dorsal and caudal fins are generally grayish, and in colour closely resemble the back. The pectoral, ventral, and anal fins are more reddish brown. During youth, "up to a length of at least 42 mm.[a], the Crucian Carp is marked on the peduncle of the tail with a whitish band and, in front of this, with a black band, sharply defined posteriorly" (MALM).

The common Crucian Carp may undergo the same change of colour as its nearest congener, the Goldfish. PALLAS states that the most handsome specimens of this golden form occur in the desert lakes along the course of the River Ural and in its salt tributary, the Solanaja. v. SIEBOLD observed a similar, but stunted form (of the following variety) in small, stagnant pieces of water near Braunsberg and Königsberg in East Prussia.

B: The Pond Crucian Carp (*Cyprinus gibelio*, BL., auctt.) — Plate XXX, fig. 3.

In Sweden the Pond Crucian Carp is usually of insignificant size. Its ordinary length is about 7—12 cm., while the largest specimen EKSTRÖM saw measured nearly 2 dm. In 1835 FRIES took a specimen 23 cm. long at Morlanda (Bohuslän); and MALM mentions the capture of a female 34 cm. long in the pond at the park of the Gothenburg Horticultural Society.

The body of this variety, as compared with that of the preceding one, is more elongated, less compressed in front, and shallower. The greatest depth, which lies somewhat nearer to the head than in the Lake Crucian Carp, is less than half (about $^2/_5$) of the length of the body to the base of the caudal fin, or about $^1/_3$ of the length to the end of the said fin. The greatest thickness is more than $^1/_3$ of the greatest depth.

The shape of the back is the same as in the common Crucian Carp. The dorsal profile runs in a regular and not very high arch, without any angle at the beginning of the dorsal fin, and is in general less strongly depressed between the end of the dorsal fin and the beginning of the caudal fin than in the preceding variety. The elevation at the very tip of the tail (the urostyle), on the other hand, is sometimes more marked in the Pond Crucian Carp. The belly from the isthmus to the ventral fins is convex, seldom flat as in the preceding variety, and between the ventral and anal fins compressed, almost carinated. The curve of the ventral profile is nearly equal to or somewhat sharper than that of the dorsal, whereas in the common Crucian Carp the former is more gradual than the latter. From the anal to the caudal fin the depression is more distinct. The tail is deep and short, though longer than in the preceding variety, the distance between the anal fin and the caudal fin being there almost exactly half the depth of the body at the end of the former fin, but here $^2/_3$ thereof.

The head is apparently larger — which is always the case when the fish acquires a more elongated form — but its relative length is really the same as in the Lake Crucian Carp, varying between about 27 % (in young specimens) and about 22 % (in old) of the length of the body. Its breadth, however, measured across the gill-covers, is greater in proportion to the breadth of the trunk here than in the preceding variety. Seen in profile, the head also appears shorter and more obtuse than in the latter. The forehead is somewhat broader and less convex. The snout is blunter, and the cleft of the mouth ascends more sharply, the lower jaw closing the mouth like a lid, and the angle formed by the lower jaw at its articulation being thus rendered more distinct. The pharyngeal teeth in number and form exactly resemble those of the Lake Crucian Carp. The opercula are distinguished by their being more or less convex, whereas in the preceding variety they are almost flat. The branchial arches, the branchiostegal membranes, and the eyes, both in form and position,

[a] Even at a length of 81 mm. this marking is still present in the specimens preserved in spirits in the Royal Museum. That it may be even longer persistent in the more elongated varieties of this species, appears from figs. 5 and 6 in SIEBOLD's *Süsswasserfische Mitteleuropas*.

resemble those of the Lake Crucian Carp; and this applies also to the nostrils, though they are sometimes set a little higher.

The scales are like those of the preceding variety in form, number, and distribution. The lateral line shows some difference, being generally somewhat more curved, and lying nearer the back. The position of the vent is the same.

The dorsal fin, which in the number of the rays resembles that of the Lake Crucian Carp, is distinguished from the latter by the difficulty which often involves the detection of the first ray, and which not unfrequently causes this ray to be overlooked. In form the difference is greater, the dorsal fin of the Pond Crucian Carp being always higher in front and less arcuate at the margin. The anal fin may be recognised by its somewhat greater height and less rounded anterior corner. The caudal fin, even when strongly expanded, and even in old and large Pond Crucian Carp, is concave at the hind margin. The pectoral and ventral fins of the two varieties are alike in all essential respects. The above differences in the form of the fins in general range the Pond Crucian Carp on a level with young individuals.

The coloration of this variety is generally darker than that of the Lake Crucian Carp. The back is of a dark olive green, and the top of the head still darker. The dark tint of the back grows somewhat lighter down the sides, the inner coat of brassy yellow being more distinct here than on the back, where it is often invisible. The belly is dark yellow. The dorsal fin is of the same colour as the back; the other fins are gray, more or less deeply tinged with red. The iris is brassy yellow, but often rendered brown by the dense dots with which it is strewn. The pupil, however, always has a fine, brassy yellow rim.

In the structure and arrangement of the internal organs there is only one difference: in the air-bladder of the Pond Crucian Carp the round anterior part is comparatively larger, and the posterior part not so sharply curved, shorter, and narrower, a circumstance which seems to depend on the stronger contraction of the hind part of the abdominal cavity.

The Crucian Carp, which in Scania and Bohuslän is called *Karussa* (probably from the Danish *Karudse*), occurs almost everywhere in Sweden, even in the District of Norrbotten[a]. In Norway and Finland, according to COLLETT and MELA, the northern range of the Crucian Carp is about equally great, extending to at least 66° N. lat.[b] The individuals that occur in these northern regions do not, however, attain any considerable size. The species seems also to diminish in size towards the west, for though even in the District of Gefleborg it attains a weight of $3^3/_4$ lbs. (17 hectogrammes), COLLETT mentions a specimen 260 mm. long as the largest Crucian Carp from the neighbourhood of Christiania preserved in the University Museum of that city; and this specimen probably weighed no more than 7 or 8 hectogrammes. In the central and southern provinces of Scandinavia the species is extremely common, and it is here too that it attains the greatest size. In Wermland it is rarer and smaller. The Crucian Carp is also spread over the whole of Europe[c] and Central Asia, together with Siberia, eastwards to Amur and China.

The favourite haunts of the Crucian Carp are small lakes with shallow water and weedy and oozy bottom. When it is found in larger pieces of water, as in the western island-belt of the Baltic or Lakes Wener, Wetter, and Hjelmar, its occurrence is confined to shallow, weedy, and muddy inlets. It also thrives well in small ponds, peat-haggs, and other collections of stagnant water, and is the only one of our indigenous fishes, except the Three-spined Stickleback, that is plentiful and multiplies freely in such localities, for the Carp cannot be regarded as an indigenous Scandinavian species. Hence the Crucian Carp, like the Carp, is kept in ponds, almost as a domestic animal, to supply the wants of the table. It can even put up with polluted water. PALLAS also tells us that the Crucian Carp, which does not even disdain the salt water of the steppes, is the first fish to make its appearance in new-formed lakes and fens, of which fact he saw instances in the basin of the Isset, a tributary of the Tobol (Siberia).

In such small pools, where there is never a sufficiency of food for any considerable number of fishes,

[a] Cf. Underd. Bet. Försl. Ny Fiskeristadga 1883, Bilaga III, p. 158.

[b] GRIMM (*Fishing and Hunting on Russian Waters* 1883, p. 13) sets the northern limit of the Crucian Carp's range in Russia at "about 65° N. lat."

[c] APOSTOLIDES (*La Pêche en Grèce*, 1883), however, does not include the Crucian Carp among the fishes of Greece.

the Crucian Carp gradually degenerates, and after some generations assumes the form described above under the name of the Pond Crucian Carp. This form never occurs in lakes or such localities as were first mentioned as the favourite haunts of the species. There only the Lake Crucian Carp is met with; but if specimens of this variety be put in a small fish-pond, in the course of some years the pond will be found to contain Crucian Carp of an intermediate form, difficult to refer to either variety, and at a still later period only Pond Crucian Carp.

These two forms are consequently not distinct species, as was long assumed on BLOCH's authority. It is probable, however, that the Crucian Carp does not degenerate with equal rapidity everywhere, but that the course of degeneration is arrested at an earlier or later stage, according to the nature of the water and the supply of food. Small pools are, at all events, often inhabited by the said intermediate forms, which seem to have lived and multiplied there for a long time without further transformation.

That the Pond Crucian Carp resumes its original form, is shown by the fact that if a few small specimens of this variety be placed in a large pond, where the supply of food is abundant, they soon acquire the intermediate form. But when they have been allowed to multiply to any great extent, so that food is scarce, and the pond overstocked, they revert to the normal form of the Pond Crucian Carp. Furthermore, we have actual evidence to show that specimens of the Pond Crucian Carp, which have been transferred to lakes, have at length been restored to the original form of the Lake variety. In a small lake in Södermanland EKSTRÖM found large Lake Crucian Carp, the progeny of Pond Crucian Carp which, according to the statements of trustworthy persons still living at the time, had been taken 40 or 50 years previously from a neighbouring pond still inhabited by the latter variety.

EKSTRÖM elucidated this question in the Proceedings of the Swedish Academy of Science for the year 1838; and at the present time his opinion on the subject is almost universally accepted.

The Crucian Carp is very sluggish in temperament, never undertaking any long excursions, and always staying near its birthplace, unless compelled by fortuitous circumstances to change its abode. This innate distaste for active motion deprives it of any great timidity and renders it oblivious of danger, as it hides in the ooze at the bottom, where the water is deep, or among the weeds nearer the shore. When it ascends towards the surface, which seldom happens except when the heat of the sun entices it forth, it is however shy, and takes to flight at any noise. It then makes straight for the bottom, and there seeks a safe refuge, from which it is not easy to unearth. Its movements in the water are often active and speedy, though they lack endurance.

The spawning-season occurs in spring and summer, some days earlier or later according to the situation of the water where the fish has its home. In Central Sweden the Crucian Carp spawns in June, about midsummer, when the weather is warm and fine. The fish then ascend to shallow water near shore. Here they spawn among the weeds, assembling in dense shoals and circling rapidly round each other, now and then raising their snouts above the surface, where each fish leaves a bubble that bursts with a faint sound. A murmuring hubbub, like the noise of boiling water, is thus produced. The roe is deposited at the bottom on the weeds, to which it adheres, and is soon hatched when the weather is favourable. The fry do not grow very rapidly, but soon reach maturity. This faculty of early reproduction, combined with the comparatively large size of the ovaries and the smallness of the eggs, their diameter, when deposited, being only slightly more than 1 mm., as well as their great number (100,000—300,000 in each female), renders the Crucian Carp extremely prolific. The duration of the spawning-season is protracted, in this species as in others, by the older fish spawning first, the younger ones later in the year. But the erroneous supposition that the Crucian Carp spawns several times a year, has arisen from the circumstance that during the months of July and August, when the weather is calm and fine, these fishes shoal in exactly the same manner as when they are spawning.

The Crucian Carp is a glutton, and lives on insects, worms, water-plants, and mud. The flesh ranks as a delicacy, but its reputation depends principally on the skill of the cook. Large Crucian Carp, taken in clear water, are best and by no means bad eating; but small specimens from muddy lakes always have a more or less tainted flavour, and their flesh is also bony.

The Crucian Carp is extremely tenacious of life. In lakes and ponds where the bottom freezes, it can survive the winter, and after being kept frozen for a long time, may be restored to life by cautiously thawing the ice. How great sufferings it is capable of enduring, may be gathered from EKSTRÖM's account of a specimen described in his "*Mörköfiskar*". "This specimen was procured from the island-belt, where it had been kept several days in a cauf. About five o'clock in the morning it was taken out of the cauf and carried to the rectory. It was then laid on a gutting-board and left there during the whole time occupied in describing and drawing it. About six o'clock p. m., when the fish had been out of the water quite thirteen hours, it was cut in two close to the beginning of the dorsal fin. The heart, liver, etc. were removed, and the surface of section was drawn. When all this was finished, and the pieces were to be thrown away, the forepart of the fish still showed signs of life, the gill-covers being opened and closed, and the mouth protruded and drawn back. I left the pieces where they lay, in order to observe how soon all manifestations of life would cease. Not until nine o'clock in the evening had all signs of vitality disappeared. The fish had thus lived sixteen hours without water, three hours cut in two and without heart."

Of the age attained by the Crucian Carp LINNÆUS tells us (*Skanska Resan*, p. 256) that a Crucian Carp had lived "certainly more than 70 years" in a spring at Ma in the parish of Svensköp. During all this time it had not grown to a greater length than 6 in. (15 cm.), and the colour of the back was very dark. "The meagre water of the spring had probably denied it a sufficiency of food."

The Crucian Carp is taken chiefly in traps (see above, p. 33, fig. 7), during the spawning-season in gill-nets, and often in trammel-nets[a]. In the last case the water should be thick, for otherwise the fish seldom suffers itself to be driven into the net, but buries itself in the mud. (EKSTRÖM, SMITT.)

[a] Fr. *tramail* (*trois mailles*), Sw. *skottnat*, *skotnot*, or *pulsnot*. In this fishery, which is generally employed for the Cyprinoids, and which is unfortunately very destructive if practised during the spawning-season, the necessary tackle comprises, besides the coble, the net itself (fig. 183), the 'shoes' (Sw. *kabbarne*, fig. 184), a pole, and a 'beater' (Sw. *puls*, *fork*, or *torfel*, fig. 185). The depth of the net is between 12 and 16 dm., the length 14–16 metres if the net is to be managed by one man, but much greater when there are two fishermen. Besides the net itself (the inner net — fig. 183, *G*), which resembles an ordinary gill-net, and is made of very fine twine, the size

Fig. 183.

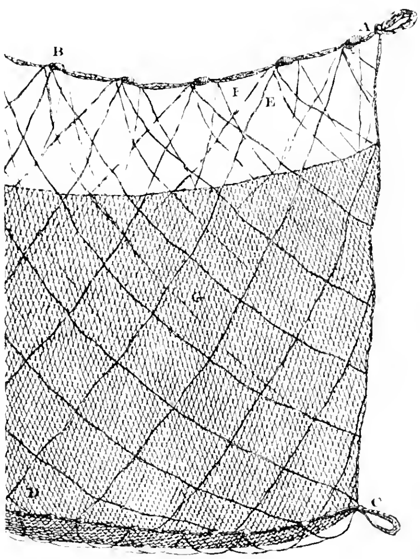


Fig. 184.

Fig. 185.

Fig. 183. One end of a trammel-net. *AB*, the head rope. *CD*, the foot rope: *E* and *F*, the two outer nets: *G*, the inner net.
Fig. 184. Shoe. Fig. 185. Beater.

of the meshes depending on the kind of the fish for which the net is to be used, the trammel should consist of an outer net (Sw. [illegible]) with very large meshes, and made of coarse and strong twine. The outer net should be equal in length to the inner net, if it is to extend along only one side of the trammel, or twice as long, if, as is usually the case, it is to cover both sides (fig. 183, *E* and *F*). When

GENUS GOBIO.

Base of the dorsal fin less than twice as long as that of the anal. Branched rays in the dorsal fin at most 8, in the anal at most 7. Neither of these fins with any spiniferous ray. Scales middle-sized — 40 or a few more in the lateral line — and rather thin. Distance between the anal fin and the vent about equal in length to the base of the fin.

In this genus and the following one we pass from the Macroenteric Cyprinoids and also draw nearer to the Leuciscine group, the dorsal fin being reduced both in the number of the rays and the length of the base. The external form of the body is also approximated to the Leuciscine type. Still its affinity to the genus *Barbus*, which abounds especially in India, connects *Gobio* with the true Carps. The genus *Gobio* was established by CUVIER[a] as a subgenus of *Cyprinus*; but FLEMING[b] was the first to adopt it as the name of a distinct genus. Only two species, both European, have hitherto been recognised within this genus. One of them, the smaller, but more elongated of the two (*Gobio uranoscopus*), belongs exclusively to Austria and Bavaria. The other is

the fish comes in contact with the inner net, it pushes a part thereof in front of it through one of the meshes of the outer net, and is thus enclosed in a kind of pocket, from which it cannot retreat. The size of the meshes in the outer net varies according to the depth of the trammel, which should be five meshes deep. In the inner net, which is to form the pockets, the netting should be deeper, a trammel 12 dm. deep requiring an inner net 16½ dm. in depth. The art of constructing a trammel-net is difficult enough; but space permits us only to refer the reader to the figure. The head rope (Sw. *flarntelnen*) should, if possible, be furnished with round floats (Sw. *flarn*) of pine-bark, attached at a distance of 17—20 cm. from each other. The foot rope (Sw. *stentelnen*) should be weighted with plummets of lead. At each end of the head rope a so-called 'shoe' is fastened. The shoe is made of wood, in the form of a pointed and hollow cone, and from its base there projects a wooden disk, pierced at the end with a hole, by means of which the shoe is attached to the head line.

In addition to the net described above the fisherman should have a coble or punt, furnished at the prow with a ring of iron, rope, or twisted rushes, about 15 cm. in diameter. The *pole*, with which the net is shot, is made of spruce, and should be 7 or 8 metres long, not too thick to be easily grasped by the hand, and not so thin as to bend beneath the weight of the net. The tackle should be completed by a so-called 'beater', with shaft 4 or 5 metres long. The shaft should consist of a thin stake, sharpened like a sword at one end to enable the fisherman to drive it with ease into the bottom, and furnished at the other end with a lump of wood which varies in shape, but generally resembles a hemisphere hollowed into the form of a funnel. When this end of the 'beater' is thrust into the water, the air contained in the hollow is forced below the surface, and increases the noise of the blow.

Armed with these implements, the fisherman betakes himself some fine summer day to a shore overgrown with grass or reeds. When he has found a suitable spot, he passes the pointed shaft of the beater through the ring at the prow of the coble, and drives it into the bottom hard enough to moor his boat safely. Then he lets down the net, which should have been properly arranged beforehand, into the water at the bows, takes the pole, inserts its end into the shoe, and thus shoves out the net in an oblique direction towards the shore. When he has spread half the net to the full length of the pole, he suddenly plucks the latter out of the shoe, and the net stays in position. He now inserts the tip of the pole in the same manner into the shoe at the other end of the trammel, and sets this part of the net in a similar way, so that, when both halves of the net are shot, it lies in the form of a snow-plough (V), with the entrance of the angle turned towards the shore, and its point towards the bows of the coble. The fisherman next draws up the 'beater', adjusts the middle part of the net, the part which the length of the pole has not enabled him to set before, and with the aid of the 'beater' pushes the coble round one end of the net towards the shore. Having got as close in shore as possible, and keeping the net in front of him, he turns the other end of the 'beater' downwards, and plunges it into the water in the direction of the net, thus driving the fish before him, and gradually pushing the coble forward, until he is able to touch the net with the 'beater'. With the same implement he then lifts the foot rope of the net above the surface, takes the foot rope and head rope in his hand, and draws up the net into the boat. After arranging the trammel by taking one of the ropes in each hand and laying the net carefully in the coble, he proceeds to another spot, where he repeats the operation.

When the trammel-net is so large that two men are required to manage it, it is set like a seine in a semicircle, and when they are ready, one of the fishermen rows the coble from land towards the trammel, while the other stands in the boat and with the 'beater' drives the fish into the net.

[a] *Régn. Anim.*, ed. 1, tom. II, p. 193.

[b] *Brit. Anim.*, p. 186.

THE GUDGEON (SW. SANDKRYPAREN OR SLÄTTINGEN)

GOBIO FLUVIATILIS.

Plate XXXI, fig. 3.

Least depth of the tail about 1/3 (30—35 %) of the length of the head. Dorsal and anal fins (sometimes the other fins also) with spotted rays. Pharyngeal teeth set in two rows, the largest ones with compressed, simple, obliquely set masticatory surface; the tip hamate: 2(3),5—5(4),2(3).

Fig. 186. Pharyngeal bones and pharyngeal cartilage of *Gobio fluviatilis*. Magn. 3 diam. *a*, *b*, and *c* as in the preceding figure.

R. br. 3; *D.* $\frac{2-3}{7-8}$; *A.* $\frac{2-3}{6-7}$; *V.* $\frac{2}{7-8}$; *P.* $\frac{1}{13-16}$;
C. $x + 1 + 17 + 1 + x$; *Lin. lat.* 41—45; *Lin. tr.* $\frac{6}{4}$ 1; *Vert.* 37—41

Syn. Gobio, AUSON., *Mosell.*, vers. 132; *Gobio fluviatilis*, RONDEL., *De Pisc.*, part. II, p. 206. *Fundulus*, CHARL., *Onomast. Zoic.* p. 157; SCHONEV., *Ichthyol. Slesv. Hols.*, p. 35. *Cyprinus* quincuncialis maculosus, maxilla superiore longiore, cirrhis duobus ad os, ART., *Ichthyol.*, *Gen.*, p. 4; *Syn.*, p. 11; *Spec.*, p. 13. *Gudgeon*, PENN., *Brit. Zool.* (ed. 1776) tom. III, p. 316.

Cyprinus Gobio, LIN., *Syst. Nat.*, ed. X, tom. I, p. 320; BL., *Fisch. Deutschl.*, part. I, p. 57, tab. VIII, fig. 2; RETZ., *Fn. Suec. Lin.*, p. 355; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 295; AGASS., *Isis*, vol. XXI (1828), p. 1049, tab. XII, fig. 2; NILSS., *Prodr. Ichthyol. Scand.*, p. 33; SCHAGERSTR., Physiogr. Sällsk. Tidskr. 1837, p. 295; GTHR (*Leuciscus*), Jahresh. Ver. Vat. Naturk. Württemb., IX (1853), p. 268.

Gobio fluviatilis, FLMNG, *Brit. Anim.*, p. 186; CUV., VAL., *Hist. Nat. Poiss.*, vol. XVI, p. 300, tab. 481 (+ *Gob. obtusirostris*, p. 311); BONAP. (+ *Gob. venatus*) *Iconogr. Fna Ital.*, *Pesc.*, tab. 110, figg. 5 et 6; KR., *Danm. Fisk.*, vol. III, p. 334; NILSS., *Skand. Fn.*, *Fisk.*, p. 300; DYBOWSKI, *Cyprinoid. Livl.*, p. 72; SIEB., *Susswasserf. Mitteleur.*, p. 112; MGRN, *Finl. Fiskfn.*, p. 40; CANESTR., Arch. Zool., Anat., Fisiol., vol. IV, fasc. 1 (1866), p. 80; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 172; BUCKL., *Nat. Hist. Brit. Fish.*, p. 100; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 115; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 386; FATIO, *Fn. Vert. Suisse*, vol. IV, p. 280; MELA, *Vert. Fenn.*, p. 320, tab. X; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 172; tab. CXXXI, fig. 2; MOB., HCKE, *Fisch. Osts.*, p. 107; HERZENST., WARP., *Nat. Fischf. Amurb.*, p. 28; LILLJ., *Sv.*, *Norg. Fn.*, *Fisk.*, vol. III, p. 161.

Gobio vulgaris, HCKL., KN., *Susswasserf. Ostr. Mon.* p. 90. *Gobio Benacensis*, POLLINI; *Gobio lutescens*, DE FIL.; *Gobio Pollinii*, DE BETTA; vide FATIO, l. c., p. 294.

The Gudgeon, according to BLOCH, attains a length of 8 in. (21 cm.), and PENNANT was told of a specimen that weighed half-a-pound; but in Scandinavia it always belongs to the small fishes, being at most about 15 cm. long. The body is elongated and fairly thick, with broad, convex back, flat belly, and more or less perpendicular sides. The greatest depth of the body, which occurs just in front of the beginning of the dorsal fin, measures about 16—18½ % of its length, and the greatest thickness, across the opercula, is about ⅔ of the greatest depth. The least depth of the tail is about 8 (sometimes 8½) or 7 % of the length of the body. The dorsal profile thus forms a very elongated curve, which generally shows quite a distinct depression at the occiput. The ventral profile is straighter in front and ascends, strictly speaking, only behind, at the beginning of the anal fin.

The form of the head, bluntly pointed in front, otherwise passes evenly into that of the trunk, but is diversified in the nasal region, just in front of the eyes, by a swelling, which, according to LILLJEBORG, is larger in the males than in the females — a statement of which we have failed to find corroboration in our specimens

[a] Sometimes 39, according to KROYER.
[b] ,, 4, 6—5, 3, according to FATIO.
[c] ,, 36, according to MOREAU.

— and which in its most advanced development has given rise to the establishment of a distinct species, *Gobio obtusirostris*. This swelling — even when it is not very prominent — and also the projection beyond the mouth of the blunt tip of the snout most strongly characterize the head of the Gudgeon. The length of the head varies between about $^1/_4$ and a little more than $^1/_5$ (26—22 %) of that of the body, being as usual comparatively greater during youth. The eyes are extremely mobile, round, set fairly high — their upper margin being almost in a plane with the slightly convex forehead — and rather large, their longitudinal diameter varying between about 7 and $4^1/_2$ % of the length of the body or about 27 and 21 % of the length of the head. In young specimens this longitudinal diameter is about equal to the breadth of the interorbital space, in old less, sometimes only $^7/_{10}$ thereof. The position of the eyes is also such that the length of the snout — with considerable individual variations[a] — measures on an average $^2/_5$ of that of the head. The nostrils lie on the rounded margin between the sides and back of the snout, much nearer to the eyes than to the tip of the snout. Together they form on each side a round cavity, divided externally by the oblique partition wall between them, which is raised into a lid. The mouth is small and lies, as we have mentioned, entirely on the under side of the head, with the maxillary bones extending back to about a line with the anterior nostrils and with the articulation of the lower jaw in a line with the anterior margin of the orbit. The lips are fleshy, and the dermal fold that lies on each maxillary bone is elongated behind into a barbel of moderate length, which extends when laid back hardly any distance, if at all, behind the perpendicular from the anterior margin of the eye[b]. The palatal curtain within the upper jaw is well-developed. The tongue is fleshy, but hardly at all free from the bottom of the mouth. The gill-rakers are short, scattered, blunt, and soft, developed on the first branchial arch only in the inner (posterior) row, which contains about 8. Among the pharyngeal teeth (fig. 186) only the three posterior in the inner row have a distinct, obliquely cut masticatory surface, while the others — both the two anterior, thicker teeth in the inner row and the two or three teeth in the outer row — are of a straighter cylindrical form, though obliquely hooked at the tip. The pharyngeal cartilage is soft, scarcely cartilaginous, and triangular, with the upper (anterior) side slightly curved upwards (convex). The pseudobranchiae are distinct on the inside of the upper part of the hyomandibular bone, though small, with about 6 filamentous lamellae. The operculum is trapezoidal, its upper and lower sides being parallel, but the former only about $^2/_3$ as long as the latter and throughout united to the dorsal side. The branchiostegal membrane is extraordinarily narrow along the hind margin of the operculum, but all the broader along the suboperculum and in its lower part, where it is extended by three, fairly broad, sabre-shaped rays. The height of the gill-openings is about equal to the postorbital length of the head; their upper angle lies hardly on a level with the superior margin of the eye, and their lower angle lies in about a line with the hind margin of the preoperculum, where the branchiostegal membranes on the ventral side coalesce with the isthmus.

The dorsal fin is trapezoidal, with the upper margin straight or slightly concave and the high anterior margin composed of the first three (simple) rays. The first of these rays is extremely short, sometimes scarcely possible of external detection, while the second is nearly half as long as the third. The fin begins at a distance from the tip of the snout which measures on an average 42 % (varying between 41 and 43 %) of the length of the body, and its length (base) is 11 or 12 % (in the males sometimes nearly 13 %) of the same. Its height (the length of the third ray) is always greater than its length and varies between about 16 and 21 % of the length of the body.

The anal fin is of the same form and structure as the dorsal. Its distance from the tip of the snout is on an average 62 % (varying between 60 and 63 %), its length $7^1/_2$ % (varying between 7 and $8^1/_2$ %), and its height $13^1/_2$ % (varying between 12 and 16 %) of the length of the body.

The caudal fin is deeply forked at the hind margin, most so in old specimens, and thus forms an obtuse angle with somewhat convex edges to the lobes. The length of the middle rays, which occupy about 11—9 % of the length of the body, is as a rule in young specimens equal to or a little more than half,

[a] Varying between 34 and 45 % of the length of the head.

[b] CANESTRINI, however, mentions a specimen, a male $74^1/_2$ mm. long, in which the length of the barbels was somewhat more than half that of the head.

in old specimens a little less than half that of the longest outer rays.

The paired fins are similar to each other in general form, when the ventrals are not fully expanded. Both pairs are of an oblique oval shape; but the pectoral fins are more pointed and longer. The length of the latter varies between about 20 and 15 %, that of the ventral fins between about 15 and 13 % of the length of the body. In their position too, these paired fins resemble each other, the pectoral fins when expanded being drawn down to the flat ventral margin, where they project horizontally outwards like the ventral fins. The position of the latter is such that the distance from the tip of the snout to the foremost (outermost) point of their insertion is about 43 % of the length of the body, and from the said point in the insertion of these fins to the corresponding point in that of the pectorals about 23 % of the same.

The scales are of moderate size, but rather thin, and their form varies considerably, being rounded and quadrangular, semi-elliptical (rounded behind), or rounded and triangular. In the anterior (covered) part, which is the shorter, but deeper, we find only concentric, fine striae; the posterior part, on the other hand, is marked with a number (as many as 24) of radiating striae, the ends of which at the hind margin of the scale form fine and fairly regular notches in this margin. The lateral line is fairly straight, in front slightly curved in a downward direction, and keeps to the middle of the sides of the body.

In coloration the Gudgeon is one of the most singular of our Cyprinoids, not indeed for any remarkable beauty of colour — though in this respect it is but little inferior to our most handsome species, the Minnow — but for its possession of more varied hues than most of the Scandinavian forms of this family. The back is grayish green, darker (shading into brown) or lighter according to the colour and light of the environments of the fish, and transparent when the light falls directly upon it. The belly is milky white. The colour of the back extends forward on the top of the head, the snout, and the outside of the barbels. On the upper part of the sides of the snout, just below the nostrils, appears a dark, fairly broad, longitudinal band, which is continued across the upper part of the eye more or less distinctly on the temple. Below the eye too, lies a more or less distinct band, formed by more or less densely agglomerated collections of dark pigment. Similar irregular spots also occur on the operculum and preoperculum; but the sides of the head are otherwise coated with a brassy and silvery lustre finely punctated with brown. The lower jaw and the branchiostegal membrane are of the same colour as the belly. The iris is below of a silvery lustre, but finely punctated with brown. The silvery lustre of the sides of the body shades more or less distinctly into violet, and this bluish colour collects at certain points into a more or less regular row of undefined spots above and along the lateral line, now of a lighter blue, now shading even into blackish brown. The scales of the lateral line are marked, at least in the anterior part thereof, by a dense agglomeration of dark brown pigment on each side of the canal itself; and more scattered dots of similar pigment at the margins of the scales form a network of brown over the whole body. All the fins are light and transparent, of a more or less pronounced yellowish green. This last colour is most prominent on the rays, which are also marked — in the dorsal and caudal fin always, in the other fins sometimes, but with far less density — with brownish, elongated spots, together forming more or less regular transverse bands and most distinct on the caudal fin.

The most trustworthy external distinction between the sexes during the spawning-season is the dermal eruption, consisting of small, fine, verrucose tubercles on the head and the forepart of the back, which is general among the male Cyprinoids. A dark blue spot on the gill-cover, more prominent than in the females, is also a usual characteristic of this sex during the said period. Furthermore, according to FATIO, the longest rays in the pectoral fins of the male are thickened during the spawning-season; but we have failed to find any evidense of this. The most general difference between the sexes lies, however, in the longer and higher fins of the males; but the changes of growth — young specimens of both sexes being similar in this respect — impair the validity of the sexual characters drawn from this relation. We have, however, found one of these characters to hold good in all our specimens: in all the males the length of the lower jaw is less, in the females more, than 55 % of the length of the ventral fins[a].

[a] The position of the vent, which in other cases gives the most easily expressed sexual character, and which has been stated in the Gudgeon to lie in the females behind, in the males in front of, the middle of the body, varies so considerably that in a male 107 mm. long for example we found the distance from the vent to the tip of the snout to be 58 mm.

The internal organs agree with the description given above of the structure of the Brachyenteric Cyprinoids. The stomach extends back to about a line with the insertions of the ventral fins, from which point the intestine first runs forward, to the left of and above the stomach, until at the very front of the abdominal cavity it bends suddenly back to return straight to the vent. The entire length of the digestive canal is only about $^3/_5$ of the length of the body. The dorsal part of the musculature contains on each side an ellipsoidal organ of hitherto unexplained signification, proximally and dorsally attached to the fourth rib (the first of the normal ribs). This organ is white and fairly large, being nearly 3 mm. long in a Gudgeon 110 mm. in length. It consists of transversely striped muscle fibres, externally longitudinal, internally transversal, and is attached by connective tissue to the said rib. As for its morphological significance, we can find no better comparison than with the above-mentioned (p. 704) *introitus capsulæ vesicæ* in the Cobitoids.

The Gudgeon has a wide geographical range to the east and west, from Amur and China[a] to England and Ireland. To the north and south its range extends in Europe from Southern Finland (Lat. 62° or 63° N.), the extreme south of Sweden, and Liim Fjord, to Central Italy. In Greece and Spain it is unknown. Its Swedish range consists principally of Scania, where it is fairly common in several localities. When RETZIUS in 1800 introduced it into the fauna of Sweden, it already possessed at Lake Finja a special Swedish name, *Slätting* (*slät* = smooth). The species is also known to occur in Scania in Lake Vester and the Rönne River to the west, where according to SCHAGERSTRÖM it is called *Gralänning*, and in the streams of Helge and Arup to the east. From the River Morrum in Blekinge Baron G. C. CEDERSTRÖM in 1856 forwarded several specimens to the Royal Museum. The Zoological Museum of Upsala, according to LILLJEBORG, has received specimens through Dr. SCHEUTZ from the neighbourhood of Wexiö. According to NILSSON the Gudgeon also occurs in the River Nissa at Halmstad and is there called *stensugare* (Stone-sucker)[b]. KRØYER did not know it from the Danish islands; but in recent times it has been found in Zealand (FEDDERSEN). In Jutland it is common south of Liim Fjord. In Germany and the Baltic Provinces of Russia it is also common, as well as in Central and Western Europe. It is one of the inhabitants of the Cavern of Adelsberg. In the water-courses of Switzerland it ascends, according to FATIO, to a height of about 800 metres above the level of the sea; south of the Alps it is of rarer occurrence.

The habits of the Gudgeon are fairly well expressed by its Swedish name of *Sandkrypare* (Sand-creeper). As it lies, usually in companies, close to the bottom, with the paired fins horizontally expanded, on a bed of sand, gravel, stone, or even of mud, it still keeps a careful watch, and by fits and starts displays great activity. It takes a hook freely. It is fairly tenacious of life, but like all the Cyprinoids, sensitive to changes in the weather and incapable of enduring bad respiration. The living specimens in our aquaria kept close to the bottom and remained still in a packed mass, as long as the water was fresh; but as soon as it had stood an hour or so the crowd dispersed, and its members ascended severally to the upper layers of the water. In spite of this the Gudgeon can live in muddy or even polluted streams, and readily haunts the openings of sewers, provided they are in running water.

VALENCIENNES experimented on this fish in order to ascertain the effect produced on it by atmospheric rarefaction. The air-bladder became completely empty, its gas passed into the intestine, the belly swelled up, and the fish floated on its back, but was alive and seemed to steer its course in the water. After 24 hours' continued operation of the air-pump he restored the fishes to a normal atmospheric pressure; and after the lapse of 6 hours they were quite recovered, with the air-bladder full almost exclusively of nitrogen.

As we have remarked above, the comparatively short intestinal canal of the Gudgeon indicates that its food is chiefly animal. It lives principally on insects and their larvae, crustaceans, worms, and the roe and fry of various fishes; but it is fond of rooting up its food in sand and mud, and also devours decomposing substances, both animal and vegetable.

The spawning-season of the Gudgeon occurs in Sweden at midsummer or earlier — in more southern countries even at the beginning of April. Before this time it has ascended from its winter-quarters to shallower spots in rivers or brooks. In the River Hofdala,

[a] HERZENSTEIN and WARPACHOWSKY, l. c.

[b] Renewed attempts to procure the Gudgeon from this locality have, however, failed.

[c] CUV., VAL., l. c., p. 14.

according to Baron CEDERSTRÖM, the Gudgeon is oftenest taken in early summer in traps (*ryssjor*, see above, p. 33, fig. 7), which are set in the middle of the river against the stream. The Gudgeon ascend the river in the evening to spawn[1], but in the morning return to Lake Finja. On the 25th of May, 1858 CEDERSTRÖM observed the Gudgeon spawning in this locality; he was told that the spawning had already lasted a week here and along the shores of Lake Finja. RUSCONI describes the spawning of the Gudgeon in Lombardy as follows[2]: "During my stay at Desio, on a most lovely day in July, I was walking early in the morning along the shore of the little lake of Villa Traversi. Suddenly a noise reached my ear. I thought at first that some one was beating the water with sticks or with the flat of an oar. On glancing along the shore I soon detected the spot from which the sound proceeded, as well as the cause of this disturbance; it was caused by spawning fishes. Eager to obtain a closer view of this sight, I stealthily made my way towards them, and under cover of the bushes that fringed the shore, I got near enough to observe them with ease and without betraying my own presence. They lay at the mouth of a small brook, the water of which was cool and clear, but so scanty that the pebbles at the bottom were almost dry. They were Gudgeons. They approached the mouth of the brook. With rapid strokes they came swiftly on and advanced about a metre up the brook, not leaping, but in a manner gliding over the pebbles. After this first spurt they stopped, bent the trunk and tail alternately to the right and left, and in this way rubbed the ventral side against the bottom. With the exception of the belly and the lower part of the head their whole body now lay out of the water. They retained this position for seven or eight seconds. Then they dealt a sharp blow with the tail on the bottom, splashing the water in all directions, turned round, and darted back to the lake, soon to repeat the same operation".

The eggs are comparatively large when deposited, about $1^1/_2$ mm. in diameter, but also rather few in number, at most some thousands in each female. They are transparent, with a dash of blue or yellow. VALENCIENNES supposed that the Gudgeon spawns several times a year. The only evidence of this seems to be that the female does not deposit her roe all at once, but bit by bit. That the spawning-season is of long duration, however, is shown by the fact that FATIO in Switzerland, and LILLJEBORG here in the North, found females full of roe, but not yet ready to spawn, late in July[3].

To the angler the Gudgeon affords excellent sport. It readily takes a bait of flies or worms; and tenacious of life as it is, it may be used with advantage as live bait for larger fish. Its greatest value lies, however, in the flesh, which is of delicious flavour and easy of digestion. BUCKLAND writes: "When out gudgeon-fishing on the Thames, be sure and take a frying-pan, as gudgeons taken out of the water and immediately fried are delicious. Clean, wipe, and flour, then well fry in boiling fat, or, better, in oil, till they are crisp and of a light brown colour. Such a fish dinner is always a great feature in a pic-nic on a fine day". A somewhat similar method is employed in Scania in the preparation of *fiskakaka* (fish-cake) from Gudgeons and other small fishes.

GENUS TINCA.

Base of the dorsal fin less than twice that of the anal. Branched rays in the dorsal fin at most 9, in the anal at most 8. Neither of these fins furnished with a spiniferous ray. Scales small and thin — their number in the lateral line at least about 90. Distance between the anal fin and the vent only $^1/_2$ or $^1/_3$ of the base of this fin.

By the deeper form of the body this genus is more closely approximated to the true Carps; but it also comes nearer the Leuciscines, among which the Minnow with its small scales reminds us most of *Tinca*. Only

[1] According to FATIO the Gudgeon spawns in the daytime.

[2] See BREHM, *Thierleben*, Aufl. 2, Abth. 3, Bd. 2, p. 275.

[3] VALENCIENNES also states that the spawning lasts from April to the end of July or the middle of August. The Gudgeons we received this year (1891) at the beginning of June from the Finja, had just commenced spawning.

one species of this genus is known, for the Siberian species, *Cyprinus perenurus*[a], which PALLAS established, and which has otherwise been referred to this genus, is based merely upon a defective description in the manuscripts left by STELLER and has been explained by WARPACHOWSKI as a *Phoxinus*. The history of the genus is the same as that of the preceding one. The name is derived originally from AUSONIUS (in the fifth century) and RONDELET (in the sixteenth century). It was adopted as a specific name by LINNÆUS, as the name of a subgenus of *Cyprinus* by CUVIER[b], and raised by FLEMING[c] to the rank of a generic name.

THE TENCH (SW. LINDAREN OR SUTAREN).

TINCA VULGARIS.

Plate XLI, fig. 4.

Barbel at each corner of the mouth small. All the fins rounded. Mouth situated at the tip of the snout, beginning of the dorsal fin just in front of the middle of the body. Muciferous pores in the cephalic system of the lateral line especially distinct in the supraorbital, suborbital, and preoperculo-mandibular branches. Pharyngeal teeth set in a single row, with narrow, one-grooved masticatory surface: 4(5)—5(4).

Fig. 187. Pharyngeal teeth and pharyngeal cartilage of *Tinca vulgaris*. Natural size. *a*, *b*, and *c* as in the preceding figure.

R. br. 3; *D.* $\frac{3(4)}{8(9)}$; *A.* $\frac{3(4)}{7(8)}$; *P.* $\frac{1}{15-17}$; *V.* $\frac{2}{(8)9}$;
C. $x + 1 + 17 + 1 + x$; *L. lat.* (90)100—114(120); *L. tr.* $\frac{30-33}{21-23}$ 1;
Vert. 37—41.

Syn. *Tinca*, AUSON., *Mos.*, vers. 125; RONDEL., *De Pisc.*, part. II, p. 157; BEL., *Nat., Div. Poiss.*, p. 325; SCHONEV., *Ichthyol. Slesv. Holst.*, p. 76. *Cyprinus* mucosus totus nigrescens, extremitate caudæ æquali. ART. *Ichth., Gen. Pisc.*, p. 4; *Syn. Pisc.*, p. 5; *Descr. Spec. Pisc.*, p. 27. *Cyprinus* pinna ani ossiculis undecim, cauda integra, LIN., *Fn. Suec.*, ed. I, p. 122.

Cyprinus Tinca, LIN., *Syst. Nat.*, ed. X, tom. I, p. 321; BL., *Fisch. Deutschl.*, part. I, p. 83, tab. XIV (+ *Der Goldschlei*, p. 90, tab. XV); RETZ., *Fn. Suec. Lin.*, p. 354; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 296; EKSTR., Vet.-Akad. Handl. 1830, p. 200; NILSS., *Prodr. Ichth. Scand.*, p. 31; EKSTR., V. WR., *Skand. Fisk.*, ed. 1, p. 205, tab. 52; GTHR (*Leuciscus*) Jahr. Ver. Vat. Naturk. Würtemb., IX (1853), p. 274; REUT., SUNDM. (*Tinca*) *Finl. Fisk.*, tab. VIII.

Tinca vulgaris FLMNG, l. c.; CUV., VAL., *Hist. Nat. Poiss.*, vol. XVI, p. 322, tab. 484; YARR., *Brit. Fish.*, ed. I, vol. I, p. 328; KR., *Danm. Fiske*, vol. III, p. 351; NILSS., *Skand. Fn., Fisk.*, p. 297; HCKL, KN., *Susswasserf. Oestr. Mon.*, p. 75; DYBOWSKY, *Cypr. Livl.*, p. 66; SIEB., *Susswasserf. Mitteleur.*, p. 106; MGRN, *Finl. Fiskfn.* (disp. Helsingf. 1863), p. 39; CANESTR., Arch. Zool. Anat., Fisiol., vol. IV, fasc. I (1866), p. 69; BLANCH., *Poiss. d. eaux douces Fr.*, p. 317; LINDSTR., Gotl. L. Hush. Sallsk. Arsber. 1866, p. 17 (sep.); GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 264; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 183; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 383; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 111; MELA, *Vert. Fenn.*, p. 318, tab. X; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 188, tab. CXXXIV, fig. 2; MÖB., HCKE, *Fisch. Osts.*, p. 114; NORB., *Handl. Fisker., Fiskafv.*, p. 430, fig. 138; LILLJ., *Sv., Norg. Fn., Fisk.*, vol. III, p. 169.

Tinca Chrysitis (+ var. *aurata*), AGASS., Mem. Soc. Sc. Nat. Neuch., tom. I, p. 37; BONAP. (+ *T. italica*), *Iconogr. Fna Ital.*, tom. III (*Pesci*), tab. 93.

Tinca Linnei, MALM, *Gbgs. Boh. Fn.*, p. 564.

[a] *Zoogr. Ross. Asiat.*, tom. III, p. 299.
[b] *Règn Anim.*, ed. 1, tom. II, p. 193.
[c] *Brit. Anim.*, p. 186.

The average length of the Tench in Sweden is about 2 or 3 dm. The largest specimen EKSTRÖM ever saw was 47 cm. long — already an extraordinary size — but NILSSON had a specimen nearly 55 cm. in length. According to BLANCHARD the fish attains at the age of one year a weight of about 125 gm., at the age of three years about 1—1 $^1/_2$ kgm., at the age of six or seven years 3—4 kgm. This last weight is generally given, on BLOCH's authority, as the maximum weight of the Tench, and according to the reports sent in to the Swedish Fisheries Committee of 1881 the species attains in the District of Jönköping a weight of 8 Swedish pounds (3 $^2/_5$ kgm.), but this statement needs confirmation[a]. According to FATIO Tench 4 dm. long weigh about 1 $^1/_4$ kgm., and Tench 5 dm. long 2 $^1/_6$ kgm.

The body is thick, but laterally compressed and fairly deep, the greatest depth, at the beginning of the dorsal fin, being more than $^1/_4$ of the length[b]. The depth is comparatively greatest, however, in the hind part of the body, for the Tench is the only one of our Cyprinoids in which the minimum depth of the tail, at least in adult specimens, is about 14 % (13 $^1/_2$—15 $^1/_2$ %) of the length of the body or $^3/_5$ (58—65 %) of the length of the head[d]. The dorsal profile ascends only slightly, but in a regular curve. The back is convex throughout its whole length, flatter behind than in front of the dorsal fin. The belly, on the other hand, is flatter in front of than behind the ventral fins, but in the males is sometimes concave in the median line between the ventral fins and the anal fin.

The head, the length of which is about 22—24 % of that of the body, is thick and somewhat compressed. Its breadth is about equal to its vertical depth at the anterior margin of the orbit. The forehead is broad and evenly convex, and lies in a line with the snout and occiput. Its breadth is always somewhat (about $^1/_{10}$) greater than the length of the blunt snout, which in adult specimens occupies about 38 % of the length of the head. The mouth is small, but turned sharply upward; the lips are thick. The length of the barbel at the corner of the mouth is usually less than half the diameter of the eyes. The length of the upper jaw is about $^1/_4$ (24—27 %) and that of the lower jaw about $^1/_3$ (30—34 %) of the length of the head. The lower jaw is always somewhat shorter than the suture between the suboperculum and the operculum, which suture is as a rule equal in length to the snout. The eyes are small, but comparatively larger as usual in young specimens: during the growth of the fish from 15 to 40 cm. their longitudinal diameter (slightly greater than the vertical) varies between about 15 and 13 % of the length of the head or 40 and 34 % of that of the snout. They are set about half-way between the occiput and the tip of the snout, and so high that the line from the middle of the margin of the upper jaw to the middle of the caudal fin touches the inferior margin of the iris. The nasal cavities, which lie twice as far from the tip of the snout as from the eyes, are furnished, here as in the preceding genera, each with two closely adjoining nostrils. The anterior nostril is the smaller and has a projecting dermal flap at the hind margin. The gill-openings are fairly large, their height being about equal to the least depth of the tail. The opercula are smooth, rounded at the margin, and furnished with a broad rim, which extends from the upper angle of the gill-opening to the point where the branchiostegal membrane is attached to the isthmus, at a distance of half the diameter of the orbits from the branchiostegal membrane of the other side. The three rays in each branchiostegal membrane are bent, broad, and strong. The gill-rakers are short and scattered, numbering about 13 in the outer row on the first branchial arch, 16 on the outer margin of the pharyngeals. The five, or sometimes only four (more usually five on one side, four on the other) pharyngeal teeth (fig. 187) are more or less (the foremost tooth least) transversely (behind and in front) compressed, with simple masticatory surfaces, depressed in the transverse median line, and with the upper inner corner more or less (most in the hindmost tooth) hooked. The pharyngeal cartilage is reddish brown like horn, of a pointed oval shape (triangular with rounded lateral corners and arcuate anterior margin), and almost hooked

[a] YARRELL tells us (from DANIEL's *Rural Sports*) of a Tench 33 in. long and 11 lbs. 9 $^1/_4$ oz. in weight, which had long lived closely confined among some roots in a pond choked up with mud.

[b] In adult specimens about 27—31 % of the length of the body. In young specimens about 7 cm. long this percentage is about 21, according to CANESTRINI.

[c] In young specimens, however, according to KRØYER, about 11 $^1/_2$ %.

[d] In exceptional cases, however, these percentages may be found in the Crucian Carp and the White Bream.

at the inferior extremity. It may be easily detached from its place.

The body is covered with very thin, oblong, and imbricated scales, which are deeply inserted in the skin and thus appear externally to be very small. One of the larger scales above the lateral line in a Tench 4 dm. long is 9 mm. in length and 5 mm. in breadth, but only the hindmost 2 mm. project out of the follicle. The nucleus lies far forward in the covered part. A great number of radiating grooves run from the nucleus in all directions to the margin of the scale (the most numerous and densest to the hind margin); and the fine, numerous, concentric striae encircle the nucleus, running parallel to the margin of the scale. The scales and follicles are clothed with a fairly thick, soft, and slimy epidermis. The lateral line bends down in front, and then runs straight along the body, about equally distant from the back and belly. It contains about 100 scales. Above the line there lie about 30 scales, below it about 20, in an oblique row from the beginning of the dorsal fin.

The height of the dorsal fin is greater than the length of its base: the former measures in adult specimens about 18 % (17—19 %) and the latter about $13^1/_2$ % (12—15 %) of the length of the body. The distance between this fin and the tip of the snout is about 48 % (47—49 %) of the length of the body, or about twice as long as the dorsal margin of the peduncle of the tail (between the dorsal and caudal fins). Its first four rays are simple; but the first ray is always so short that it does not even project above the skin; the second ray is also short and in old specimens difficult of detection, the third about half as long as the fourth, which is only slightly shorter than the second or third among the branched rays. These last two rays are the longest in the fin. Sometimes, however, even the fourth ray may be branched; and simple or branched, but narrow rays may be inserted here and there between the branched rays, which are otherwise as a rule 8 in number.

The anal fin is of exactly the same structure as the dorsal and of essentially the same form; but its base is still shorter in proportion to its height. The latter measures about 14 % (13—$15^1/_2$ %) of the length of the body, the former about 8 % (7—9 %) of the same. The beginning of the fin lies at a distance from the tip of the snout of about 63 % (60—64 %) of the length of the body. The vent is usually separated from the beginning of the anal fin by a distance about equal to the diameter of the eyes (a little more or less).

The caudal fin is broad and slightly concave at the end, almost truncate when expanded. The length of its middle rays, measured from the point where the scales end, is about 14 % ($15^1/_2$—$13^1/_4$ %), that of its longest lateral rays about 16 % (18—$15^1/_2$ %), of the length of the body.

The paired fins are broad and obliquely oval. The most distinct external differences between the sexes find expression in the dimensions of these fins. In young Tench and in the males the ventral fins are longer than the pectoral fins, in adult females shorter. The length of the pectoral fins is about $16^1/_2$ % (16—18 %) of that of the body: the length of the ventral fins is in the females less than 17 % (15—16 %), in the males more than 17 % (about 18 %) of the same. It is also a rule that in the females the ventral fins, when laid back, do not extend to the vent, while in the males their tips reach beyond it. In the males too, the second ray in these fins is very thick and broad. The distance between the ventral fins and the tip of the snout is about 42 % ($39^1/_2$—44 %) of the length of the body, their position being generally farther back in the females.

The coloration of the Tench adapts itself to the water in which the fish lives. In clear water the whole body is yellowish green on a golden ground, with fine, golden dots at the tip of each scale. The top of the head is darker than the back, the latter in its turn darker than the sides, which fade below into the whitish yellow colour of the belly. This last colour also extends to the lower parts of the head and of the gill-covers. All the fins are light green. The iris is coppery red. — When the fish has been so long out of the water that life is extinct, the colour is entirely changed. The body is now dark green. The back, and in particular the top of the head, are blackish green. The fine, golden dots have vanished. The belly is yellow. The fins are dark purplish red or nearly black. These last organs are also the first parts of the body to change colour. — When the Tench lives on a muddy bottom, it presents the appearance shown in our figure. When it is found in the forest tarns, where the water is generally very dark, the entire upper part of the body is black, as though dipped in ink, only the belly being somewhat lighter. A not uncommon variety is the Golden Tench, of a spotted or plain orange colour. This form is often kept in fish-ponds both in Germany and England.

The internal organs essentially resemble those of the preceding genus. The liver follows the intestinal canal backwards in two long, pointed lobes, the right lobe being the longest and extending back to the vent. The intestinal canal is short and thick, only slightly longer or even shorter than the fish, with only two coils and without dilatation or special stomach. The air-bladder is large and, as usual, contracted at the first third of its length. The anterior, smaller part is cylindrical with rounded ends, the posterior part pointed behind. The ovaries and testicles are paired and occupy the ordinary position.

The Tench is more of a European fish than the preceding species, but otherwise has essentially the same geographical range. It occurs throughout the whole of Europe, northwards in places to the 62nd degree of latitude. It is also known in Asia Minor, and in the extreme south of Europe it is common. How far its range extends in Siberia, is unknown; but PALLAS says that it is common around the Yenisei. In the west of Europe it does not seem to go so far north as in the east of the same continent. THOMPSON[a] regarded the Tench as of foreign origin in Great Britain and Ireland. DAY says that it is commoner in the east of England than in the west. KRØYER had no knowledge of its presence in the north of Jutland; but according to FEDDERSEN it has subsequently been found in Lake Ravnstrup, a little north of the east end of Liim Fjord. In Norway, according to COLLETT, the Tench occurs at only two spots, situated in the coast regions of the extreme south, namely Kragerö and the park at the Näs Iron-works. To the latter locality it has been transplanted from Denmark. In the southern tracts of Sweden it is fairly common; but the northern limit of its range lies in about 60° N. lat., in Wermland and Westmanland, according to the reports sent in to the Fisheries Committee of 1881, though it is said to have been planted in the District of Gefleborg. In Finland, according to MELA, its range extends to 61° 40′ N. lat. According to REUTER it occurs even at Archangel; but according to GRIMM[b] its range to the north is bounded in Russia by the 62nd degree of latitude. According to FATIO it ascends in Switzerland to lakes situated as much as 1,600 m. above the level of the sea.

In Sweden the Tench is most commonly found in small lakes, ponds, and fens, with a muddy and weedy bottom. It is worthy of remark that this fish also occurs in the central part of the western island-belt of the Baltic, where it invariably chooses its haunts, however, in shallow and weedy inlets in the innermost part of the archipelago. Sluggish and indolent by nature, it loves quiet and is destitute of the activity displayed by the majority of the following genera of this family. Except during the spawning-season it lives almost constantly at the bottom, most often embedded in mud among the weeds. It is especially prone to this latter habit in winter, at which time it generally lies still in a kind of dormancy; but, according to SIEBOLD, it is sometimes met with in this position even in the hottest summer. Now and then, though seldom, it may be seen in summer, when the water is calm, at the surface. Being very tenacious of life, it may be transported considerable distances without dying, and is thus easily planted in ponds. It was one of the fishes earliest selected for this purpose.

The spawning-season generally occurs in Sweden at the beginning of June or somewhat later, according to the state of the weather. The oldest females spawn first, the younger ones later in the season. The spawning takes place in shallow and weedy inlets, ponds, and small lakes, without any boisterous demonstrations. The fine, yellowish eggs are deposited on the weeds; they are generally hatched in a week's time. The fry grow rather slowly[c], though the rate seems to vary according to the spawning-place and the state of the water. The number of the spawning females is usually less than that of the males. YARRELL estimates the proportion of the sexes at two males to one female, or not less than three to two. This disparity in number might have a detrimental effect on the propagation of the species, if the fecundity of the Tench did not compensate the scarcity of females. In a female $1^{3}/_{4}$ kgm. in weight BLOCH estimated the number of the ova at 297,000. HARMER, according to DAY, found as many as 383,253 ova in one female.

The food of the Tench consists of mud, worms, and insects. It is seldom caught in the seine, generally in fish-traps (*katsor*, see fig. 204, p. 816, below, and

[a] *Nat. Hist. Irel.*, vol. IV, p. 136.
[b] *Fish., Hunt. Russ. Wat.*, p. 14.
[c] In the month of October LILLJEBORG took a young Tench 70 mm. long.

ryssjor, see above, p. 33, fig. 7). It bites freely at a bait of the common earth-worm. The qualities of the flesh as an article of food are extolled by some and decried by others[a]. This depends in most cases upon the manner of dressing it for table, and a Tench may be made into a good dish. The flesh is white, free from bones, and firm, but is considered indigestible and therefore unwholesome. The muddy flavour which it generally possesses, disappears if the fish be scalded in hot water before cooking, to remove the thick coat of of slime which covers the body. This slime has been supposed to deter predatory fishes from attacking the Tench. But this is not the case: both the Pike and Salmon eat Tench with avidity, and small Tench are excellent live-bait, especially in trolling for Pike.

The Tench, which is known in Sweden as *Lindaren*, *Sutaren* (the Danish *Suder*), and *Skomakaren*[b], was regarded by the popular belief of ancient times as the physician of the other fishes; and in human medicine it was employed in several ways. It was used as a remedy for ague and a preventive of malaria, by its aid jaundice could be removed from the constitution[c], and its liver was a cure for toothache.

(EKSTROM, SMITT.)

SUBFAMILY LEUCISCINÆ.

Base of the dorsal fin about equal in length to that of the anal (the latter varying between 70 and 130 % of the former, but less than 16 % of the length of the body). Distance between the dorsal fin and the tip of the snout more than twice the length of the head. No spinous ray in the dorsal or the anal fin[d]. *Lateral line (where present) situated at the middle of the depth of the tail or lower. Abdominal margin in front of the vent uninterruptedly covered with scales in the median line. Mouth without barbels. Length of the lower jaw more than 47 % of the base of the anal fin. Pharyngeal cartilage as a rule oblong (oval), rounded or pointed in front. Length of the intestinal canal as a rule less than that of the body.*

As we have mentioned above, we have chosen as the principal character of the subdivisions of the Cyprinoid family, the correlative size of the dorsal and anal fins. Within the Scandinavian fauna this distinction is adequate; but the natural connexion between this subfamily and the following one produces hybrid forms, which even in our fauna are exceptions to the rule — a Bream form (the so-called *Abramidopsis Leuckartii*) with Leuciscine characters and Leuciscine forms (*Bliccopsis*) with Abramidine characters.

The Scandinavian forms belonging to the subfamily *Leuciscinæ* are distributed among the following genera:

A: Length of the base of the anal fin less than 19 % of the distance between this fin and the tip of the snout.
- *a*: Distance between the dorsal fin and the tip of the snout more than 82 % of that between the anal fin and the same point. Scales small .... Genus *Phoxinus*.
- *b*: Distance between the dorsal fin and the tip of the snout less than 82 % of that between the anal fin and the same point. Scales of moderate size Genus *Leuciscus*.

B: Length of the base of the anal fin more than 19 % of the distance between this fin and the tip of the snout.
- *a*: Distance between the dorsal fin and the tip of the snout less than 86 % of that between the anal fin and the same point. Lateral line complete.
  - *α*: Beginning of the dorsal fin situated behind the middle of the body. Length of the lower jaw less than $^2/_5$ of that of the head.............. Genus *Scardinius*.
  - *β*: Beginning of the dorsal fin situated in front of the middle of the body. Length of the lower jaw more than $^2/_5$ of that of the head ... Genus *Aspius*.
- *b*: Distance between the dorsal fin and the tip of the snout more than 86 % of that between the anal fin and the same point. Lateral line incomplete Genus *Leucaspius*.

[a] An allusion to the contempt with which the Tench was regarded survives in the well-known lines of AUSONIUS:

"Quis non et virides vulgi solatia tincas
Norit" . . .
"Who knows not the green Tench, the mob's delight?"

[b] *Sutare* and *Skomakare* both mean *shoemaker*, a name perhaps derived from the colour of the fish. TR.

[c] *Icteri magnes*, LINNÆUS.

[d] In Scandinavian forms.

GENUS PHOXINUS.

Scales very small, at least about 80 in a row along the sides of the body and about 30 in a transverse row on each side of the trunk. Lateral line usually incomplete. Jaws equally projecting. Lobes of the caudal fin blunt (rounded). Base of the anal fin less than 19 % of the distance between this fin and the tip of the snout.

The genus of the Minnows, which was introduced into the system by AGASSIZ[a], is well defined in the Scandinavian fauna, not only by its small scales, but also by the elongated and terete form of the body. From Siberia, however, WARPACHOWSKI has described some forms[b] more closely approximated by the deep and laterally compressed form of the body to the other *Leuciscinae*. In Southern Europe too, the limit between this genus and the other genera of the subfamily is difficult to maintain, forms of the genus *Leuciscus*[c] occurring there, which have as many as 80 scales in the lateral line, though, to judge by the descriptions, they differ from *Phoxinus* in having at most 26 scales in a transverse row. In North America the genus *Phoxinus*, as defined by JORDAN and GILBERT[d], also contains species with larger scales. A chromatic character fairly constant in the Minnow, a more or less prominent, dark stripe along the sides of the body, and another fairly characteristic peculiarity, the tumid form of the snout, reappear in the *Leuciscus* (*Telestes*) *muticellus* of Southern Europe, a form which also composes a remarkable connecting-link between the genera of this subfamily, and which has sometimes borne the systematic name of the Minnow. VALENCIENNES[e] and GÜNTHER[f] have therefore found it advisable to unite the genus *Phoxinus* with *Leuciscus*. But it cannot be denied that the Minnow is the most singular of all our *Cyprininae*, or that it is well deserving of a distinct rank as a connecting-link between the dark and small-scaled Tench of the preceding subfamily and the following Whitefishes with their larger scales.

The name of *Phoxinus* is derived from ARISTOTLE, who merely remarks, however, that the fish is a freshwater form, capable of reproduction at its very birth and always full of roe. Following BELON and RONDELET, ichthyologists have assumed that ARISTOTLE here referred to the Minnow.

[a] Mém. Soc. Sc. Nat. Neuch., tome I (1835), p. 37.
[b] Bull. Acad. St. Petersb., tom. XXXI (1887), p. 533.
[c] *Leuciscus microlepis*. Cf. CANESTRINI, Arch. Zool., Anat., Fisiol., vol. IV (1866), p. 109.
[d] Bull. U. S. Nat. Mus., No. 16, p. 242.
[e] CUV., VAL., *Hist. Nat. Poiss.*, vol. XVII, p. 363.
[f] *Cat. Brit. Mus., Fish.*, vol. VII, p. 207

THE MINNOW (SW. ELRITZAN).

PHOXINUS APHYA.

Plate XXXIII, fig. 3, ♂ and ♀.

Body elongated and terete, its greatest depth being less than $^1/_5$ (17—19½ %) of its length[1], greatest thickness at least half the greatest depth, and least depth (least depth of the tail) less than half the greatest depth or than $^1/_3$ of the length of the tail from a line with the end of the base of the anal fin to the middle of the base of the caudal fin. Length of the head about 21—23½ % of that of the body. Pharyngeal teeth pointed, hooked at the tip, with the masticatory surface sharpened, but smooth or even hardly distinguishable, and set in a double or single row: 2, 5(4)—4(5), 2 or 5—4.

c

a b

Fig. 188. Pharyngeal bones (*a* and *b*, as in the preceding figure) and covering of the pharyngeal process (*c*) in *Phoxinus aphya*. Magn. 3 diam.

R. br. 3; *D.* $\frac{(2)3}{7(8)}$; *A.* $\frac{(2)3}{(6)7}$; *V.* $\frac{(1)2}{(6)7(8)}$; *P.* $\frac{1}{13—16}$[2]; *C.* x + 1 + 17 + 1 + x; *L. lat.* (85)90—110; *L. tr.* $\frac{15—20}{14—16}$; *Vert.* 38—40.

Syn. *Οἱ φοξῖνοι*, Aristot., *De Anim.*, lib. VI, cap. XIII et XIV. *Phoxinus*, *Veron*, Belon, *Nat.*, *Div. Poiss.*, p. 324. *Pisciculus varius*, Rond., *De Pisc.*, part. II, p. 205. *Phoxinus lævis*, Schonev., *Ichthyol. Slesv. Hols.* p. 57. *Cyprinus* tridactylus varius oblongus teretiusculus, pinna ani ossiculorum octo, Art., *Ichthyol.*, *Syn. Pisc.*, p. 12 + *Cyprinus* biuncialis, iridibus rubris, pinna ani ossiculorum novem, Id., ibid. (excl. syn. Schonev.) et *Descr. Spec. Pisc.*, p. 30. Lin., *Fn. Suec.*, ed. I, p. 125, No. 331; Id., *Alkufira*, *It. Westrog.*, p. 232.

Cyprinus Phoxinus, Lin., *Syst. Nat.*, ed. X, tom. I, p. 322; Bl., *Fisch. Deutschl.*, part. I, p. 60, tab. VIII, fig. 5; Retz., *Fn. Suec. Lin.*, p. 356; Pall., *Zoogr. Ross. Asiat.*, tom. III, p. 330; Flmng (*Leuciscus*), *Brit. Anim.*, p. 188; Ekstr., (*Cyprinus*), Vet.-Akad. Handl. 1830, p. 166; Nilss., *Prodr. Ichthyol. Scand.*, p. 29; Id. (*Leuciscus*), *Skand. Fn.*, *Fisk.*, p. 319; Sundev. (*Cyprinus*), Stkhlms L. Hush. Sälls. Handl., H. 6 (1855), pp. 82 et 175; Thomps. (*Leuciscus*), *Nat. Hist. Irel.*, vol. IV, p. 138; Lindstr., Gotl. L. Hush. Sallsk. Årsber. 1866, p. 18 (sep.); Gthr, l. c.; Olsson, Öfvers. Vet.-Akad. Förh. 1876, No. 3, p. 131; 1882, No. 10, p. 48; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 185, tab. CXXXIV fig. 1; Möb., Hcke, *Fisch. Osts.*, p. 113.

Cyprinus Aphya, Lin., *Syst.*, l. c., p. 323; Bl., l. c., part. III, p. 143, tab. XCVII, fig. 2, quæ figura tamen pessima potius forsan ad Leuc. grislaginem referenda; Retz., l. c.; Nilss., *Prodr.*, l. c.; Kr. (*Phoxinus*), *Danm. Fisk.*, vol. III, p. 524; Coll., Forh. Vid. Selsk. Christ. 1874, Tillaegsh., p. 183; 1879, No. 1, p. 96; N. Mag. Naturv. Christ., Bd. 29 (1884), p. 111; Malm, *Gbgs, Boh. Fn.*, p. 564; Fedders., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 91; Mela, *Vert. Fenn.*, p. 321, tab. X; Lillj., *Sv., Norg. Fisk.*, vol. III, p. 179.

Cyprinus rivularis, Pall., *Russ. Reis.*, part. II, p. 717.

Phoxinus lævis, Agass., l. c.; Hckl, Kn., *Süsswasserf. Oestr. Mon.*, p. 210; Dybowski, *Cypr. Liel.*, p. 105; Sieb., *Süsswasserf. Mitteleur.*, p. 222; Mgrn, *Finl. Fiskfn.* (disp. Helsingf. 1863), p. 48; Bncke, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 141; Mor., *Hist. Nat. Poiss.*, tom. III, p. 392; Fatio, *Fn. Vert. Suisse*, vol. IV, p. 638.

The Minnow is the smallest Scandinavian Cyprinoid, with the exception of the *Orsianka* (*Leucaspius delineatus*), and is generally no larger than the latter. Its ordinary length in Sweden is about 6—9 cm. Our largest specimen, from Lake Korn in Northern Bohuslän, measures 105 mm. to the end of the caudal lobes

[1] Except in gravid females.

[2] Fewest in the males, in which, according to Fatio, the number is further reduced during the spawning-season.

or 99 mm. to the tips of the middle caudal rays. From Ireland, however, though the species is supposed to have been planted there, THOMPSON mentions a specimen 6 in. (152 mm.) in length. The females attain a greater size than the males. In shoals of spawning Minnows HECKEL and KNER found the length of the females to vary between 92 and 105 mm., that of the males between 52 and 79 (exceptionally 92) mm. The largest specimens in their possession were 131 mm. long and came from Hungary.

The body is elongated and of fairly uniform thickness, the anterior part of the trunk showing so little compression that the greatest thickness is at least $2/3$ of the depth. Posteriorly the lines of the body converge, as usual, even from the sides, but the tail is still comparatively terete. The depth of the head at the occiput is slightly greater than its breadth. The back is broad and depressed in the median line into a groove, which may be exchanged in front of the dorsal fin for a low carina. The belly is even and terete, or, at the isthmus, flat. The dorsal profile shows a more or less distinct break at the occiput, but is otherwise regular, like the ventral profile, which differs from that of the other Whitefishes in being free from any perceptible break, even at the vent or along the anal fin.

The most characteristic point in the form of the head consists of a swelling (thickening of the ethmoid bone) on the snout between the nostrils. The occiput and forehead are slightly convex or (especially the latter) nearly flat; the gill-covers and cheeks almost perpendicular. The eyes are middle-sized and set so high that their superior margin lies almost in the same plane as the forehead. Their longitudinal diameter measures in young specimens ($1/2$ dm. long) about 30 %, in average-sized specimens about 28 %, and in specimens 1 dm. long about 23 %, of the length of the head; the vertical diameter is $9/10$—$4/5$ of the longitudinal. They lie almost entirely in the anterior half of the head, the postorbital length of the latter being only slightly less than the length of the snout and the eye together. The breadth of the interorbital space is always greater than the diameter of the eyes and varies between 40 and 30 % of the length of the head. The horizontal profile of the snout is obtusely (slightly) rounded, and its tip generally projects a little beyond that of the lower jaw. The cleft of the mouth, with its fleshy lips, is small and turned slightly upwards. The length of the upper jaw from the middle of the tip of the snout is, as a rule, equal to that of the snout, or about 30 % of that of the head. The length of the lower jaw is about the same as the breadth of the interorbital space, or on an average $1/3$ of the length of the head. The nostrils are round and rather large, but set close together, the posterior nostril being usually covered to a great extent by the dermal flap that rises from the narrow bridge between them. They lie much nearer to the eyes than to the tip of the snout. The gill-openings are comparatively large, extending above along about half the upper margin of the gill-cover, and separated at the isthmus by a distance sometimes scarcely half the diameter of the eyes. The branchiostegal rays as well as the rim outside them are broad. The gill-rakers are small; in the outer row on the first branchial arch they are about 8 in number, scattered, verrucose, and hardly distinguishable. The pharyngeal teeth show considerable variation in number. In most cases they are set in two rows, the large row on the inside of the lower arm of the bones generally containing 5 teeth on the left side and 4 on the right, and the smaller row, outside the former one, consisting of 2 small, almost cylindrical teeth. Sometimes, however, not a trace of this smaller row can be found. We have never found the pharyngeal cartilage present: according to FATIO it is of an obtuse heart-shape, with the posterior part attached like a knob to the anterior.

Our figure (fig. 188, *c*) shows, on the other hand, how the mucous membrane of the pharynx covers the downward process of the occipital bone at the spot where the pharyngeal cartilage is otherwise developed. This figure may also assist in the explanation of the form possessed by the pharyngeal cartilage in the majority of the following Leuciscines, at least in the larger ones. The surface of this cartilage is heart-shaped. On each side of it the roof of the pharynx shows deep hollows, converging in a forward and upward direction (downward in the figure, which is drawn from a specimen laid on its back, with the head turned towards the artist). But at the middle of the base of this heart-shape the mucous membrane is continued (upward in the figure) in a rounded (convex) coat over the lower (posterior) part of the said occipital process, until it leaves this process and passes into the upper wall of the œsophagus. This convex part forms the foundation of the callosity which, especially in the larger Whitefishes (see, for example, the Chub, fig.

191, cf. p. 769 below), composes a continuation of the pharyngeal cartilage in an inverted canaliculate form, more or less sharply defined and more or less raised above the remaining surface of the cartilage.

All the fins are of a somewhat rounded shape, reminding us in some degree of the Tench. The dorsal fin begins at a distance from the tip of the snout which on an average measures very nearly half the length of the body, but varies between 48 and 52 % thereof. Its base measures on an average $^1/_{10}$ of the length of the body, varying between 9 and 11 % of the same. Its height (the length of the longest, the first branched ray) is always greater than the length of its base and measures in the females about 13—15 %, in the males nearly as much as 17 %, of the length of the body. As a rule the first ray is imperceptible above the skin. The same remarks apply to the anal fin, which is of the same obliquely quadrilateral form, with more or less distinctly rounded corners, and as a rule of the same size. The distance between this fin and the tip of the snout is greatest in the females and varies between about 55 and 61 % of the length of the body. The caudal fin is not very deeply forked. Its middle rays occupy in average-sized specimens about 9—11 % of the length of the body and measure more than half (53—64 %) of the length of its longest rays.

In this species too, the paired fins afford the most trustworthy distinctions of form between the sexes. Both pairs are rounded and obliquely oval. The pectoral fins are set, as in the Gudgeon, so low that when expanded they lie almost in the same plane as the ventrals. In both sexes the length of the pectoral fins is as a rule about 13—15 % of the length of the body, but in the males it may rise during the spawning-season to 18 % thereof. In the males the upper (anterior) rays (5—7) are thick and have more markedly distinguished articulations than in the females. The pectoral fins of the Minnow thus supply us with similar sexual characters to those afforded by the ventral fins of the Tench. Here, on the other hand, the ventral fins of the two sexes differ both in their position — somewhat further back in the females — and their length, which in the males is more, in the females less than 13 % of the length of the body. The distance between these fins and the tip of the snout measures during youth and in the males about 40—42 %, in the females 42—46 % of the length of the body, and the distance between them and the anterior angle of the pectoral fins (the preabdominal length) during youth and in the males 19—22 %, in the females 22—26 % of the same length. In consequence hereof the tips of the pectoral fins, when laid back, may sometimes extend in the males nearly to the bases of the ventral fins, while the tips of the latter fins in the same position reach in the females scarcely to the vent, in the males beyond this point or even to the beginning of the anal fin. The vent, which protrudes considerably and is fairly wide at its junction with the urogenital aperture, lies perceptibly, though not far, in front of the beginning of the anal fin. Here, as in the Cobitoids (see above), we find no special scaly appendage at the outer angle of the ventral fin.

The covering of scales shows quite a considerable external resemblance to that of the Tench; but the scales are of exactly opposite form, deeper than long, of a more or less broad elliptical shape, with the longitudinal axis turned in the transverse direction of the body. Instead of being inserted in the skin for the greater part of their length, as in the Tench, they are chiefly free and hardly imbricated in the longitudinal direction of the body, though in a transverse row on the back each scale may slightly overlap the one below it. The texture is rather coarse, but densely striated with concentric ridges, which are interrupted throughout the circumference of the scale by radiating grooves extending to a greater or less distance inward from the margin. The striæ are thus divided into patches of oblong triangular shape, crossed by transverse streaks and with their apex directed towards the central nucleus of the scale. The belly is naked in front and at the isthmus, but is furnished on each side in front of the pectoral fin with a triangular patch of about 8 rows of scales. The lateral line pierces its scales throughout the greater part of their breadth (in the longitudinal direction of the body), but is very often partially or entirely wanting on the sides of the tail. It forms a downward curve from the temporal region, so sharp that it reaches the middle of the sides in front of the perpendicular from the tip of the pectoral fin, when laid back, and runs back from this point in a straight line to the middle of the base of the caudal fin.

The coloration in conjunction with the well-proportioned form of the body renders the Minnow one of our most handsome fishes. The colours show considerable variation, however, according to the locality, the season, the sex and the mood of the fish. No long description can so clearly delineate the coloration of the Minnow as v. WRIGHT's two figures: a female and a male in the spawning-dress. The back is olive brown or nearly blackish, purer green between the dark transverse bands that run down towards the sides. The middle of the sides generally shows a pattern of equally dark shade, a row of blackish brown spots, partly or completely coalescing into a stripe, which runs from the snout, interrupted by the eyes, to the lower part of the caudal fin, where it ends in an obliquely set spot, as a rule the most constant and persistent trace of this stripe, even in specimens preserved in spirits. The ventral side is light, milky white or silvery. Very often the colour of the sides is dashed with gold, especially on the gill-cover and above the dark stripe; and the ventral side assumes a reddish tint, punctated more or less densely with blackish brown dots, the last distribution of colour being most prominent on the forepart of the body in the males. All the fins are transparent, shading into yellow, gray, or green. In the spawning-dress all the colours are brighter, most so, as usual, in the males: the sides become emerald green, the belly reddish, the golden lustre comes forth on the suboperculum, and on the upper part of the operculum, as far as it is free from the side of the body and forms the upper margin of the gill-opening, there appears a lustrous, white spot, especially conspicuous in the males on the black ground composed of the occiput, the preoperculum, a part of the operculum, and the remainder of the branchiostegal membrane. In the males ready to spawn this lustrous white also extends to the bases of the paired fins and the inner anterior corner of the anal fin. The corners of the mouth are carmine red. The iris glitters with a lustre of silver and gold. In light environments the fish has a lighter dress, and the body grows somewhat transparent. The fish is also lighter by day than at night, has a richer dress when well fed than when starved, and changes colour rapidly enough under the influence of the passions. "The coloration varies considerably in different individuals," writes EKSTRÖM; "it also changes speedily on the death of the fish. To observe the numerous and bright hues with which this fish is adorned, it should be seen in the water or at the moment of its capture. Though kept alive in a vessel of water, it changes colour soon enough." In England a gold-coloured variety of the Minnow has been found[a].

The Minnow has many Swedish names: *Elritza* (Germ. *Elritze*), in Halland and Bohuslän *Ålling* or *Ållepytta* (Dan. *Elbut* or *Elbutte*) and *Alkula*, in Dalsland *Alkufra*, in Öster Gothland *Alkutta*, in Wester Gothland *Hundgadda* and *Gli*, in Westerbotten *Glirr*, in Dalecarlia *Qridd* and *Iggling* (LINNÆUS), in Jemtland *Blindsill* (OLSSON), in Lapland *Solsensodg* (LINNÆUS), among the islands of the Baltic *Hamntorsk* in the District of Stockholm (SUNDEVALL) and *Lorthuk* in Södermanland (EKSTRÖM), and in Gothland *Laxbadd* (LINDSTRÖM). ARTEDI also gives the names of *Mudd* and *Skitspigg*, LINNÆUS that of *Budd* (Germ. *Butt*). This multitude of names is alone sufficient to prove the common occurrence of the Minnow throughout Sweden and in the island-belts of the Baltic and the Gulf of Bothnia. The species is also common in Norway both to the extreme north (south to about 69° N. lat.) and the extreme south (north to about 63° N. lat.), but not in the intermediate districts (COLLETT, cf. the occurrence of the Perch in Norway, see above, p. 28, note *d*). Its geographical range embraces the whole of Europe — with the exception, as far as is known at present, of the Iberian Peninsula — and Northern Asia, east to the Amur. In Switzerland, according to FATIO, it ascends the cold Alpine streams and lakes to a height of nearly 2,500 metres above the level of the sea. In Norway, according to COLLETT, it lives high up in the birch region of the fells, at an altitude of about 900 metres.

The appearance[b] and habits of the Minnow have been compared, not without reason, to those of Salmon-fry in the stage termed *parrs*. They are also often found in company, the Minnow being generally an inhabitant of clear streams and brooks with sandy or gravelly bottom. But the Minnow lives, as we have mentioned, not only in running fresh water and in lakes, but also in the sea, where it often appears in shoals off the piers among the island-belt. EKSTRÖM describes its habits in these latter haunts as follows: "It lives off rocky promontories and stony shores in deep water, especially where there is a current, associates exclusively with its own kin, and seems to avoid places frequented by other species. Where it occurs, it is always found in large numbers. During the greater

[a] MANLEY, see DAY, l. c.

[b] "Facies Truttae seu Salmonis". LIN., *Fn. Suec.*

part of the day it lies still, almost motionless, at the bottom, where it seeks its food. Now and then, however, it rises to the surface, quick of movement and voracious for its size. With greedy eagerness it catches the insects that fall into the water. It dies almost instantaneously when taken out of its native element." In fresh water it is less sensitive to the influence of the air and is sometimes seized with the same wandering spirit as the Salmon, leaping over obstacles with vigour relatively the same and no less eagerness. It sometimes forces its way along the tiniest, half-dry brooks and pools, if only it feels running water — and may subsequently be found in puddles, where it is scarcely possible to explain its presence. In fresh water it is also more sociable in its relations to other fishes: in the Nissa River (Halland) I have often caught Minnows in company with Salmon-fry.

Its food is chiefly composed of insects, small crustaceans and mollusks, and worms. In the island-belt it often keeps watch at the landing-places, where fish is gutted and rinsed, and seizes small fragments of the offal. Fish-roe and small fry, even of its own species, also form a part of its diet. It does not disdain a bait of wheat dough, though it bites less readily at this; and in an aquarium it may be fed on bread-crumbs. Its voracity entices it forward at the least cause and gives it an inquisitiveness of which the fisherman may take advantage. FATIO tells us that he caught quantities of Minnows in a landing-net, by holding it still in a stream. As soon as the leader and the van of the shoal had entered to see what they might discover in the net, the others followed without hesitation.

The spawning-season seems to vary according to the early or late arrival of the summer warmth. In the tracts bordering on the Rhine the Minnow is taken in large numbers, together with a multitude of other small fishes (Salmon-fry among others), all known by the common name of *Rümpchen*, during the months of May and June, at which time the Minnow ascends the brooks to spawn on a stony or gravelly bottom. EKSTRÖM states that in the island-belt of Södermanland it spawns at the end of June or beginning of July. According to FATIO the spawning may begin in the Swiss valleys at the middle of April, but in the higher Alpine regions is sometimes delayed till August. The eggs are not very numerous, at most about 1,000 in the same female, but comparatively large, being 1—1¼ mm. in diameter. They are hatched, sooner or later according to the temperature of the water, in from 6[a] to 15[b] days. "It is a mistake," writes SAUVADON[c], "to suppose that the eggs of the Minnow are strewn about and carried away by the current among the gravel and stones, as soon as they have been deposited. During the spawning the fish are so numerous and packed so close together that their bodies are enough to neutralise the gentle current that otherwise passes over the spawning-place. Furthermore, these small, glutinous ova adhere to each other and fill all the interstices between the stones, on which they may often be found in layers 1—5 cm. thick and 5—20 cm. long. All these eggs stick fast together and form a layer firm enough to withstand a current ten times stronger than that which runs at the spawning-place. On the 30th of May I have myself gathered at least 3 kgm. of Minnow-eggs." In the first week of August YARRELL found young Minnows three-quarters of an inch (19 mm.) long. The Minnow reaches maturity, according to FATIO, at a length of 35—40 mm.

At the approach of autumn the Minnow retires to deep water, there to pass the winter in company with other Cyprinoids. As food the Minnow is not to be despised, especially if the gall-bladder, which otherwise gives it a bitter taste, be removed. In Sweden, however, it is seldom eaten; here and there in the country it is fried and made into the so-called *fish-cake*. Further south, where it is still more plentiful, it is a more appreciated dish. In England, according to DAY, it is eaten freely, being prepared for table like Whitebait[d]. In Sweden it is most important as bait for Salmon and Perch; but as it is not very tenacious of life, it must not be left long on the hook.

[a] According to DAVY, see DAY, l. c.

[b] According to FATIO.

[c] Bull. Soc. Zool. D'Acclimat. Paris, série 2, tome IV (1867), p. 721.

[d] BUCKLAND says that on the 16th of September, 1394 Bishop WILLIAM of Wykeham, the founder of Winchester College, gave a dinner to the King and Queen and 210 other guests, the menu including a number of fish courses, among others 7 gallons of Minnows.

GENUS LEUCISCUS.

Scales as a rule middle-sized[a], numbering in all the Scandinavian species about 40—60 in the lateral line, which is complete. Jaws projecting equally far, or nearly so. Lobes of the caudal fin pointed. Base of the anal fin less than 19 % of the distance between this fin and the tip of the snout. Distance between the dorsal fin and the tip of the snout less than 86 % of that between the anal fin and the same point.

This genus was already known by its modern name[b], which means *Whitefish*, in the time of GALEN (the second century A. D.). At many places, both in Sweden and elsewhere, Whitefish is a trivial name common to the Cyprinoids (especially *Leuciscus* and *Alburnus*) and Coregonoids. BELON referred the name of *Leuciscus* to the Dace, RONDELET both to the Roach and the Dace. KLEIN, as we have mentioned above, gave the genus a definition which corresponded in essential respects to that of the modern subfamily *Leuciscinæ*. LINNÆUS did not recognise this genus — he employed *Leuciscus* as one of his specific names for the Dace — but CUVIER[c] adopted it as a subgenus; and it was subsequently raised by FLEMING[d] to the rank of an independent genus. The number of the species is so great, about a hundred being known, that attempts have with reason been made to subdivide the genus. But the ground on which most authors, following HECKEL's example, have proposed to base this subdivision — the number and arrangement of the pharyngeal teeth, their similarity or dissimilarity on the two pharyngeals and their distribution in one or two rows — has proved untenable, as we have already been enabled to conclude from the Minnow, where the smaller row may sometimes disappear without leaving a trace of its presence. The Scandinavian fauna contains only four recognised species, which may be distinguished as follows:

A: Anal fin concave.
- *a:* Least depth of the tail less than 43 % of the length of the peduncle of the tail between the perpendicular from the end of the base of the anal fin and the middle point in the line of demarcation between the scales and the caudal fin .... *Leuciscus grislagine.*
- *b:* Least depth of the tail more than 43 % of the length of the peduncle of the tail measured as above.
  - *aa:* Base of the dorsal fin less than $^1/_4$ of the distance between this fin and the tip of the snout... *Leuciscus idus.*
  - *bb:* Base of the dorsal fin more than $^1/_4$ of the distance between this fin and the tip of the snout ... *Leuciscus rutilus.*

B: Anal fin convex. ... ... *Leuciscus cephalus.*

[a] As for the exceptions, see the observations on the preceding genus.
[b] From the Greek λευκός, white.
[c] *Règne Animal*, ed. I, tom. II, p. 194.
[d] *Brit. Anim.*, p. 187.

THE DACE (SW. STÄMMEN).

LEUCISCUS GRISLAGINE.

Plate XXXII, fig. 2

Scales in the lateral line about 52 (50—54). Branched rays in the dorsal fin 7. Least depth of the tail less than the length of the base of the dorsal fin, or than 43 (41) % of the length of the peduncle of the tail between the perpendicular from the end of the anal fin and the middle point in the termination of the scales at the base of the caudal fin. Outer (lower posterior) margin of the anal fin concave. Pharyngeal teeth curved at the tip or straight, with narrow and smooth or hardly perceptible masticatory surface: 2(3), 5—5, 2(3).

Fig. 189. Pharyngeal bones and pharyngeal cartilage of *Leuciscus grislagine*, 3 times the natural size. *a*, *b*, and *c* as in fig. 178.

R. br. 3. *D.* $\frac{3}{7}$; *A.* $\frac{3}{8}$[b]; *P.* $\frac{1}{17-18}$; *V.* $\frac{2}{8}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 50[a]—54; *L. tr.* $\frac{8}{4}$ 1 (supra pinn. ventr.); *Vert.* 41—44[c].

Syn. Leuciscus, BELON, *Nat., Div. Poiss.*, p. 313. *Leucisci 2:da Spec.*, RONDEL., *Pisc.*, part. II, p. 192. *Cyprinus* novem digitorum, rutilo longior et angustior, pinna ani radiorum decem. ART., *Ichthyol.*, *Syn. Pisc.*, p. 9 (Gallis *Vandoise*). *Cyprinus* oblongus, figura rutili, pinna ani ossiculorum decem ART., ibid., *Gen. Pisc.*, p. 5; *Syn. Pisc.*, p. 5; *Descr. Spec.*, p. 12 (Suecis *Stam*). *Cyprinus* pedalis gracilis oblongus crassiusculus, dorso crasso, pinna ani ossiculorum novem. ART., ibid., *Syn.*, p. 10 (Tigurinis *Hasel*). LIN., *Fn. Suec.*, ed. 1, p. 123 (Angermannis *Stam*).

Cyprinus Grislagine, LIN., *Syst. Nat.*, ed. X, tom. I, p. 323; RETZ., *Fn. Suec. Lin.*, p. 357; EKSTR.(?), Vet.-Akad. Handl. 1830, p. 157, tab. IV; NILSS., *Prodr. Ichthyol. Scand.*, p. 27; AGASS. (*Leuciscus grislagine* + *L. argenteus* + *L. rostratus* + *L. rodens* + *L. majalis*), Mem. Soc. Sc. Nat. Neuch., tom. I (1836), p. 38; EKSTR., v. WRIGHT (*Cyprinus*), *Skand. Fisk.*, ed. I, p. 69, tab. 14; KR. (*Leuciscus*), *Danm. Fiske*, vol. III, p. 472; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Handl., H. VI, 1855, p. 81; NILSS. (*Leuciscus*), *Skand Fn., Fisk.*, p. 303; WIDEGR. (*Cyprinus*), *Fiskfn., Fisker. Norrb. L.*, Landtbr. Akad. Handl. 1861, p. 12 (sep.); COLL. (*Leuciscus*), Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 181; MALM, *Gbgs. Boh. Fn.*, p. 562; MELA, *Vert. Fenn.*, p. 326, tab. X; ID. et SUNDM., *Finl. Fisk.*, tab. XXVI; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 198.

Cyprinus Leuciscus, LIN., *Syst. Nat.*, l. c.; BL., *Fisch. Deutschl.*, part. III, p. 141, tab. XCVII, fig. 1; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 318; HCKL. KN. (*Squalius*), *Susswasserf. Oestr. Mon.*, p. 191 (+ *Squ. lepusculus*, p. 186, + *S. chalybaeus*, p. 188, + *S. rodens* (ex AGASS.), p. 189, + *S. rostratus* (ex AGASS.), p. 192); DYB., *Cypr. Livl.*, p. 126; SIEB., *Susswasserf. Mitteleur.*, p. 203; MGRN, *Finl. Fiskfn.*, p. 47; BLANCH, *Poiss. d. eaux douces Fr.*, p. 401 (+ *Squ. bearnensis*, p. 400, + *S. burdigalensis* (ex. VAL.), p. 403); FEDDERSEN, Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 88; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 139; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 425; FATIO, *Fn. Vert. Suisse*, vol. IV, p. 582.

Cyprinus Dobula, LIN., *Syst. Nat.*, l. c.; BL. l. c., part. I, p. 42, tab. V; YARR. (*Leuciscus*) *Brit. Fish.*, ed. 1, vol. I, p. 346 (+ *Leuc. vulgaris*, p. 353, + *Leuc. Lancastriensis* (ex SHAW), p. 355).

[a] Sometimes 47, according to SIEBOLD.
[b] „ 9, „ „ „
[c] According to FATIO, 40—45 according to JEITTELES.

Leuciscus vulgaris, FLMNG., *Brit. Anim.*, p. 187; CUV., VAL., *Hist. Nat. Poiss.*, vol. XVII, p. 202 (+ *Leuc. rostratus* (ex. AGASS.) + *L. rodens* (ex. AGASS.) + *L. lancastriensis*, (ex. SHAW), p. 216 + *L. burdigalensis*, p. 218, nec *L. grislagine*, p. 220); GTHR., *Cat. Brit. Mus., Fish.*, vol. VII, p. 226; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 180, tab. CXXXIII, fig. 1; MOR., HEKT., *Fisch. Osts.*, p. 109.

The Dace is one of the smaller species of the genus. Its ordinary length is between 15 and 20 cm., and in Sweden probably does not exceed 25 cm. Further south it seems to attain a somewhat greater size: FATIO found in the Rhine a gravid female of this species, 275 mm. long and 300 grammes in weight. DAY states that in the Thames the Dace attains a length of about 3 dm.

Of all the Scandinavian species within the Leuciscine subfamily the Dace is the most elongated in proportion to the depth of the body, and is easily recognised by this character. The body is deepest a little in front of the dorsal fin, and the greatest depth measures in adult specimens, 18—21 cm. long, about 21—24 % of the length of the body. In younger specimens the greatest depth is even relatively less, as elsewhere in the family. The least depth of the body (of the peduncle of the tail) measures in adult specimens about $8^1/_2$—$7^1/_2$ % of its length. The back is terete, though less so just in front of the dorsal fin, and the sides are moderately compressed. The back rises in a gradual curve from the head to a point a little in front of the dorsal fin, though it is straighter than in the Scandinavian congeners of the Dace, and the curve does not increase in sharpness at the occiput. From this point the dorsal profile slopes gently, almost in a straight line, to the base of the caudal fin. The ventral profile forms a similar or even more gradual curve from the chin to the vent, which protrudes slightly, and then runs straight to the caudal fin.

The head is of moderate size (in adult specimens about 21—19 % of the length of the body), with broad and rather flat forehead, sloping with a slight convexity towards the broad and very obtuse snout, which projects a little in front of the jaws. The mouth is small and turns slightly upwards, as in the rest of the *Leuciscinæ*, the upper jaw is slightly more prominent than the lower, and the corners of the mouth extend a little behind the perpendicular from the posterior nostril. The length of the upper jaw from the middle of the tip of the snout measures in adult specimens rather more than $^1/_4$ (about $25^1/_2$—28 %) of that of the head. The length of the lower jaw is equal to or somewhat greater than that of the snout, or about $^1/_3$ (32—35 %) of that of the head. The eyes are fairly large, their longitudinal diameter being only slightly less than $^1/_4$ (about 23—$24^1/_2$ %) of the length of the head. They are generally set just in front of the middle of the head[a] and so high that the line drawn from the middle of the caudal fin to the margin of the upper jaw touches the inferior margin of the eye. The least breadth of the interorbital space is about $^1/_3$ ($32^1/_2$—34 %, exceptionally 37 %) of the length of the head, or $1^1/_2$—$1^1/_4$ times the longitudinal diameter of the eyes. The nostrils are rather large, and lie in a deep cavity, nearer to the eye than to the tip of the snout. The gill-rakers are small and scattered, but pointed, numbering 8 in the outer row on the first branchial arch and 7 on the pharyngeal bones. Each pharyngeal is armed as a rule with 7 teeth (fig. 189), set in two rows. The inner row contains 5 long and fairly straight teeth, curved upwards at the tip, but usually not much hooked[b], and without incisions or spines on the indistinct masticatory surface. The teeth in the outer row are generally 2, sometimes 3, in number, short, straight, and conical. The pharyngeal cartilage is soft, thin at the edges, heart-shaped, and deciduous. The gill-openings do not extend at all above the upper margin of the gill-cover, and below they coalesce with the isthmus at a distance from each other of about half the diameter of the eyes.

The dorsal fin, the height of which is greater than its length at the base, has an obliquely truncate margin with somewhat rounded corners. Behind it is half as high as in front, a rule which applies to most of the *Leuciscinæ*. It begins at a distance from the tip of the snout which in adult specimens measures on an average half the length of the body, varying, however, between $46^1/_2$ and 54 % thereof. Its base occupies $^1/_{10}$ (varying in our specimens between $9^1/_2$ and $10^1/_2$ %) of the length of the body; and its height (the length of the longest ray), which is as a rule equal to the length of the pectoral fins, varies in our specimens between 15 and $16^1/_2$ % of the length of the body. The first three rays

[a] The postorbital length of the head varies in our specimens between $48^1/_2$ and 54 % of its entire length, the variations essentially depending on the breadth of the opercular rim.

[b] In specimens from Lake Wener, however, we find the hooked tips well developed in the two hindmost teeth of this row.

are simple, the first being hardly perceptible externally[a], the third the longest ray in the whole fin, or equal in length to the fourth. The last seven rays are repeatedly branched at the tip, and the last ray is cloven almost to the base.

The anal fin is of nearly the same shape as the dorsal, and of exactly the same structure, except that it has an additional branched ray. Its corners, especially the posterior, are more pointed, and the margin is slightly concave. The fin begins at a distance from the tip of the snout that measures on an average somewhat less than $^2/_3$ (varying in our specimens between 63 and $66^1/_2$ %) of the length of the body, and its base occupies on an average about $^1/_{11}$ (varying in our specimens between 8·9 and 9·8 %) of the same length. Its height is on an average about $^1/_8$ (varying in our specimens between 12 and 13 %) of the length of the body.

The pectoral fins are obliquely pointed, and consist of 1 simple and 17 or 18 branched rays, of which the last (lowest) two or three are small and difficult to distinguish. The ventral fins, on the other hand, are broader and more rounded, and are furnished on their front (outer) side, as usual in this family, with two simple rays, so closely united that the first is not always distinguishable. Their length measures in young specimens about 14 %, in old about $12^1/_2$ % of that of the body. The distance between the foremost (outermost) point in their insertions and the corresponding point in the insertions of the pectoral fins is on an average about $^1/_4$ (varying in our specimens between $23^1/_2$ and 28 %) of the length of the body. The distance from the former point to the tip of the snout varies between about 14 and 18 % of the length of the body, and to the beginning of the anal fin between about 20 and $21^1/_2$ % of the same length. The bases of these fins are furnished as usual with a pointed, lanceolate appendage.

The caudal fin is forked, with lobes of equal length. Its middle rays occupy about 8—7 % of the length of the body, and are less than $^1/_2$, sometimes only $^1/_3$, as long as the longest rays.

The scales which cover the body, are of moderate size, but in comparison with those of the Roach rather small. They are imbricated, and lie in distinct series. They are of a rounded quadrilateral form, but the two anterior corners are generally well marked and separated by sinuses from the middle of the anterior margin, which is convex and crenulated by three or four small undulating sinuses, into which the grooves[b] radiating forward from the central nucleus open. The posterior (free) part of the scale contains from two to nine such grooves, more or less distinct. The lateral line descends at first, and then runs (from about the middle of the abdominal region) parallel to the ventral line and nearer to the belly than to the back. The number of scales in the lateral line (about 52 in Dace from the north) is the greatest possessed by any Scandinavian *Leuciscus* except the Ide. The said number would thus give us the most easily applicable character for the Dace, if it were not stated from more southern localities that the species may have only 44 scales in the lateral line[c].

The coloration shows great resemblance to that of the kindred species; but the colours of the Dace are paler, less diversified, and not so bright. The top of the head and the back are dark olive brown, the sides silvery gray and lustrous, with a strong tinge of pale ochreous yellow during the spawning-season. The iris is silvery with a dash of yellow and a narrow ring of deeper yellow next the pupil; it is finely punctated with green pigment, and has a dark, curved band at the top. The sides of the head are silvery with a strong tinge of yellow, and shade into various colours. The dorsal fin is plain, pale grayish brown, the caudal fin bright olive green, and all the lower fins pale with a dash of yellow, especially at the base. The rays of the last-mentioned fins are flame-coloured at the middle, and the bases of the ventral fins are of the same hue. In young specimens the lower fins are light and quite colourless.

In the internal organs, on examining them within the abdominal cavity, we found no essential difference from other species.

The geographical range of the Dace extends over the whole of Europe north of the Alps, with the exception of Scotland and Ireland, and over Western Siberia, where the species has been found, according

[a] ARTEDI overlooked the first, short ray, but counted the last, deeply cloven ray twice over, thus arriving at the correct number of rays in the dorsal fin.

[b] The number of these grooves is generally about 11; but on the caudal scales they may be much more numerous, as many as 28, though only a few, about 9, extend to the nucleus of the scale.

[c] JEITTELES, *Fische der March bei Olmutz*, II Abth., pp. 15 and 16.

to MELA, in the River Obi[a]. In Scandinavia it is evidently a northern and eastern fish, being rare in Denmark. In the north of Sweden it is common in all the large rivers and lakes connected with the Baltic, from the Muonio to the Dal elf inclusive. In these regions it is found especially in the large lakes and also in the rivers, penetrating into Lapland as far as the rivers afford it a passage. In the Tornea Elf it is unknown above Kengis Force; but WIDEGREN says that it ascends from this river into the Muonio, in 68° N. lat. In Lycksele Lappmark it is taken in quantities. Its most common provincial name in the north is the one given above. In Dalecarlia it is known as the *Sträfling*, and in the neighbourhood of Gefle as the *Veling*. It is also common in the large rivers and lakes of Wermland and in Lake Wener, where it is called *Stafling*. South of the River Gotha we have personally no information of its occurrence in Sweden. Of the other Swedish names for this species we will mention *Skall-id*, *Skalljer*, and *Adrag*. In the island-belt of Stockholm SUNDEVALL found the Dace to be very rare, though, according to EKSTROM, it occurs, but is not very common, among the islands off the coast of Södermanland[b]. In Norway, according to COLLETT, the Dace is common in the south. It is dispersed throughout Finland, and in Russian Karelen was taken by MALMGREN in the River Kem, near the White Sea. In Denmark, where it was not known with certainty by KROYER, it occurs, according to FEDDERSEN, in the Nips, a river of south-western Jutland.

The Dace, like the Ide and Chub, is partial to running water, and in spring ascends from the lakes and the Baltic island-belts into the rivers to breed. It is more easily overpowered by the current, however, than the others, and therefore prefers quiet streams[c]. It passes the winter in the depths of large lakes, or in deep water among the islands on the Baltic coast. Early in the spring, soon after the ice has broken up, the Dace assemble in large shoals, begin to ascend the rivers, and commence spawning in May on a sandy bottom, as a rule eight or ten days after their arrival. On the completion of the spawning, they usually remain at most a fortnight longer, and then desert the spawning-place. In the Klar Elf, however, the Dace, it is stated, remains all the year round. It is one of the less prolific Cyprinoids, the female containing a comparatively small number of rather large eggs. FATIO counted about 17,100 ova, about 2 mm. in diameter, in a female 27 cm. long.

The Dace is a timid fish, and takes to flight at the least noise. Its movements in the water are very rapid and active, and it often leaps over the net. It is tenacious of life, young Dace being therefore excellent live bait, especially as their skin is bright and lustrous. The flesh is white, not very bony, and of good flavour. Still, owing to its insignificant size, the Dace is in little request, and it is only in localities where it is plentiful, and where for the time being other fish is scarce, that this species is used as food.

The Dace is taken in the seine during the whole summer, where this method of fishing is employed for other species; but only solitary specimens are caught in this manner. It is principally taken 1) in gill-nets, which are set in quiet bends and long windings of the streams, such places being favourite haunts of the Dace on bright and warm summer days, 2) with trammel-nets, which are used at the same time of year in shallow and weedy inlets of the lakes, 3) in traps (see above, pp. 32 and 33), which are set during the spawning-season at places that the fish must pass, the narrowest channels and those easiest to close being selected for this purpose. (EKSTROM, SMITT.)

[a] PALLAS (l. c., p. 314) applies to his *Cyprinus lacustris* the Finnish name of *Kortsa*, which, according to MELA, belongs to the Dace. Thus, according to PALLAS, the Dace is common throughout Western Siberia and especially plentiful in Lake Baikal. The *Cyprinus Grislagine* of PALLAS is, according to GRIMM, a variety of Roach.

[b] Unless EKSTRÖM's description of the Dace in the *Vet.-Akad. Handl.* for 1830 referred principally to the Ide.

LILLJEBORG was told, however, that "the Dace can surmount rapids with a fairly strong current".

THE IDE (SW. IDEN).

LEUCISCUS IDUS

Plate XXXII, fig. 1 and Plate XXXV, fig. 1.

Scales in the lateral line about 57 (55—60[a]). Branched rays in the dorsal fin 8[b]. Least depth of the peduncle of the tail more than 43 % of its median length, but as a rule somewhat less than the length of the base of the dorsal fin. Outer (lower posterior) margin of the anal fin concave. Pharyngeal teeth hooked at the tip or straight, with terete and smooth, indistinct masticatory surface: 3, 5[c]—5, 3.

Fig. 190. Pharyngeal bones and pharyngeal cartilage of *Leuciscus idus*, natural size. *a*, *b*, and *c* as in the preceding figure: *d*, the last (hindmost) tooth in the inner (larger) row, seen from behind.

$R.\ br.\ 3;\ D.\ \frac{3}{8^b};\ A.\ \frac{3}{10-11^d};\ P.\ \frac{1}{17-18^e};\ V.\ \frac{2}{8-9};$ $C.\ x+1+17+1+x;\ Lin.\ lat.\ 55-60^a;\ L.\ transv.\ \frac{8-9^f}{4-5}\ 1;$ $Vert.\ 46-47^g$

Syn. Capito fluviatilis ille, quem *Jesen* appelant Germani quidam: nos differentiæ caussa coeruleum cognominemus licet, GESN., *Hist. Anim.*, lib. IV, Paralip., p. 9 + Capito fluviatilis subruber, quem Germani orfum appellant, ibid., p. 10. *Cyprinus* iride sublutea; pinnis ventralibus anique rubris, ART. *Ichthyol.*, *Gen., Pisc.*, p. 5; *Syn. Pisc.*, p. 14; *Descr. Spec., Pisc.*, p. 6 + *Cyprinus* Orfus dictus, ibid., *Syn. Pisc.*, p. 6 + *Cypr.* cubitalis, pinna ani ossiculorum quatuordecim, ibid., p. 7. *Cyprinus* pinna ani ossiculis tredecim rubra, LIN. *Fn. Suec.*, ed. 1, p. 121.

Cyprinus Idbarus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 324; RETZ. *Fn. Suec. Lin.*, p. 356. *Cyprinus microlepidotus*, EKSTR. *Fisch. Scheer. Morko*, p. 18, tab. II.

Cyprinus Idus, LIN., *Syst.*, l. c.; RETZ., l. c., p. 358; EKSTR., Vet.-Akad. Handl. 1830, p. 146, tab. III; NILSS., *Prodr. Ichthyol. Scand.*, p. 27; EKSTR., v. WRIGHT, *Skand. Fisk.*, ed. 1, p. 59, tab. XI; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, vol. XVII, p. 228; KR., *Danm. Fisk.*, vol. III, pag. 447; LILLJ. (*Cyprinus*), Vet.-Akad. Handl. 1850, p. 305; NILSS. (*Leuciscus*), *Skand. Fn., Fisk.*, p. 306; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Sällsk. Handl., H. 6 (1855), pp. 81 et 170; Vet.-Akad. Handl. 1855, p. 15, tab. III, fig. 7—11; LLOYD, *Scandinavian Adventures*, vol. I, p. 55 cum fig. (*Ide*); LINDSTR. (*Leuciscus*), *Gotl. Fisk.*, Gotl. L. Hush. Sällsk. Arsber. 1866, p. 17 (sep.); NYSTR., *Iaktt. fn. Jemtl. Vatt.* (disp. Ups. 1863), p. 4; GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 229; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 181; ibid. 1879, No. 1, p. 96; OLSS., Öfvers. Vet.-Akad. Förh. 1876, No. 3, p. 130; MALM, *Gbgs. Boh. Fn.*, p. 562; MÖB., HCKE, *Fisch. Osts.*, p. 108; MELA, *Vert. Fenn.*, p. 328, tab. X; REUT. et SUNDM. *Finl. Fisk.*, tab. XIII; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 207.

Cyprinus Orfus, LIN. *Syst.*, l. c.: var. hujus speciei, vide HCKL, KN., l. c., p. 150 + *Idus miniatus*, p. 151.

Cyprinus Jeses, LIN., *Syst.*, l. c., p. 325; BL., *Fische Deutschl.*, part. I, p. 45, tab. VI; CUV., VAL. (*Leuciscus*), l. c., p. 160; MOR. (*Idus*), *Hist. Nat. Poiss. Fr.*, tom. III, p. 417.

Idus melanotus, HCKL, KN., *Süsswasserf. Oestr. Mon.*, p. 147; DYB., *Cypr. Liv.*, p. 141; SIEB., *Susswasserf. Mitteleur.*, p. 176; MGRN, *Finl. Fiskfn.*, p. 45; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 133; GRIMM., *Fish., Hunt. Russ. Wat.*, p. 14.

[a] In exceptional cases 54 or 61.
[b] In exceptional cases 7 or 9.
[c] According to MOBIUS and HEINCKE sometimes 2, 5 or 4, 5, the latter numbers being also given by EKSTRÖM.
[d] In exceptional cases 9 or 12.
[e] In exceptional cases (young) 16.
[f] Sometimes 10, according to HECKEL and KNER.
[g] Sometimes 45, according to KROYER, or 48, according to LILLJEBORG.

The Ide is one of the larger species within this genus. According to the reports sent in to the Swedish Fisheries Committee of 1881, it attains in Sweden a length of about 9 dm. and a weight of $6^1/_4$ kgm. These statements, however, undoubtedly refer to exceptions, unless they are exaggerated, or perhaps depend on a confusion of this species with the Asp (*Aspius rapax*). The ordinary length of the Ide in an adult state is about 3 or 4 dm. At a length of 5 dm. it weighs at most from 2 to $2^1/_2$ kgm.

The body is moderately compressed or even rather bulky. The greatest depth, which lies just in front of the beginning of the dorsal fin, usually measures in young specimens rather more than $^1/_5$, in old 25—30 %, of the length of the body, and the greatest breadth or thickness is not quite half the depth. The latter measurement varies, however, according to sex, age, or season, in young specimens being sometimes only about $^2/_5$ of the depth, and rising in old specimens to about 15—51 % thereof. The least depth of the body is in young specimens about 10 % ($9^1/_2$ %), in old about 11 %, of its length. The back, which is fairly broad and convex, and which rises more or less abruptly, according to the fatness of the fish, from the occiput, forms a slight upward curve. The belly from the isthmus to the vent is fairly straight, except during the spawning-season, when it forms in the female a downward curve, beginning at the chin. Between the pectoral and ventral fins the belly is flat, but subsequently, between the latter and the vent, becomes convex and somewhat carinated.

The length of the head usually occupies in moderate-sized specimens a little more than $^1/_5$ ($22^1/_2$—$21^1/_2$%) of that of the body. In old specimens this proportion is almost exactly $^1/_5$, and in young ones the head is as usual larger in comparison with the rest of the body. The front part of the head is broad and convex, forming a gradual curve from the snout to a point somewhat in front of the nostrils, where it is slightly depressed[a]. The breadth of the interorbital space increases, even relatively, with age from a little more[b] than 37 % to nearly 46 % of the length of the head, the latter in specimens 4 or 5 dm. long. As a rule, however, this breadth is less than $^3/_4$ of the base of the dorsal fin, and we have never found it to exceed 85 % thereof. The sides of the head are somewhat compressed and flattened. The snout is blunt, broad, and only slightly projecting, the margin of the upper jaw (middle of the intermaxillaries) being the most prominent point. The mouth is small and turned slightly upwards. In full-grown specimens the corners of the mouth do not extend behind the perpendicular from the middle point between the eye and the nostrils, while in young specimens they reach comparatively a little further back, or to a line with the anterior margin of the eye. The length both of the snout and the upper jaw increases, even comparatively, with age, most, however, in the former case; the length of the snout increasing in specimens 8—42 cm. long from about 27 to 34 % of the length of the head, and that of the upper jaw from about 27 to 31 % of the same. A retrogression to the characters of youth may sometimes be found, however, in old specimens. When the mouth is opened, the upper jaw is slightly protruded. The length of the lower jaw measures about 36—40 % of that of the head. The longitudinal diameter of the eyes decreases comparatively, during growth, in the above-mentioned specimens, from about 30 to 15 % of the length of the head, i. e. from a little less than the breadth of the interorbital space to only $^1/_3$ thereof. At the same time the postorbital length of the head increases from somewhat less than $^1/_2$ to about 56 % of its entire length. The nostrils are set, as usual in the genus, close to each other and nearer to the eye than to the tip of the snout, the narrow partition-wall between them being elevated into a kind of lobe. The anterior nostril is round, the posterior crescent-shaped and larger. The distance between the two anterior nostrils is about half the breadth of the interorbital space. As usual in the genus, the head is scaleless, and is covered on the sides with a thin, transparent skin, through which the opercular and facial bones are distinctly visible. The occiput and forehead, on the other hand, are clothed with a thicker, firmer, and richly muciferous skin, which has a smooth and even surface. The branchiostegal membrane extends behind the gill-cover in a broad rim: its three rays are flat, broad, and curved: and below, as is usually the case in the genus, it is united to the isthmus, in a line with the hind margin of the preoperculum. The pseudobranchiæ are well-developed.

[a] With regard to this depression see above, p. 716, note *a*.

[b] In exceptional cases a little less.

The gill-rakers in the outer row on the first branchial arch are 10 in number, flat at the tip, and divided into two or three digitate branches. The pharyngeal teeth (fig. 190) are set, as mentioned above, in two rows, 5, as a rule, in the inner row, and 3 smaller teeth in the outer one. During the shedding of the teeth, however, these numbers are altered, and we find, on the one hand, new and more or less undeveloped teeth (at first cucullate), lying loose in the gums or beginning to fix themselves, and on the other hand, old teeth more or less completely detached from their alveoli. The masticatory surface of the largest (middle and posterior) teeth in the inner row does not become quite distinct until the fish has attained some considerable size. The front tooth in this row (as well as the first, the two first, or even all three teeth in the outer and smaller row) is straighter and conical or cylindrical, the remaining teeth being hooked at the tip.

The dorsal fin begins at a distance from the tip of the snout that in young specimens measures about 48 or 49 % of the length of the body, in old 50 or 51 % thereof. Its origin generally lies above the middle of the insertions of the ventral fins; but on examining a number of specimens we find a variation even in this respect. The height of this fin is greater than its length, the former measuring on an average 18—16 % of the length of the body, and the length of its base 11 or 12 % of the same. The margin is obliquely truncate, with more or less rounded corners, at least in front; and the fin leans slightly backwards. The beginning of the anal fin lies at a distance from the tip of the snout that in young specimens and the males varies between 60 and 65 %, in the females between about 67 and 68 % of the length of the body, though this measurement is also subject to individual variations. The height of the fin varies between 13 and 15 % of the length of the body, the length of its base between 10 and 12 % of the same. When it is folded, the margin is deeply concave; when expanded, almost straight, though even then the concavity is quite perceptible. The length of the rays in proportion to each other is usually such that the tips of the third and fourth rays, which are the longest, extend to the tip of the last ray, when the fin is completely folded. The caudal fin is forked, with pointed corners, the lower lobe being hardly any longer than the upper. The length of the middle caudal rays occupies in young specimens about 12—10 % of that of the body, in old about 8—7 % thereof, and measures in the former about $^1/_2$, in the latter about $^2/_5$, of that of the longest rays in the fin.

The pectoral fins are of oblong shape, with rounded tip when laid back; their length varies between about $17^1/_2$ and 15 % of that of the body. The ventral fins are broader and more rounded. The distance between the latter fins and the tip of the snout measures in old specimens about 45 or 46 %, in young specimens about 43 %, of the length of the body, the distance between the foremost point in their insertions and the corresponding point in the insertions of the pectoral fins (the preabdominal length) in old specimens about 23 or 24 %, in young about 21 or 22 %, of the same length, and the distance between the former point and the beginning of the anal fin (the postabdominal length) in old specimens about 21—24 %, in young about 18 %, of the same. The length of the ventral fins themselves is about $13^1/_2$—$14^1/_2$ % of that of the body.

The scales are of the same shape as in the preceding species, but their texture is somewhat firmer, with denser and coarser radiating grooves, which render their hind margin more distinctly crenulated. The lateral line, which slopes slightly at first, runs almost parallel to the ventral margin, and lies much nearer to the belly than to the back. It contains in most cases about 57 scales, the greatest number in any Scandinavian *Leuciscus*. Above the lateral line there are 8 or 9 rows of scales, and below it 4 or 5, counting from the dorsal and ventral fins to the lateral line, and excluding the scales of the line itself. Between the vent and the lateral line there are 5 or 6 rows of scales.

It is only during the spawning-season that any external difference between the sexes can easily be distinguished. During this period the scales of the male are furnished with a rim, consisting of a row of clear, yellowish, verrucose tubercles, with dark tip, which are wanting in the female, and disappear as soon as the spawning is over.

The coloration of the Ide is subject to considerable variations; but the most striking alteration in its dress depends on the time of year. In *spring* the Ide wears its spawning-dress, and the prevailing ground-colour is brassy yellow, which gleams through the green pigment wherewith the scales, especially at their insertions, are coated. This pigment grows darker towards the back, which is almost plain grayish green, and lighter, gradually disappearing, towards the belly. The head is above of the same colour as the back, but somewhat darker; on the sides yellow, shifting into a number of bright hues. The iris is yellow, with fine, dark dots and a dark spot above the pupil. The dorsal and caudal fins are dark olive gray, the former entirely plain, the latter more or less reddish at the base of the lower lobe. The ventral and anal fins are carnation, with pale base and margin. The pectoral fins are pale, with a faint tinge of red. In *autumn* the ground-colour is whiter, with hardly any brassy lustre, and the pigment of the scales lighter, sometimes imperceptible. The iris is silvery white, with a fine, brassy yellow ring round the pupil and a dark spot above the latter. The figure (Plate XXXII, fig. 1) represents a male assuming the spawning-dress, and is drawn from a specimen taken in the Baltic island-belt.

The young Ide (Plate XXXV, fig. 1), known in the islands round Mörkö as *idplugg* and *lannare*, in other localities as *idbarn*, *skall-id*, *gall-id*, etc., differs in several respects from the adult form. It is somewhat plumper in appearance. The head is larger in proportion to the length of the body. The dorsal margin and the occiput form an almost continuous curve. The snout is rather prominent, extending almost in front of the margin of the upper jaw (the intermaxillaries). The first simple ray in the dorsal and anal fins is generally imperceptible. The body is yellowish white, the back darker with bright greenish tinge, the occiput dark. The fins are light and somewhat reddish, especially the ventral and anal, which in front shade more or less distinctly into red.

The Gold Ide, LINNÆUS's *Cyprinus orfus*, a product of Central and Southern Germany and of Austria, is a variety often kept in ponds and aquaria.

The range of the Ide extends throughout all the countries of Central, Northern, and Eastern Europe as well as the west of Siberia[a]. In Great Britain and Ireland, in Switzerland and the countries bordering on the Mediterranean, and, according to GRIMM, in the Caucasus, the Ide is wanting. In France it is rare. In Sweden it is spread almost everywhere, from Tornea Lappmark to Scania. It is also common throughout Finland, and LILLJEBORG found it at Archangel; but in Norway Lake Mjösen, according to COLLETT is the northern limit of its extension. In Denmark the Ide, which is there called *Emd*, has been found only on the islands of Fünen and Zealand.

In Sweden the Ide occurs in all the great lakes and the waters connected with them or with the Baltic and the Sound. But it is not equally plentiful everywhere. In the Muonio Elf, which river, according to LÆSTADIUS and W. v. WRIGHT, the Ide ascends to Karesuando (68° 30′ N. lat.), it is somewhat rare. This seems to be the case wherever it occurs in Lappmark. In Jemtland it is common, according to OLSSON, at many places in the lowlands, but not in the highland lakes. The Ide is most plentiful in the eastern provinces of Central Sweden, especially to the lee of the island-belt and in the fresh water running seaward from the coast. Off Gothland it cannot be called rare, especially in the month of April, according to LINDSTRÖM, when Ide are taken in great numbers at the mouths of the rivers.

The favourite haunts of the Ide are large lakes and the inner part of the island-belt, where the water is not too salt. In small lakes it is less frequently met with. From these haunts, where it passes the winter in deep water, it ascends early in the spring, soon after the breaking up of the ice, towards the shore, and repairs to the mouths of the rivers and brooks where it intends to spawn. At this season it is known by the fishermen as the Ice-fish (*isfisk*).

The spawning generally takes place in Central Sweden about the end of April. The males, mustered in large shoals, lead the way to the spawning-place, which is chosen in very shallow rivers, brooks, and meres, often where narrow ditches are the only path open to them. During these migrations, which are often attended with the greatest difficulties, the Ide displays great strength, surmounting most of the obstacles to its progress, and skilful in avoiding the traps set in its way. Like the Salmon, it leaps with ease over stones, logs, and small cascades, and when the water grows so shallow that further advance seems impossible, to the surprise of the observer the fish turns on its side, and thus pursues its course. When such obstacles bar its progress, it pauses for a while, as though deliberating what path to adopt. Meanwhile several of its comrades have come up, and when one of the company has plucked up courage and darted ahead, the others at once follow

[a] According to PALLAS the Ide is common in Siberia east to Lake Baikal and the Lena; but whether his statement really applies to this species, is somewhat doubtful, as PALLAS refers the fish in question to BLOCH's Plate XXXVI in *Fische Deutschlands*. During NORDENSKIÖLD's expedition of 1876, however, an Ide 47 cm. long was taken by THÉEL and TRYBOM in the Yenisei off Geroschinskoje.

this example. Should one of them fail in its endeavour, it then awaits the arrival of a new company before renewing the attempt. In this manner the males press on as far as possible until they find a spot suitable for their object, weedy at the bottom and in shallow running water. Some days later, when the weather has become mild and fair, and the water has attained a temperature of about + 9° C. (48·2° Fahr.), the females reach the spawning-place in a similar manner, also collected in shoals, and join the males. The spawning now begins, being always accompanied with noisy tumult, and lasting about three days, night and day, unless interrupted by a cold north wind, rain, or storm, in which case it is postponed until finer weather sets in. The roe is deposited on twigs, the weeds at the bottom, stones, or some hard object, where it adheres firmly. The eggs are numerous[a] and, when deposited, about $1^1/_2$ mm. in diameter. When the spawning is over, the fish return by the same route, male and female now in company.

The ova are hatched in 14—30 days[b], according to the weather; and the young, says SUNDEVALL, are about $7^1/_2$ mm. long when excluded from the egg. In July, according to CEDERSTRÖM[c], when the fry are about 12—18 mm. long, they sometimes begin their journey to more open water; but they generally stay at the spawning-place, unless the water dries up, till the end of August, when they have attained a length of about 40—50 mm.[d] They now rove in vast, close-packed shoals to the shores of deeper water, where they remain some time among the reeds. But they seem soon to disperse and to lead a more solitary life. At first their growth is irregular and slow. In its second summer, however, at the age of a year and a half, the Ide measures about 80—115 mm. in length; at the age of two years, according to MAKLIN[e], its length is about 180 mm., and at that of three years 215—220 mm. According to SUNDEVALL's estimate the young Ide, about 175—220 mm. long, sometimes to be seen among larger Ide in the market-places of Stockholm, are three or four years old; and the species, he says, does not reach maturity, or a length of 3 dm., before the age of four or five years.

In summer the older Ide are found in deep water on stony shores shaded by trees, and in calm evenings rise in companies to the surface; while the young appear on fine and warm days at shallow, weedy places along the shore. Towards the end of autumn the Ide again resorts to the shallows, and often ascends the streams and brooks visited by it in the spring during the spawning-season. As soon as the lakes are frozen, it retires to its haunts in deep water.

The food of the Ide consists properly of plants, insects with their larvæ, and crustaceans. Instances are recorded, however, of its partiality to small fishes. The flesh is flabby and bony, but of far from unpleasant taste, and retains its flavour unimpaired for a considerable time. After somewhat elaborate preparation it is good eating. According to BLOCH it should be stewed in beer in the same way as Carp, or sent to table fried, with vinegar and salad-oil or a sauce of mustard, capers, and wine. It is also dressed in numerous ways, either salted or dried in the sun. When boiled, it acquires a reddish colour, which may be further heightened by allowing the fish for some time to lie in salt. It then resembles Salmon, and in many places is eaten without further preparation.

In a cauf the Ide may be kept alive for a long time, especially if set in clear water with a slow current. In most parts of Sweden it is known by its common name of *id;* but in the southern provinces it is called *ort* or *ört*, and on the coast of Lake Mälar, in the neighbourhood of Eskilstuna, it is honoured by the name of *karp*.

The most successful fisheries for Ide are those carried on at the spawning-place and along the course followed by the fish on its way thither. Traps (*ryssjor*, see p. 33, fig. 7) are set in the small streams and brooks which it passes, and also at the place where it spawns. They should be placed so as to close the passage entirely, for if any opening be left at the sides of the trap, the Ide avails itself of this way of escape.

[a] In a female weighing $1^1/_2$ lbs. BLOCH estimated the number of the eggs at 92,720; according to REUTER a middle-sized female lays about 70,000 eggs.

[b] Generally in 14—18 days, according to SUNDEVALL.

[c] Öfvers. Vet.-Akad. Förh. 1851, pp. 163 seqq.

[d] According to CEDERSTRÖM and SUNDEVALL the fry which they kept in a pond, had not attained a greater length than 20—28 mm. by the 10th of September.

[e] See REUTER, l. c.

Hand-nets (*haf*) are also used, between two weirs or dams built across the stream. The upper weir is kept shut, the lower being opened at intervals, until the fisherman sees that a sufficient number of fish have passed, when it is suddenly closed, and the fish are netted. The Ide is also taken in gill-nets, which are set in spring along its route to the spawning-place, and in autumn in shallow coves. They are seldom used in summer; but when this is done, they are shot in deep water off stony and shady shores. At these latter places the Ide is caught throughout the summer with the 'sinking rod' (*sänkspö*). The hook is baited with grasshoppers, the shelled tails of crayfish, worms, and, above all, beetles, the legs and wing-cases being first removed. The seine is employed, especially during spring, in shallow inlets near the spawning-place. In summer the Ide is seldom taken in the seine, and then by accident: it usually steals out of the sweep of the seine, and if no other course be open to it, turns on its side close to the bottom and lets the net pass over it. The use of the ice-seine (*eckelnot*) is confined to the island-belt, late in autumn, as soon as the ice on the shallow, innermost coves is strong enough to bear the fisherman's weight. This net is hauled close in shore, in very shallow water, where the Ide assemble before withdrawing to their winter-quarters in the depths. The Ide may also be speared by torchlight on dark and calm evenings in autumn. As it never keeps still, always moving about, considerable skill and practice are required to strike the fish. It is seldom and only by chance that the Ide is caught on pole lines (*stang-krok*) baited with small fish.

(EKSTRÖM, SMITT.)

THE CHUB (SW. FÄRNAN OR HARNACKAN).

LEUCISCUS CEPHALUS.

Plate XXXII, fig. 3.

Scales in the lateral line about 45 (44—46[a]). Branched rays in the dorsal fin 8[b]. Least depth of the peduncle of the tail more than 43 % (47 %) of its length at the middle, or about equal to the length of the base of the dorsal fin. Outer (lower posterior) margin of the anal fin convex. Pharyngeal teeth hooked at the tip, with sharp or worn, not very marked, and more or less distinctly granulated masticatory surface: 2, 5—5, 2.

Fig. 191. Pharyngeal bones and pharyngeal cartilage of *Leuciscus cephalus*, natural size, *a*, *b*, and *c* as in the preceding figure. *d*, the hindmost teeth seen from in front.

R. br. 3; *D.* $\frac{3}{(7)8^b}$; *A.* $\frac{3}{8-9^c}$; *P.* $\frac{1}{14-15^d}$; *V.* $\frac{2}{8^e}$; *C.* $x+1+17+1+x$; *L. lat.* 44—46[a]; *L. tr.* $\frac{7}{3}\text{—}\frac{8}{4}$ 1; *Vert.* 43[f]

[a] 42—46, according to GÜNTHER.
43—48, „ „ DAY.
39—45, „ „ STEINDACHNER.

[b] In exceptional cases 7.

[c] „ „ „ 7, according to HECKEL, see KRØYER.

[d] Sometimes 16, according to EKSTRÖM and KRØYER.

[e] In exceptional cases 10.

[f] 42, according to KRØYER; 43—45, according to FATIO.

Squ. Venet. et Rom., *Cavedano* Milan., BELON, *Nat., Divers. Poiss.*, p. 315. *Cephalus fluviatilis*,ROND., *De Pisc.*, part. 2, p. 190. *Capito sive Cephalus*, WILLUGHB., *Hist. Pisc.*, p. 255; *Cyprinus* oblongus macrolepidotus, pinna ani ossiculorum undecim, ART., *Ichthyol.*, *Gen. Pisc.*, p. 5; *Syn. Pisc.*, p. 7; + (?) *Cyprinus* Albo italis dictus, *Syn.*, p. 13. *Nolldt* (err. pro *Nold-id.*), LIN., Act. Soc. Ups. 1744—50, p. 35, tab. III.

Cyprinus Cephalus, LIN. (p. p., nec *Cyprinus cylindricus*, *Mus. Ad. Fred.*), *Syst. Nat.*, ed. X, tom. I, p. 322; FLMNG (*Leuciscus*), *Brit. Anim.*, p. 187; EKSTR., v. WR. (*Cyprinus*), *Skand. Fisk.*, ed. I, p. 67, tab. XIII; KR. (*Leuciscus*), *Danm. Fisk.*, vol. III, p. 482; DYBOWSKI (*Squalius*), *Cypr. Livl.*, p. 119; SIEB., *Susswasserf. Mitteleur.*, p. 200; MGRN, *Finl. Fisk.*, p. 46; STEIND., Stzber. Akad. Wiss. Wien, Math. Naturw. Cl. LIV. I (1866), p. 262; BLANCH, *Poiss. d. eaux douces Fr.*, p. 392 (+ *Squ. meridionalis*, p. 396, + *Squ. clathratus*, p. 398); GTHR (*Leuciscus*), *Cat. Brit. Mus., Fish.*, vol. VII, p. 220; COLL., Forh. Vid. Selsk. Christ. 1874, Tillaegsh., p. 181; MALM, *Gbgs, Boh. Fn.*, p. 561; MOR. (*Squalius*), *Hist. Nat. Poiss. Fr.*, tom. III, p. 422; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 137; FATIO, *Fn. Vert. Suisse*, vol. IV, p. 557; MELA (*Leuciscus*), *Vert. Fenn.*, p. 325, tab. X; APOSTOL. (*Squalius*), *Pêch. Gr.*, p. 31; DAY (*Leuciscus*), *Fish. Gt. Brit., Irel.*, vol. II, p. 178, tab. CXXXII, fig. 1; MÖB., HCKE, *Fisch. Osts.* p. 110; GRIMM (*Squalius*), *Fish., Hunt Russ. Wat.*, p. 14.

Cyprinus Idus, BL. (syn. err.), *Fisch. Deutschl.*, part. I, p. 253, tab. XXXVI.

Cyprinus Dobula, RETZ. (syn. err.), *Fn. Suec. Lin.*, p. 356; CUV. (syn. err.), *Regn. Anim.*, ed. 1, tom. II, p. 195; NILSS., *Prodr. Ichth. Scand.*, p. 26; AGASS. (*Leuciscus*), Mém. Soc. Sc. Nat. Neuch., tom. I, p. 38; CUV., VAL., *Hist. Nat. Poiss.*, tom. XVII, p. 172 (+ *Leuc. Albiensis*, p. 194 + *Leuc. frigidus*, p. 234); KR., *Danm. Fisk.*, vol. III, p. 463; HCKL (*Squalius*), Stzber. Akad. Wiss. Wien, Math. Naturw. Cl. IX (1852), p. 80, tab. VIII. HCKL, KN., *Susswasserf. Oestr. Mon.*, p. 180 (+ *Squ. svallize*, p. 197 + *Squ. albus*, p. 198, vide CANESTRINI).

Cyprinus Jeses, DONOV. (syn. err.), *Brit. Fish.*, tab. CXV; JUR. (excl. syn.) Mém. Soc. Phys., Hist. Nat. Genève, tom. III, part. I, p. 207, tab. XI.

Leuciscus cavedanus + *L. tiberinus* (= *L. squalius*, VAL.) + *L. Pareti* + (?) *L. albus*, BONAP., *Iconogr. Fn. Ital.*, part. III (Pesci), tab. 112 et 113; vide CANESTRINI, Arch. Zool., Anat., Fisiol., vol. IV (1866), p. 103, et FATIO, l. c.

Leuciscus latifrons, NILSS., *Skand. Fn., Fisk.*, p. 309; WIDEGR. (*Cyprinus*), Landtbr. Akad. Tidskr. 1863, pp. 202 et 208; LILLJ. (*Leuciscus*), *Sv., Norg. Fn., Fisk.*, vol. III, p. 223.

Leuciscus cii, RICHARDS., Proc. Zool. Soc. 1856, p. 375.

The Club probably attains the same size as the Ide, and in Sweden seems to be the largest Leuciscine, though we do not possess such statements of its extraordinary size as those given in the description of the preceding species. EKSTRÖM's largest specimen was 5½ dm. long. Most Club taken during the spawning-season are of the same length as the Ide 3 or 4 dm., and weigh about 3—3½ kgm.[a]

The body is shallow and thicker than that of the Ide, and the back broader and more convex, sometimes with a slight depression in the median line near the occiput. The greatest depth of the body is at most about 26 % of its length, and the greatest thickness in adult specimens is distinctly more than half the depth, sometimes 60 % thereof. The least depth of the body measures in young Chub about 9 %, in old about 10—10½ % of its length. Seen in profile, the dorsal margin rises slowly (in old specimens in a scarcely perceptible curve) from the occiput to the beginning of the dorsal fin, where the body is deepest, and then slopes towards the caudal fin nearly in a straight line. The ventral profile forms a slight curve, almost without a break, from the chin to the vent.

The head, compared with the body, is somewhat longer than in an Ide of the same size, varying in Chub 16—42 cm. long between about 26 and 22 % of the length of the body. Above it is flat, with eyes comparatively wide apart, for the breadth of the interorbital space, compared with the length of the head, is indeed about equal to the corresponding measurement in the Ide, but compared, for example, with the base of the dorsal fin, distinctly greater, being as a rule greater than the length of this base, or at least more than 90 % thereof. The great breadth of the forehead is highly characteristic of the Chub at all ages, and in some localities has gained for this species the name of *Dick-Kopf*. The frontal line is almost straight, slightly steeper in its anterior part; and the snout is shallower (more pointed when seen from the sides) than in the Ide. The sides of the head are flattened and slope towards the snout, which, seen from above, is broad and more or less obtuse, but generally rather more pointed than in the Ide. In the other structural features of the head the Chub almost exactly resembles the Ide; but the mouth is somewhat larger, as may most readily be shown by a comparison of the length of the lower jaw with the suture between the operculum and suboperculum. The length of the latter is in the Ide at least 90 % (100—91 %, according to our measurements) of that of the lower jaw, but in the Chub at most 90 %

[a] According to DUHAMEL (*Traité des Pêches*, pt. II, p. 502) the Chub attains in the Moselle a weight of 10—12 lbs.; in the lakes of Upper Austria, according to HECKEL, it sometimes weighs 8 or 9 lbs. NORDMANN (*Demid. Voy. Russ. mer.*, p. 484) describes an Abkhasian variety (?) of this species that attains a length of 9½ dm.

(72—89 %, according to our measurements) of the same. The gill-rakers are short and scattered, their number in the outer row on the first branchial arch being about the same as in the Ide (9—11), most of them simple, but at least the middle ones in old specimens branched at the tip, as in the Ide. The pharyngeal teeth (5 large ones in the inner row, and 2, a little more than half as large, in the outer) are distinguished (fig. 191) for their strength, their sharp, hooked tip, and the tendency to pectination indicated by the small, terete protuberances on the masticatory surface. The pseudobranchiae are well-developed.

The dorsal fin, the position of which is such that the anterior margin lies in a line with the termination of the insertions of the ventral fins, is rather more than twice as high in front as behind, and its superior margin is truncate, slightly rounded. In old specimens its shape and backward direction are as represented in our figure; but in young Chub it is quite upright, with pointed front angle. It begins at a distance from the tip of the snout measuring about 48—50 % of the length of the body; its height is about 17—15 %, and the length of its base about 9 or 10 %, of the same. Thus its base is generally equal to or slightly less than the least depth of the body[a], a point which among our Cyprinines is especially characteristic of the Chub, though subject to exceptions, just as in young Ide the least depth of the body may exceptionally be equal to the length of the base of the dorsal fin. The structure of the anal fin is unparalleled among our Cyprinines, and thus affords a character excluding all possibility of confusion between the Chub and other species. In all the others there is a considerable difference in the height of the fin behind and in front, the last ray being often not half as long as the fourth or the longest anterior ray. But in the Chub the difference is not so great, the length of the last ray being at least about 56—60 % of that of the fourth. Nor is this all: the margin of this fin in the Chub is convex, when expanded, the middle rays too being comparatively longer than in the rest of our Cyprinines, sometimes, in old specimens, the longest in the whole fin. This is the case in our figure, and we will only add that the fin may be still more strongly expanded than it is there, and that the margin then forms a complete curve, the greater the older the fish. The anal fin begins at a distance from the tip of the snout measuring about 64—67 %, its length is about 8—11 %, and its height about 12 or 13 % (in exceptional cases 14 %), of the length of the body. The caudal fin resembles that of the Ide, but is generally not so deeply forked, its middle rays occupying between about 9 % and a little over 8 % of the length of the body, and measuring in young Chub about half or rather more than half, in old about 48 or 47 %, of the length of the longest caudal rays.

The pectoral and ventral fins resemble those of the Ide. The length of the former is about 17—16 % of the length of the body, that of the latter about 15—14 % (in the females exceptionally 13 %) of the same. The distance between the ventral fins and the tip of the snout is about 46 % (in exceptional cases 47 or 48 %) — 44 %, that between these fins and the pectorals (the preabdominal length) about 23—26 % (sometimes 27 %), and that between them and the beginning of the anal fin (the postabdominal length) about 19—22 %, of the length of the body.

The scales are comparatively large and thick, but otherwise resemble in form and texture those of the Ide. The lateral line, which first descends in a curve and then runs nearer to the belly than to the back, is generally covered by 45 scales, a number which in the Scandinavian Chub examined by us varies only between 44 and 46, in exceptional cases 47. According to other writers, however, the variation extends, as mentioned above, between 39 and 48. The lateral line is generally separated from the anterior part of the base of the dorsal fin by 7 rows of scales, and from the ventral fins by 4 rows.

Full-grown Chub display a handsome and varied coloration on a silvery gray ground, most like the colours of the Roach. The back is dark olive green, the scales are tipped with a metallic lustre. On the sides above the lateral line the bases of the scales are dark olive green, thus forming as it were dark frames within which their lustrous tips are still more prominent. Below the lateral line this dark setting fades and gradually disappears, the scales acquiring a more yellowish tinge, which grows more distinct on the belly. Behind the

[a] In 11 specimens 17—42 cm. long the average length of the base of the dorsal fin in % of the length of the body is 9·3, and the average for the least depth of the tail 9·4. In 5 specimens 37—89 mm. long, on the other hand, the corresponding averages are respectively 9·9 and 9·1, so that the character is not distinct until the fish has attained a length of about 1½ dm.

gill-opening the margin of the clavicle is dyed almost black, though this dark stripe is generally concealed by the broad rim of the branchiostegal membrane. The top of the head is dark olive brown, its sides and under surface have a silvery lustre, shading into yellow with a play of various colours. The iris is light yellow, below silvery, above marked with a dark band. The pectoral, dorsal, and caudal fins are nearly plain olive brown; the ventral and anal fins, on the other hand, of a beautiful, bright red colour, both with yellowish base, and the latter fin with rose-coloured rays. The coloration of the fins is, however, subject to variation. Our figure is coloured from a specimen taken shortly before the spawning-season. Younger Chub are paler in hue, with the inferior fins light and colourless.

In Scandinavia the range of the Chub is confined to the south of Sweden and the south-east of Norway. In Denmark the Chub has not been found. In Finland too it is a southern species, common, according to MELA, only to the extreme south. It is one of the rarest Scandinavian Cyprinoids, and in contradistinction to most of them, it is taken only in small numbers and never in any quantity, even during the spawning-season. RETZIUS knew that it occurred in the Nissa, a stream in Småland, where it was called *Bjelke*. Towards the mouth of this stream, near Halmstad, in Halland, it is often hooked, in company with the Ide, and is here known as *harnacka*. It bears the same name, according to LLOYD[a], at Falkenberg on the Ätra. To EKSTRÖM it was known from only three localities in Sweden, namely, Norrköping River, where the fishermen called it *Färna*, the River Gotha off Gothenburg, where it was entitled *Dick-kopp*, and Lake Hjelmar, with its affluent the Stor river, where the name of the species was *Årännaren*. But he remarked that its occurrence in waters so far apart showed that these could not be its only haunts in Sweden. It has subsequently been found by SCHAGERSTRÖM and others, according to LILLJEBORG, in the Helge in Scania; by MALM and others at a few places in Wester Gothland and Bohuslän, e. g. in Lake Stenstorp 20 miles east of Gothenburg, and in the Örekil at Krokstad and Qvistrum, where it is called *Åbuk*; by LLOYD and others in the south part of Lake Wener; and by HARDIN and WIDEGREN in the north of Lake Wener and in the Klar Elf. In Norway, according to COLLETT, the occurrence of the Chub is confined to Lake Mjösen, the south part of the Glommen with its tributaries, and the brackish water at the mouth of the Tistedal Elf off Fredrikshald. In Central and Southern Europe, on the other hand, the range of the Chub is very extensive, and in England, Scotland, and the countries bordering on the Mediterranean this species replaces the Ide. According to GRIMM the Chub occurs throughout Russia-in-Europe, with the exception of Transcaucasia. RICHARDSON described it (*Leuciscus Cii*) from Anatolia in Asia Minor. In mountainous regions, according to BENECKE[b], it ascends the rivers and brooks to a height of about 1,000 m. above the level of the sea.

In all these southern countries the Chub has long been better known than in Sweden. It has the reputation of a strong, but timid swimmer, eagerly hiding in the shade of any object or behind a stone, and is accused of comparatively great voracity, not only snapping up insects at the surface or such fruit as may fall into the water, but also preying on small fishes, frogs, and water-shrews. It possesses great cunning, and will not bite readily, if the line be visible. From its habit of frequenting the eddies below mill-wheels, it has received in France the name of *Meunier* (miller). According to information supplied to EKSTRÖM by Mr. LENNING and Dr. HANSSÉN of Norrköping and Mr. HAMNSTRÖM of Örebro, the Chub lives in Sweden during the greater part of the year in lakes and extensive pieces of water, but keeps to comparatively shallow places, where the bottom consists of mud or weeds. In the month of May it begins to ascend the river at Norrköping, and being a powerful swimmer, is met with where the current is strongest, endeavouring with all its might to stem the stream. About the end of June — in more southern countries in May or even April — the spawning-season begins, as shown by the presence, in specimens caught in the middle of June, of roe and milt ready to be deposited. But here as in the case of the other Cyprinoids, this season varies, no doubt, according to the state of the weather; and MALM quotes a statement to the effect that in the River Gotha the Chub spawns at the end of April. The fish assemble in large shoals, according to FATIO, with tumultuous uproar, not far from land and by preference

[a] *Scandinav. Adventures*, I, p. 64.
[b] *Handb. Fischz. und Fischerei* (MAX V. D. BORNE), p. 134.

in slowly running water. Here the eggs attach themselves to the gravel and stones. According to BENECKE each female deposits about 100,000 ova. In a Chub weighing 3 lbs. BLOCH found 67,600 yellowish eggs of the size of poppy seed.

Till the month of October the Chub stays in the rivers, and then returns to its winter-quarters.

In Norrköping River the Chub was taken, according to the authorities cited above, in strong nets stretched across the stream and in traps. As a rule, however, this fish is caught by angling, the bait consisting of a worm, the shelled tail of a crayfish, a fly, a caterpillar, a bit of cheese, or, we may almost say, any eatable substance, for the Chub is not hard to please, though the sight of the rod, the line, or the angler frightens it away in a moment[a]. The best time of day is the morning or evening, and in the lakes the fisherman should choose a stony bottom, in the rivers a rapid part or race.

The flesh of the Chub, though palatable and not unlike that of the 'Asp' (*Aspius rapax*), contains numerous loose bones, and is therefore not much esteemed.

(EKSTRÖM, SMITT.)

THE ROACH (SW. MORTEN).

LEUCISCUS RUTILUS.

Plate XXXIII, fig. 1.

Scales in the lateral line about 43 (40—46). Branched rays in the dorsal fin 9—11. Least depth of the peduncle of the tail more than 43 % of its length at the middle, but much less than the length of the base of the dorsal fin. Outer margin of the anal fin concave. Pharyngeal teeth hooked at the tip or blunt, with smooth masticatory surface, very faintly granulated, slightly pectinated, or worn into a single deep groove; set in one row: 6(5)—(5)6.

Fig. 192. Pharyngeal bones and pharyngeal cartilage of *Leuciscus rutilus*, natural size. *a*, *b*, and *c* as in the preceding figure.

R. br. 3; *D.* $\frac{3}{9-11}$; *A.* $\frac{3}{10^{b}-11}$; *P.* $\frac{1}{14-17}$; *V.* $\frac{2}{8}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* (40)43—46; *L. tr.* $\frac{8(7)}{4(3)}$1; *Vert.* 40[c]—42.

Syn. Leuciscus, RONDEL., *De Pisc.*, part. II, p. 131. *Rutilus* sive *Rubellus fluviatilis*, GESN., *Hist. Anim.*, lib. IV, p. 820. *Cyprinus* iride, pinnis ventralibus ac ani plerumque rubentibus, ART., *Ichthyolog.*, *Gen. Pisc.*, p. 3; *Syn. Pisc.*, p. 10; *Descr. Spec. Pisc.*, p. 10; *Cyprinus* pinnæ ani radiis duodecim rubicundis, LIN. *Fn. Suec.*, ed. I, p. 124. *Cyprinus Rutilus*, LIN., *Syst. Nat.*, ed. X, tom. I, p. 324; ÖDMANN, Vet.-Akad. Handl. 1782, p. 163; BL., *Fisch. Deutschl.*, part. I, p. 32, tab. 2; RETZ., *Fn. Suec.*, *Lin.*, p. 357; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 317; FLMNG (*Leuciscus*), *Brit. Anim.*, p. 188; EKSTR. (*Cyprinus*), Vet.-Akad. Handl. 1830, p. 153; NILSS., *Prodr. Ichthyol. Scand.*, p. 27; AGASS. (*Leuciscus rutilus* + *L. prasinus* + *L. decipiens*), Mem. Soc. Sc. Nat. Neuch., tom. I, p. 38; EKSTR., v. WR. (*Cyprinus*), *Skand. Fisk.*, ed. 1, p. 72, tab. 15; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, vol. XVII, p. 130 (+ *L. rutiloides* (ex SELYS), p. 149 + *L. prasinus* (ex AGASS.), p. 153 + *L. Selysii* (ex SELYS), p. 198); KR., *Dan. F. Fiske*,

[a] Cf. BLANCHÈRE, *Nouv. Dict. d. Pêches*, p. 174.

[b] Sometimes 9, according to MOREAU.

[c] Sometimes 39, according to FATIO, 44, according to ARTEDI.

vol. III, p. 435; NILSS., *Skand. Fn., Fisk.*, p. 316; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Sällsk. Handl., H. 6 (1855), pp. 81 et 174; Vet.-Akad. Handl. 1855, p. 13; HECKL, KN. (*Leuciscus*), *Süsswasserf. Oestr. Mon.*, p. 169 (+ *L. Pausingeri*, p. 172); DYB., *Cypr. Liv.*, p. 36; SIEB., *Süsswasserf. Mitteleur.*, p. 184; MGRN, *Finl. Fiskfn.*, p. 46; WIDEGR. (*Cyprinus*), Landtbr. Akad. Tidskr. 1863, pp. 201, 202, 207; LINDSTR. (*Leuciscus*), *Gotl. Fisk.*, Gotl. L. Hush. Årsber. 1866, p. 17 (sep.); BLANCH., *Poiss. d. eaux douces Fr.*, p. 382 (+ *Leuc. pallens*, p. 386); GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 212; COLL., Forh. Vid. Selsk. Christ. 1874, Tillægsh., p. 180; ibid. 1879, No. 1, p. 96; OLSS., Öfvers. Vet.-Akad. Förh. 1876, No. 3, p. 130; 1882, No. 10, p. 48; MALM, *Gbgs. Boh. Fn.*, p. 557; BNCKE, *Fisch., Fischer., Fischz., O., W. Preuss.*, p. 136; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 413; FATIO, *Fn. Vert. Suisse*, vol. IV, p. 479; MELA, *Vert. Fenn.*, p. 323, tab. X; GRIMM, *Fish., Hunt. Russ. Wat.*, p. 14; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 175, tab. CXXXII, fig. 2; MOB., HCKE, *Fisch. Osts.*, p. 111; REUT., SUNDM., *Finl. Fisk.*, tab. XI; LILLJ., *Sv., Norg. Fn., Fisk.*, vol. III, p. 189.

Leuciscus Heckelu, NORDM., *Voy. Russ. Mérid.* (DEMID.), tom. III, p. 491, tab. 23, fig. 1; vide GRIMM, l. c.

The Roach does not grow to any great size. Most of the specimens caught during the spawning-season are 15—20 cm. long, but many attain a length of 3 dm. The largest specimen in the Royal Museum is from Lake Wetter, and measured $3^1/_2$ dm. NILSSON once saw a Roach 371 mm. long[a]. At a length of 230—248 dm., according to FATIO, the Roach weighs 120—160 grammes[b].

The body is rather thick, but compressed, and generally thinner than that of the Ide. The greatest depth varies between about 24 and $28^1/_2$ % of the length of the body, the percentage being highest in old specimens and the females; while the greatest thickness usually measures only 36—41 % of this depth, though in gravid females it may rise to 54 % of the same. The back ascends without forming any abrupt curve from the occiput to the beginning of the dorsal fin, from which point it slopes almost in a straight line to the caudal fin. Throughout the greater part of its length it is convex, but a little in front of the dorsal fin more or less distinctly compressed or even carinated. In front the downward curve of the ventral margin is similar to the upward curve of the dorsal; but between the ventral fins and the anal aperture the belly is almost straight and slightly but distinctly carinated, and at the beginning of the anal fin it rises at an obtuse angle.

The head resembles in form that of the Ide, save that here the forehead is narrower[c] and straighter, and the snout more pointed, with a similar faint depression in front of the nostrils. The length of the head is also somewhat less, varying between about $21^1/_2$ and 20 % of that of the body. The mouth is still smaller than in the Ide, the length of the upper jaw from the tip of the snout being always less than that of the latter and varying with age[d] between about 27 and 24 or 25 % of the length of the head. The length of the lower jaw varies simultaneously between about 36 and 32 % of that of the head, and is always less than (about 95—84 % of) that of the suboperculum along the suture at the lower margin of the operculum. The longitudinal diameter of the eyes varies in the same specimens between about 27 and 18 % of the length of the head, or between about 75 and 48 % of the breadth of the interorbital space. The postorbital part of the head always measures somewhat less than half the entire length of the same, unless the rim of the branchiostegal membrane be taken into account, in which case it slightly exceeds half the said length. The position of the eyes is also such that the lower margin of the pupil touches the line from the middle of the caudal fin to the margin of the upper jaw. The nostrils resemble those of the Ide. The gill-openings are separated below, here as in the preceding forms, by the isthmus, which is rather narrow, and to which the branchiostegal membranes are united. The pseudobranchiæ are free and comparatively large in young Roach, in older specimens less distinct. The gill-rakers are short and scattered, numbering 10—14 in the outer row on the first branchial arch, 10 on the outer margin of the pharyngeal bones. In contradistinction to the three preceding species, the Roach (fig. 192) has only one row of teeth on each of the pharyngeals, generally 6 on the left and 5 on the right, though these numbers may vary, being sometimes only 5 on each side, sometimes 6. The first two teeth, here as in the preceding forms, are almost straight, blunt, conical, and without

[a] MÖBIUS and HEINCKE give 5 dm. as the maximum length of the Roach.

[b] According to ISAAK WALTON the Roach may attain a weight of 2 lbs. (907 grammes); and in 'The Field' (2 Nov., 1881) we read of a Roach weighing 3 lbs. $12^1/_2$ oz. (949 grammes), taken by Mr. STEAD in Bedfordshire.

[c] The breadth of the interorbital space is less than 38 % (35—37·8 %) of the length of the head, or than $^2/_3$ (52—64 %) of the length of the base of the dorsal fin.

[d] In our specimens, which are between 100 and 330 mm. long.

hooked tip, the others strongly curved at the tip, more or less compressed in a transverse direction (back and front), and before they are worn, more or less distinctly crenulated (pectinated), the hindmost tooth, which is the least worn, most distinctly. Sometimes only a trace of this crenulation remains, in the form of small protuberances on the masticatory surface, which is eventually hollowed into a smooth, simple furrow. A striking difference between the pharyngeals of the Roach and those of the preceding Leuciscines, and a point that calls to mind the Tench, is the prolongation common to the bases of the posterior teeth, the last two or three being set on a process jutting from the pharyngeal bone into the pharynx. The heart-shaped pharyngeal cartilage of the three preceding species is modified here, this organ being elongated into a tongue-like form, with the anterior (upper) end obtusely rounded, and the posterior, tapering extremity only slightly folded and elevated, scarcely marked off from the other part.

The dorsal fin, which is particularly remarkable for its height, is obliquely truncate at the margin, with pointed corners, especially behind. It begins at a distance from the tip of the snout that increases with age and measures about $44^{1}/_{2}$—$48^{1}/_{2}$ % of the length of the body, or half the length to the base of the caudal fin. This distance is on an average less than in any of the three preceding species. In this respect the Roach comes nearest to the Cyprinine group; and the other Leuciscines have evidently followed a special direction of development from that group, reaching different stages. The Dace has advanced furthest, as shown by the table given below[a]. The base of the dorsal fin measures about 14—12 %, its height about $20^{1}/_{2}$—17 %, of the length of the body. The anal fin, the distance between which and the tip of the snout is about 63—68 % of the length of the body, resembles in form that of the Ide. The length of its base is about 12—$10^{1}/_{2}$ %, its height about $13^{1}/_{2}$—$10^{1}/_{2}$ %, of the length of the body. The caudal fin is rather deeply forked, its middle rays occupying about 9—8 % of the length of the body and measuring about 36—40 % of that of the longest caudal rays.

The pectoral and ventral fins have the same form as in the Ide, but differ only slightly in length, that of the former varying between about 17 and $14^{1}/_{2}$ %, that of the latter between 17 and 14 %, of the length of the body. The distance between the ventral fins and the tip of the snout measures about 43—47 %, the preabdominal length about 22—25 %, and the postabdominal length about 20—22 %, of the length of the body.

The scales resemble those of the three preceding species, but are comparatively much larger than the Ide's, and as a rule larger even than the Chub's, a point which is shown by the above estimates of their number in the lateral line and in a transverse row between the dorsal and ventral fins. During the spawning-season they are destitute of the rim then present round the scales of the Ide, but are strewn in the male with the usual, pointed, verrucose tubercles.

The sexes are distinguished only by the more slender body of the male and the said spiniferous tubercles, which are scattered during the spawning-season on the skin of the head, the opercula, the scales covering the forepart of the body, and the first ray of the pectoral fins. According to a note on v. WRIGHT's original, our figure represents a male without this external sexual character.

The upper part of the head and back is of a dark, blackish green, which rapidly passes below into brighter green, and then gradually into the lustrous silvery gray of the sides, which at the middle are faintly tinged with bronze and towards the belly shade into yellow. Each of the scales is marked at the base with a greenish spot, darker on the uppermost scales, gradually fading and at last disappearing on the lower ones. In the lateral line the scales are furnished with two similar, but smaller spots, lying one on each side of the duct, which is yellowish. In some specimens the iris is of

[a]

[illegible]	*Leuciscus rutilus*		*Leuciscus cephalus*			*Leuciscus idus*		*Leuciscus grislagine*
	3 specimens 102—153 mm long	3 specimens 167—327 mm long	5 specimens 37—89 mm long	6 specimens 170—196 mm long	5 specimens 244—424 mm long	1 specimens 84—118 mm long	4 specimens 181—416 mm long	5 specimens 178—311 mm long
Length of the body expressed in millimetres	127	224.7	67.4	183.4	297.8	121	305	196.2
Distance between the dorsal fin and the tip of the snout in % of the length of the body	45.8	47.7	48.1	48.4	49.6	49.8	[illegible]	50.4

a handsome bright red, but this tint is not constant, seeming, on the contrary, to have some fixed relation to age, probably to the seasons, and above all to the nature of the water inhabited by the fish. In some of the great lakes, and also in the island-belt, the iris is usually pale orange, with a spot of darker red above the pupil. In young specimens it is very pale with a faint dash of red; but in old Roach that live in small lakes with thick water, the iris is often of so bright a red that it has given rise to the saying "*rödögd som en mört*" (red-eyed as a Roach). The dorsal and caudal fins are of a plain, light olive brown. The other fins are yellowish, more or less tinged with red, especially the ventral and anal, whose rays are of a still brighter red between the middle and the tip. The colour of the fins is, however, highly variable, and seems to be subject to the same influences as that of the eyes.

The geographical range of the Roach embraces the whole of Europe north of the Alps and the Pyrenees, except Ireland and the west and north of Norway. The species is extremely common, according to GRIMM, in the Sea of Azov and the Caspian Sea. It is also spread throughout Siberia, from the east of which region specimens were secured by HUMBOLDT and EHRENBERG. LILLJEBORG found it at Archangel, where it was also met with by Lieutenant SANDEBERG. Still it is wanting, according to REUTER, in the White Sea as well as in the Arctic Ocean. The Roach is one of the commonest and most plentiful fishes not only in the lakes, rivers, and streams of Sweden, from Torneå Lappmark to Scania, but also in the island-belt of the Baltic, as well as in the Gulfs of Bothnia and Finland. In Sweden its range is roughly co-extensive with that of the Perch, and it ascends high among the mountains. EKSTRÖM found the species in a small tarn on Akkalispudive, a mountain in Pitea Lappmark[a].

In summer the Roach frequents weedy shallows near shore. It passes the winter in deep water, but as soon as the great lakes are open in spring, it ascends in large shoals to the shores, where it spawns at the beginning of May. In their upward course the shoals are so distributed that the males lead the way, and consequently are the first to arrive at the spawning-place, being hence called *Ismört* (Ice Roach). The females, which are known as *Lekmört* (Spawning Roach) or *Löfmört* (Leaf Roach), arrive about a fortnight later. They now join the males and commence spawning among twigs and weeds, often "in water so shallow," says SUNDEVALL, "that it seems hardly sufficient to cover the spawning fish." The spawning lasts from 3 to 9 days, according to the weather. During the operation the fish pack themselves in a dense mass, and move towards the surface with such rapidity as to produce a quick hissing noise, interrupted and repeated at brief intervals. In Lakes Sommen and Wetter the older Roach often spawn, according to WIDEGREN, on a stony bottom some distance from land. The roe is fine, containing numerous eggs: in a gravid female 18 cm. long the eggs, when almost ripe, were about $1^{1}/_{2}$ mm. in diameter; and in a female 275 grammes in weight, with ovaries weighing 60 grammes, LUND[c] counted nearly 72,000 eggs. The ova are deposited on the twigs and the weeds at the bottom, "often so near the surface," says SUNDEVALL, "that they are now and then left dry, but are none the worse for this." They are hatched in 10—14 days. "The fry generally lie still at the bottom, resting on their side, or supported by and as it were suspended from plants, straws, and the like. Gradually they begin to move and to swim a little better, and after the yolk has disappeared, which apparently happens in 8—10 days, they keep swimming about in dense shoals among the reeds. At the age of two months they are 15—20 mm. long and fully developed in external form." (SUNDEV.). When three years old, they have attained a length of about 100—125[d] mm.

The Roach leads a sociable life, and roves along the shores all the summer in large and small troops. It seems as though companionship inspires it with confidence, for it is not very shy. It is indeed afraid of noise, but soon returns to the spot from which it has been frightened away. The composition of the water in which it lives, exercises great influence not only on its appearance, as we have mentioned above, but also on its flavour. When the Roach has its home in pure water, the flesh is white and free from taint: in fish

[a] In Switzerland, according to FATIO, the Roach in a natural state hardly ascends higher than the lakes about 700 metres above the level of the sea; but it has been planted there in lakes 1,160 metres above the same level.

[b] Also *Badfisk* (Bather), see LUND, Vet.-Akad. Handl. 1761, p. 186.

[c] L. c., p. 194.

[d] 135 mm., according to REUTER.

from impure and muddy water it turns red after boiling and acquires a strong, unpleasant taste of mud. On attaining a length of 20—25 cm. the Roach generally grows fat, and is then known as *Kartmort* or *Grytmört*. Its fatness depends, however, on the food-supply, which consists of vegetable substances, insects, larvae, and mollusks. It seldom lives long in a cauf, unless taken during the spawning-season.

The Roach is one of our most useful fishes, both as a welcome addition to the coarse fare of the poor[a], and as a valuable bait for larger and more esteemed fishes, in which respect it is inferior to none of our indigenous piscine forms. Though it is most often taken, in great or small numbers, with *seines* of several kinds, other tackle is also used, consisting of *traps*, which are set during the spawning-season in weirs (*verke*, see above, p. 32), or *Roach-nets*, which are employed either in summer, when they are shot off weedy shores, or during the spawning-season, round the weirs in which the traps are placed. At the latter season they may also be set round the reeds or beds of weeds where the Roach spawns, in which case the fish are driven towards the net with the *fork* (see above, p. 741, fig. 185). Lastly, the Roach is taken with rod and line, and bites during the whole summer. Winter-angling on the ice is practised only to procure Roach for bait. But few fish are caught in this manner.

The above characters seem quite sufficient to render the Roach easily recognisable; but both in form and coloration it sometimes varies beyond comprehension, and several nominal species have thus originated. FATIO has arranged these varieties in three groups: 1) *Leuciscus rutilus, var. elata*, with body of extraordinary depth, closely resembling that of the Rudd — to this group belong the *Leuciscus rutiloides* of SELYS-LONGCHAMPS[b] and NORDMANN'S (l. c.) *Leuciscus Heckelii*; 2) *L. rutilus, var. elongata*, with body extraordinarily elongated (shallow) and only slightly compressed, more like that of the Dace — comprising HECKEL'S *Leuciscus Selysii* and AGASSIZ' *L. prasinus*; and 3) *L. rutilus, var. crassa*, with body of extraordinary thickness, in appearance not unlike the Chub, but most nearly allied to the Italian *Leuciscus aula*. HECKEL found in Lake Egel (Upper Austria) a form which he called *Leuciscus Pausingeri*, with comparatively high dorsal and low anal fins. This form was again met with by MALM in Lake Bolmen (Sweden), and hence was named by him *Leuciscus rutilus, forma bolmensis*. FATIO discovered a remarkable malformation of the Roach in Lake Brunig, an Alpine lake now almost dry, and situated 1,460 m. above the level of the sea. Roach and Perch were introduced into this lake at about the middle of the last century. As the lake gradually dried up and shrank into a small, deep pool of very clear water, the Roach, which he never found to measure more than 16 cm., and whose eyes, as usual in fishes of stunted growth, were comparatively large, had suffered an albinotic change of colour. The back was pale green, the sides were pure silvery white, the fins almost colourless, but the eyes deep red. In most of them too — perhaps because they were compelled, like Bleak, to seek their food at the surface — the mouth was more oblique than usual, resembling that of the Rudd, with more projecting chin. In other localities, in Northern Germany (Danzig and the Frische Haff, according to SIEBOLD), in France (the Seille, a tributary of the Moselle), and in Switzerland (the Lake of Geneva), the said albinism has produced the *Gold Roach*, a form analogous to the *Gold Ide* already mentioned. To conclude, the sociable propensities of the Roach, in Sweden and in many other places, have induced it to join company with other Cyprinoids engaged in spawning. Hence hybrids — or at least forms reasonably capable of this interpretation — have been found between the Roach and the Rudd, Bleak, Bream, and White Bream.

(EKSTRÖM, SMITT.)

[a] The Roach is equally important in South-eastern Russia, where, according to GRIMM, three or four hundred millions are annually taken in the Caspian Sea, and about a hundred millions in the Black Sea with the Rivers Kuban and Don.

[b] *Faune Belge*, p. 212.

Genus SCARDINIUS.

Scales middle-sized. Lateral line complete. Lower jaw slightly projecting. Caudal lobes pointed. Length of the base of the anal fin more than 19 % of the distance between this fin and the tip of the snout. Distance between the dorsal fin and the tip of the snout less than 86 % of that between the anal fin and the same point.

In this genus we draw still nearer to the Abramidines, a circumstance most clearly shown by the elongation of the base of the anal fin, as remarked in the above diagnosis. In all our specimens of the preceding Leuciscines the base of the anal fin measured less than $^1/_8$ of the length of the body; henceforward it is always at least somewhat longer, except where cross-breeding impairs the natural form of the species. When BONAPARTE first established this genus (merely as a subgenus of *Leuciscus*[a]), adopting its title from the Italian name (*Scardola* or *Scardine*) of a species identified by CANESTRINI with the Rudd[b], he laid most stress on the deep form of the body, the position of the dorsal fin over the space between the ventral and anal fins, and the carination of the ventral margin between the last-mentioned fins, characters all of which we have seen indicated in the Roach. When HECKEL at a later period reformed the generic classification of the Cyprinoids, he characterized the genus *Scardinius*[c] chiefly by the pectination of the pharyngeal teeth as in the Bleaks; but we have also seen traces of this character in the Roach. The genus, as we understand it from our knowledge of a single species[d], comes so near *Leuciscus* that it can claim systematic recognition only as a remarkable stage of transition, in the external form to *Abramis*, and in the oblique mouth and the pectinated pharyngeal teeth to *Alburnus*.

[a] *Iconogr. Fn. Ital., Pesci*, in the description of *Leuciscus squalus*.

[b] To judge by the measurements given by CANESTRINI (Arch. Zool., Anat., Fisiol., vol. IV, p. 89) of the Italian *scardola*, these species seem, however, to be distinct.

[c] *Russeggers Reise*, II Th., p. 1037.

[d] All the five species established by BONAPARTE and HECKEL, which would otherwise belong to this genus, are combined into one species by CANESTRINI and FATIO; but it is quite possible that hybrid forms are thus contained within the limits of this species.

THE RUDD (SW. SARFVEN).

SCARDINIUS ERYTHROPHTHALMUS.

Plate XXXIII, fig. 2.

Scales in the lateral line about 42[a]. Dorsal fin situated over the space between the ventral and anal fins, and at a distance from the tip of the snout greater than half the length of the body. Ventral margin between the ventral fins and the anal aperture carinated. Pharyngeal teeth set in two rows, hooked at the tip, and pectinated: 3, 5—5, 3.

a b

Fig. 193. Pharyngeal bones and pharyngeal cartilage of *Scardinius erythrophthalmus*, natural size. *a*, *b*, and *c* as in the preceding figure.

R. br. 3; *D.* $\frac{3}{8-9^{b}}$; *A.* $\frac{3}{10-12^{c}}$; *P.* $\frac{1}{15-17}$; *V.* $\frac{2}{8^{d}}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 41—43[a]; *L. transv.* $\frac{7(8)}{(3)4}$ 1; *Vert.* 37—39.

Syn. Rootaug id est, *Erythrophthalmus* Germanis dictus, Bramis affinis. WILLUGHB., *Hist. Pisc.*, ed. RAII, p. 249. *Cyprinus* iride, pinnis omnibus, caudaque rubris, ART. *Ichthyol.*, *Gen. Pisc.*, p. 3; *Syn. Pisc.*, p. 4; *Spec. Pisc.*, p. 9. *Cyprinus* pinnae ani radiis quatuordecim, pinnis omnibus rubris, LIN., *Fn. Suec.*, ed. 1, p. 123.

Cyprinus Erythrophthalmus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 324; OSB., Vet.-Akad. Handl. 1771, p. 152, tab. IV, fig. 4; BL., *Fisch. Deutschl.*, part. I, p. 28, tab. 1; RETZ., *Fn. Suec. Lin.*, p. 358; DONOV., *Brit. Fish.*, tab. XL; ASCAN. (RATHKE), *Icon. Rer. Nat.*, cah. V, p. 4, tab. XLII; FLMNG (*Leuciscus*), *Brit. Anim.*, p. 188; EKSTR. (*Cyprinus*), Vet.-Akad. Handl. 1830, p. 162; NILSS., *Prodr. Ichthyol. Scand.*, p. 28; EKSTR., v. WR., *Skand. Fisk.*, ed. 1, p. 74, tab. 16; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, vol. XVII, p. 107; KR. *Danm. Fisk.*, vol. III, p. 421; NILSS., *Skand. Fn.*, *Fisk.*, p. 313; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Sällsk. Handl. 1855, pp. 81 et 174; HCKL, KN. (*Scardinius*), *Süsswasserf. Östr. Mon.*, p. 153 (+ *Scard. dergle*, p. 156 + (?) *Scard. scardafa* (ex BONAP.), p. 157 + (?) *Scard. plotizza* p. 159 + *Scard. macrophthalmus*, p. 160); DYB., *Cypr. Livl.*, p. 134; SIEB., *Süsswasserf. Mitteleur.*, p. 180; WIDEGR. (*Cyprinus*), Landtbr. Akad. Tidskr. 1863, p. 202; MGRN (*Scardinius*), *Finl. Fiskfn.*, p. 45; LINDSTR. (*Leuciscus*), *Gotl. Fisk.*, Gotl. L. Hush. Sällsk. Arsber. 1866, p. 17 (sep.); CANESTR. (*Scardinius*), Arch. Zool., Anat., Fisiol., vol. IV (1866), p. 89; BLANCH., *Poiss. d. eaux douces Fr.*, p. 377, GTHR (*Leuciscus*), *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 231; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 182; N. Mag. Naturv. Chrnia, Bd. 29 (1884), p. 111; MALM. *Gbgs. Boh. Fn.*, p. 563; FEDDERS. (*Scardinius*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 88; MOR. *Hist. Nat. Poiss. Fr.*, tom. III, p. 410; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 134; MELA (*Leuciscus*), *Vert. Fenn.*, p. 324, tab. X; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 183, tab. CXXXIII, fig. 2; FATIO (*Scardinius*), *Fn. Vert. Suisse*, vol. IV, p. 457; MÖB., HCKE (*Leuciscus*), *Fisch. Osts.*, p. 112; REUT., SUNDM., *Finl. Fisk.*, tab. II; LILLJ., *Sv.*, *Norg. Fn.*, *Fisk.*, vol. III, p. 233.

Cyprinus compressus, HOLLB., *Beskr. Boh. Fisk.*, II. III, p. 66 cum tab. (cfr EKSTR., Gbgs Vet., Vitt. Samh. Handl., N. Tidsf., II. 1 (1850), p. 24).

Cyprinus erythrops, PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 317.

The Rudd, which is usually of no considerable size, measuring in most cases 15—20 cm., seldom

[a] Sometimes 39, according to EKSTRÖM; sometimes 44 or even 45, according to MOREAU.

[b] Sometimes 10, according to FATIO.

[c] 11, according to KRØYER.

[d] Sometimes 7, according to FATIO.

30—36 cm., still attains a weight of about 1 kgm.[a] In external form it seems to occupy an intermediate position between the Leuciscines and the Crucian Carp, which it so closely resembles in this respect that in some localities it bears the name of *Sjöruda* (Lake Crucian Carp). In Halland and Blekinge it is also called *Ruda* (*Rua*), and on the Scanian coast of the Sound it is known by its Danish name of *Rudskalle* (Dan. *skalle*, Roach). The body is deeper and, in proportion to the depth, more compressed than in the preceding Leuciscines, the greatest depth being about $^1/_3$[b] of the length to the middle of the caudal fin in young specimens, in old somewhat less than $^2/_5$[c] of the same. In this respect, however, the Rudd undergoes a change of growth which during youth ranges it close beside the Roach in a more developed state[d]. The greatest thickness is about 32—42 % of the greatest depth. The least depth of the peduncle of the tail measures about $^1/_{10}$ (8—11 %) of the length of the body. The back rises somewhat abruptly from the occiput, forming a regular curve to the beginning of the dorsal fin, where it bends at an obtuse angle, and then descends in an elongated S-shaped curve, or sometimes almost in a straight line, towards the base of the caudal fin. It is convex throughout the greater part of its length, but in front of the dorsal fin compressed at the margin, as in the Roach. The belly is rather strongly compressed, but flat to the ventral fins, then carinated to the anal aperture. It runs in an unbroken curve from the chin to the vent, where it forms an angular bend, and then rises almost in a straight line to the peduncle of the tail.

The head is of moderate size, measuring about $^1/_5$ of the length of the body[e], and compressed, with broad and almost straight forehead[f] and small, blunt, flattened snout[g]. The mouth is small[h] and turned upwards, the lower jaw being somewhat longer than the upper, so that the tip of the chin is the most prominent point. The eyes are somewhat larger than in the Roach, their longitudinal diameter measuring in middle-sized Rudd about 23 %[i] of the length of the head. Their position is such that the line from the middle of the caudal fin to the margin of the upper jaw cuts the centre of the pupil; and in adult specimens the postorbital length of the head is equal to or a little greater than half the entire length thereof, but in the fry sometimes only about 43 % of the same. The nostrils are similar to those of the Roach. The gill-rakers also resemble those of the Roach; but the pharyngeal teeth (fig. 193) are set in two rows, 5 in the inner and 3 in the outer, their masticatory surface is coursed by transverse grooves on the sides and granulated (pectinated) at the margin, and the pharyngeal cartilage is furnished on the sides with oblique, transverse grooves.

The dorsal fin occupies the same backward position as in the Minnow, the Owsianka, the 'Asp', and some specimens of the Dace, lying opposite, not to the ventral fins, as in the other Leuciscines, but to the space between the ventral and anal fins, as in the Abramidines. It begins at a distance from the tip of the snout measuring about 52—56 % of the length of the body; and the distance between the ventral fins and the same point is only about 79 % (78 %)—84 % (85 %) of the former distance. The form of the fin, on the other hand, is the same as in the rest of our Leuciscines, the length of its base measuring about 11—13 % ($13^1/_2$ %), and its height about 20—17 %, of the length of the body. The anal fin is distinguished

[a] According to the reports sent in to the Swedish Fisheries Committee of 1881—83 the Rudd(?) may attain a length of $1^1/_2$ Sw. feet (45 cm.) and a weight of 4 Sw. pounds (1,700 grammes). DAY tells us of a specimen from Norfolk 3 lbs. 1 oz. (1,389 grammes) in weight. According to FATIO the Rudd weighs at a length of $15^1/_2$ cm. 45 grammes, at a length of 266 mm. 230 grammes, and at a length of 3 dm. more than $^1/_2$ kilo.

[b] 26—36 %.

[c] 36—$39^1/_2$ %, according to our measurements.

[d] In a Roach 167 mm. long the greatest depth was 26·3 %, and the greatest thickness 10·8 %, of the length of the body. In a Rudd $63^1/_2$ mm. long these percentages were respectively 26·8 and 11·0.

[e] About 23—20 % (19·8 %) of the length of the body in Rudd 63—277 mm. long.

[f] The breadth of the interorbital space increases with age in the specimens just mentioned from about 40 to 47 % of the length of the head.

[g] In the same specimens the length of the snout varies individually, though generally increasing, from about 28 % (in exceptional cases 26 %) to $33^1/_2$ % of that of the head.

[h] The length of the upper jaw from the middle of the tip of the snout varies in the same specimens between about 28 % (exceptionally 27 %) and 32 % of that of the head, and the length of the lower jaw between 39 and 36 % (34 %) of the same, being in young specimens often equal to, in old always less than, that of the suboperculum.

[i] In our smallest specimen, 63 mm. long, the longitudinal diameter of the eye measures 32 % of the length of the head, in our argest specimen, 277 mm. long, 21 % of the same.

by its great length, its base measuring about 13—$15\frac{1}{2}$ % of the length of the body, its height about 16 % (sometimes 17 %)—$13\frac{1}{2}$ % of the same. It begins at a distance from the tip of the snout measuring about 59—66 % (in exceptional cases 69 %) of the length of the body. The caudal fin is similar to that of the Roach, its middle rays occupying about $11\frac{1}{2}$—$7\frac{1}{2}$ % of the length of the body, and measuring in our youngest specimen about 53 %, in the oldest ones about 40—36 % of that of the longest caudal rays.

The pectoral and ventral fins resemble in form those of the Roach, but the former are always perceptibly longer than the latter, the length of the former being about 20—18 %, of the latter about 18—16 %, of that of the body. The distance between the ventral fins and the tip of the snout measures about 43 ($42\frac{1}{2}$) —46 %, the preabdominal length about 22—25 (25·8) %, and the postabdominal length about 19—25 (27) %, of the length of the body.

The scales are also of the same type as in the Roach, but larger and coarser, more distinctly striated, and still more closely imbricated.

To the external sexual characters the same remarks apply as in the case of the Roach.

In coloration the Rudd is one of the most handsome Leuciscines. The sides are of a silvery lustre, strongly tinged with golden yellow, a bright play of colours being thus produced. The back is dark greenish, gradually passing first into greenish yellow and then into the colour of the sides. The iris is golden yellow, shading more or less distinctly into red. The dorsal and caudal fins are of a light olive green, tipped more or less distinctly with red, especially the latter. The pectoral fins are light and transparent, with reddish tip. The ventral and anal fins, grayish yellow at the base, are of a bright red hue, of varying intensity and distribution in different specimens. In young specimens, as usual, the colours are less rich.

The range of the Rudd extends throughout Europe, except the Iberian Peninsula, and also to Asia Minor and the interior of Siberia, where HUMBOLDT and EHRENBERG traced it to the Obi and Tobolsk. But both in Siberia and Europe the species is wanting in the extreme north. In Finland, according to MELA, it penetrates to lat. 63° 20′ N. How far north the Rudd is found in Sweden, has not yet been ascertained; but there are no positive instances of its occurrence in Westernorrland, Jemtland, or Westerbotten, though EKSTRÖM was told that it occurred still farther north, in the Kalix Elf. Of its extension in Norway RATHKE states (in ASCANIUS) that it is taken in several of the Norwegian lakes, among others in Mjösen and Öjeren; but according to COLLETT its occurrence is confined to the south-east of the country, and its range scarcely extends north of Christiania (60° N. lat.). In Ireland the Rudd and the Minnow are the only indigenous Cyprinines known.

In Southern and Central Sweden the Rudd is met with in most of the lakes and rivers, as well as in the Baltic island-belt, but nowhere in any great abundance. It is known in different localities by different names, most often by those of *Sarf*[a] or *Sarfvel*, sometimes *Rödfena* (Red-fin) or *Rödmört* (Red Roach). Its favourite haunts lie in thick and weedy water. In spring and summer it frequents shallow, swampy coves with weedy or muddy bottom. In winter, like the other Cyprinoids, it withdraws to deep water.

The Rudd is not very active, and makes long sojourns at its chosen haunts. Except on very warm and fine summer days, it seldom rises in the water, but lies at the bottom, buried in weeds and mud. It is more cautious than timid, for though afraid of noise, it does not retire to any distance, but hides, when frightened, in the ooze and weeds, whence no din can dislodge it. Being a greedy eater, and living on plants, insects, worms, and mud, it indeed becomes fat towards autumn, but in the Swedish lakes never attains any considerable size. It is very sociable and cannot endure solitude, intruding itself, when it cannot find any large company of its own species, on the society of other fishes, generally those of the preceding genus, especially during their spawning festivities. Hence the origin of the Swedish proverb: *Sarfven i hvar lek*[b]. From this habit, and from the fact that large shoals are seldom found breeding at the same place, it has been supposed that the Rudd holds no spawning assemblies of its own. This opinion is, however, groundless.

The spawning-season of the Rudd occurs in Central Sweden at the end of May or beginning of June, in

[a] In Finland *Sorva*, in Norway *Sørv* or *Flasroye* (RATHKE).

[b] Lit. "the Rudd at every spawning," i. e. a finger in every pie.

more southern countries earlier, sometimes even in April. The males and females then join company and gather in shallow, weedy inlets, where the spawning takes place, accompanied by a babbling or smacking noise. This sound is produced by the fish putting their snouts to the surface, opening the mouth, and emitting an air-bubble, which floats on the water and bursts. The roe is deposited on the weeds, and is hatched in 8—10 days, the length of time required depending on the weather. In a female weighing 293 grammes BLOCH estimated the number of the eggs at 91,720.

The Rudd is used as food only by the poor. The flesh is flabby, bony, and always more or less tainted with mud. Furthermore, as the fish is hardly ever found, even during the spawning-season, in large shoals, it is only seldom that the fisherman pays any special attention to it. *Traps* (*ryssjor*, see p. 33, fig. 7) are set at the spawning-place, in which case care should be taken to lay them close to the bottom. *Wicker-baskets* (*mjardar*, see p. 32, fig. 6) may also be employed at the spawning-place, but are less useful. In the *trammel-net* the Rudd is taken all the summer on warm and fine days and at places thickly overgrown with weeds. The trammel should be shot among the weeds, for if it be set outside them, the Rudd refuses to be driven into the meshes. By *angling* it may also be caught throughout the summer, for it bites eagerly at a worm. It is almost always taken in company with other fishes.

The Rudd's fondness for joining, as an interloper, in the spawning of other fishes has produced several hybrids, one of which, JACKEL's[a] *Scardiniopsis anceps*, is a cross between this species and the preceding one. In this form the position of the dorsal fin is the same as in the Roach; but the size of the scales and the pectination of the pharyngeal teeth remind us of the the Rudd. The dorsal fin contains 10 branched rays, the anal 11 or 12. The number and distribution of the pharyngeal teeth vary, being, according to JACKEL, 5—5; 6—5, 1; 1, 5—5; or 1, 5—5, 2. This hybrid occurs in Bavaria, but has not yet been found in Sweden. Another hybrid form, a cross between the Rudd and the Bleak, is also unknown in Sweden; but a third, the result of cross-breeding between the Rudd and the White Bream, has been met with in this country, and a brief notice of this variety will be found below.

(EKSTRÖM, SMITT.)

GENUS **ASPIUS**[b].

Scales middle-sized. Lateral line complete. Lower jaw distinctly prominent, with the point fitting into an indentation in the tip of the snout. Caudal lobes pointed. Length of the base of the anal fin more than 19 % of the distance between this fin and the tip of the snout. Beginning of the dorsal fin situated in front of the middle of the body, and the distance between it and the tip of the snout less than 86 % of that between the anal fin and the same point.

Thus defined, the genus contains only one species[c], and is ranged by its flatly convex belly (only slightly carinated between the ventral and anal fins) beside the most typical Leuciscines, but owing to the comparatively great length of the anal fin forms a distinct link between the Leuciscines and the Abramidines. The character by which GÜNTHER distinguished this genus from *Alburnus*, the short and scattered gill-rakers, as well as the wide gape, is an expression of its more predatory nature, a point in which this genus is unequalled by any of our other Cyprinoids.

[a] *Die Fische Bayerns*, Abh. Zool. Miner. Ver. Regensburg, 9:tes Heft (1864), p. 64.

[b] AGASSIZ, Mém. Soc. Sc. Nat. Neuch., tom. I (1836), p. 38.

[c] The Syrian *Aspius vorax* (HECKEL, *Russegg. Reise*, Th. II, p. 1081, tab. X, fig. 3) has small scales and a short anal fin. The Chinese *Aspius spilurus* (GÜNTH., *Cat. Brit. Mus., Fish.*, vol. VII, p. 311) has large scales and an elongated body, more closely resembling *Alburnus*. KESSLER has described an *Aspius erythrostomus* from the Caspian and the Sea of Aral, and JACOWLEV an *Aspius hybridus* from the mouth of the Volga; but these forms are otherwise unknown to us.

THE ASP (SW. ASPEN).

ASPIUS RAPAX

Plate XXXVI, figs. 1 (♂) and 2 (♀)

Scales in the lateral line about 66 (62—73). Length of the lower jaw about $^{1}/_{10}$ (10 or 11 %) of that of the body, greater than the least depth of the tail, and at least $^{7}/_{10}$ (70—82 %) of the length of the base of the anal fin. Length of the upper jaw at least $^{1}/_{12}$ (9.3—8.3 %) of that of the body and greater than either the breadth of the interorbital space or the length of the suboperculum, which measurements are about equal to each other. Pharyngeal teeth set in two rows (3, 5—5, 3), hooked at the tip, with smooth, more or less sharp, and not very distinct masticatory surface.

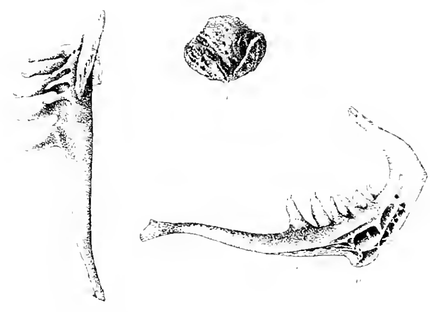


Fig. 194. Pharyngeal bones and pharyngeal cartilage of *Aspius rapax*, natural size. *a*, *b*, and *c* as in the preceding figure.

R. br. 3; *D.* $\frac{3}{7-8}$; *A.* $\frac{3}{(12)13-14(15)}$; *P.* $\frac{1}{16-17}$; *V.* $\frac{2}{8}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* (62)66—73; *L. tr.* $\frac{11-12}{(4)5-7}$ 1; *Vert.* 48—49.

Syn. *Capito fluviatilis rapax*, GESN., *Hist. Anim.*, lib. IV, Paralip., p. 9; SCHONEV., *Ichthyol. Slesv. Holst.*, p. 30; MARSIGL., *Danub. Pann. Mys.*, tom. IV, p. 20, tab. VII, fig. 2; *Cyprinus* magnus crassus argenteus; longitudine ad latitudinem quintupla, ART., *Ichthyol.*, *Syn. Pisc.*, p. 8. *Cyprinus* maxilla inferiore longiore cum apice elevato, pinna ani ossiculorum quindecim, ART., ibid., *Gen. Pisc.*, p. 6; *Syn. Pisc.*, p. 14; *Descr. Spec. Pisc.* p. 14; LIN., *Fn. Suec.*, ed. I, p. 121.

Cyprinus Aspius, LIN., *Syst. Nat.*, ed. X, tom. I, p. 325; BL., *Fisch. Deutschl.*, part. I, p. 48, tab. VII; RETZ., *Fn. Suec. Lin.*, p. 359; NILSS., *Prodr. Ichthyol. Scand.*, p. 28; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, tom. XVII, p. 265; NILSS. (*Abramis*), *Skand. Fn.*, *Fisk.*, p. 334; WIDEGR. (*Cyprinus*), Landtbr. Akad. Tidskr. 1863, p. 203; REUT., SUNDM. (*Aspius*), *Finl. Fisk.*, tab. XIX.

Cyprinus rapax, LESKE, *Ichthyol. Lips. spec.*, p. 56; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 311; AGASS. (*Aspius*), l. c.; KR., *Danm. Fiske*, vol. III, p. 500; HECKL., KN., *Süsswasserf. Östr. Mon.*, p. 142; DYBOWSKI, *Cypr. Livl.*, p. 173; SIEB., *Süsswasserf. Mitteleur.*, p. 169; MGRN, *Finl. Fiskfn.*, p. 44; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 310; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 184; 1879, No. 1, p. 96; BNCKE, *Fisch. Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 130; MOJS., HCKL, *Fisch. Osts.*, p. 120; LILLJ., *Sv.*, *Norg. Fn.*, *Fisk.*, vol. III, p. 261.

Aspius Linnei, MALM, *Gbgs. Boh. Fn.*, p. 567.

The Asp is the largest European Cyprinoid: and though it cannot rival the giants of the family in India, where *Catla Buchanani*, for example, may attain a length of at least 18 dm., still it sometimes reaches in Sweden, according to several corroborative statements[a], a weight of about 8 or 9 kgm. and a length of about 1 m. (9—12 dm.). Its ordinary size, as it is exposed for sale at Stockholm, is, however, about 4 or 5 dm., and its weight about 2 or 3 kgm. An Asp of 5 kgm., which may sometimes be seen, is about 8 dm. long. An Asp weighing 1 kgm. measures about 45 cm. to the end of the lower caudal lobe.

The body is rather elongated and compressed. In ordinary cases the greatest depth is less than $^{1}/_{4}$

[a] See *Und. Betänk. ang. Förbl. Fiskeristadgar* 1883, p. 154.

(varying between 23 and 25 %), and the greatest thickness at most about $^1/_9$ (varying between 8 and $11^1/_2$ %), of the length of the body to the end of the middle caudal rays; but in gravid females (see the figure) the former ratio may rise to $27^1/_2$ %. The least depth of the tail is about $^1/_{10}$ (varying between 9 and $10^1/_2$ %) of the length of the body.

The back is arched at the occiput, but elsewhere slopes almost in a straight line, both backwards and forwards from its apex at the beginning of the dorsal fin. Just in front of this fin it is very slightly compressed at the margin, but with this exception it is convex or even (behind the dorsal fin) flat. The belly descends from the chin in a regular curve, rather sharp in gravid females; and the ventral margin is broad and flatly convex, but furnished between the ventral fins and the anal aperture 1) in the median line with a distinct, but low carina, composed of curved scales of a special type, and 2) at the boundary between it and the sides with a similar carina, usually less prominent, but sometimes quite distinct, which runs back on each side from the outer angle of the insertion of the ventral fin.

The head is middle-sized, but laterally compressed, its length being in young specimens somewhat greater, in old less, than the greatest depth of the body, and varying between 24 and 22 % of the length of the latter. The cheeks are flat and perpendicular; the upper surface is straight and slightly convex or almost flat with a gentle slope in a forward direction; and the breadth of the interorbital space measures in young specimens 31 % of the length of the head, but rises in old to at least 35 % of the same. The eyes are set high on the sides of the head, and are comparatively small, being about equal in size to those of the Tench. They invariably lie in the anterior half of the head, for the postorbital length thereof measures in young specimens about 56 %, in old about 63 % of its entire length from the tip of the snout. In young specimens about 16 cm. long the length of the eyes, which is always somewhat greater than their vertical diameter, is about 21—20 % of that of the head. In specimens 18—22 cm. long this proportion has sunk to 18 or 17 %, and in specimens 44—66 cm. long the length of the eyes is only about $14—12^1/_2$ % of that of the head. The length of the snout, which is shallow and wedge-shaped, tapering to a sharp edge in front, measures about 28 % (27—29 %) of that of the head. The lines of the mouth are characterized principally by the sinus at the tip of the snout, into which the more or less knob-shaped point of the lower jaw fits when the mouth is closed. On each side of this sinus the labial margin forms a somewhat arcuate projection, thus giving to the margin of the upper jaw on each side the elongated S-shape pointed out by NILSSON. The lower jaw expands in a similar manner on the sides in front; and the fleshy lips, especially the lower, are tumid at the corners of the mouth. The intermaxillaries cannot be protruded beyond the tip of the snout; yet the gape is large in consequence of the length of the jaws, which is greater, compared with the size of the head, than in any other Scandinavian Cyprinoid[1], the length of the upper jaw from the tip of the snout being about 38 % (36—39 %) of that of the head, and the length of the lower jaw about 48 % (45—51 %) of the same. There is no free tongue; but the middle part of the hyoid apparatus in front (the glossohyoid region) is fleshy and soft. The nostrils are set on a level with the upper orbital margins, about twice as near to the eye as to the tip of the snout. The gill-openings are large, the broad branchiostegal membranes not coalescing with the isthmus until they reach the perpendicular from the hind margin of the eyes. Nine or ten short and scattered gill-rakers, compressed at the tip or with faint signs of digitation (cf. the Ide), compose the outer row on the front of the first branchial arch. The outer margin of the pharyngeals is furnished with 7 or 6 pointed and still shorter gill-rakers. The long pharyngeals (fig. 194) are armed, as mentioned above, with two rows of simple, but strong teeth, hooked at the tip. The pseudobranchiæ lie high on the inner surface of the hyomandibular bone, in the hollow on each side above the 'carp-tongue', and in some cases are therefore difficult of detection, though well-developed.

All the fins save, in some degree, the ventrals are distinguished by a more or less incised, pointed form. The dorsal fin begins at a distance from the tip of the snout measuring on an average $47^1/_2$ % ($46^1/_2—48^1/_2$ %) of the length of the body. Its base occupies about $^1/_{10}$ (9·3—11·1 %) of the same length, and its height is in young specimens about $18^1/_2$ %, in old about 16 %, of the same. The anal fin, which lies further back in the

[1] Compared with the length of the body, however, the jaws of the Goldfish are equally long.

females than in the males, begins at a distance from the tip of the snout measuring 62—67 % of the length of the body. The length of its base is about $13\frac{1}{2}$—$14\frac{1}{2}$ % of that of the body, and its height about 16—$13\frac{1}{2}$ % of the same, the base being as a rule in the young less than, in old specimens equal to or greater than, the height. The base is also as a rule about equal to the length of the ventral fins, which measures about 14 % of that of the body. The distance between the ventral fins and the tip of the snout is about 43—46 % of the length of the body, being greatest in the females, where the preabdominal length is thus about $^1/_4$ of the length of the body, while in the males it is only about $^2/_9$ thereof. The postabdominal length, which is also greater in the females, varies with age between about 20 and 23 % of the length of the body. The outer posterior corner of the ventral fins is indeed pointed, the second simple or the first branched ray being the longest; but the succeeding rays are only slightly shorter, and sometimes, especially in the young, the outer posterior margin of these fins, when expanded, is somewhat rounded. The pectoral fins are pointed, with a distinct contraction at the hind margin within the tip, calling to mind the genus *Pelecus;* their length is about 17 or 18 % of that of the body. The caudal fin with its pointed lobes, the lower somewhat longer than the upper, is deeply forked, the length of the middle rays being in young specimens about 9 %, in old about 7 or 6 %, of that of the body, or in the former about 38 %, in the latter about 31 %, of that of the longest caudal rays.

The scales are of moderate size and of the same type as in *Leuciscus* both in form and texture, save that the concentric striæ on the free (hind) part are more distinct, coarser, and more scattered; and as in *Leuciscus*, their nucleus is fairly central. Their number in an oblique transverse row between the ventral fins and the lateral line is 7; but on counting vertically upwards we find only 6 longitudinal rows[a].

The coloration as a whole conforms to the Leuciscine type, varying according to age, season, and environments. The colours of the young are lighter, of old specimens darker. The olive green back with its steely lustre passes towards the sides into a silvery or brassy hue, and the belly is white. Especially pretty is the brassy or golden and silvery lustre on the sides of the head, which are finely punctated with dark green. The iris is mostly silver white, but the pupil is encircled by an almost golden yellow (sometimes paler) ring, and the upper part of the iris displays a brassy tinge with a shading of dark dots. The dorsal and caudal fins are of the same colour as the back, though with a stronger dash of blue (violet) and red, and with dark margins. The other fins usually shade into red and yellow; but in the female our figure represents in her spawning-dress, they were darker. In this dress might also be traced — though they became more prominent under the action of the spirits in which the specimen was preserved — the 8 dark stripes along the sides above the lateral line, formed by a dark streak along the middle of each scale's free surface, and shown in the above-quoted figure by MARSIGLI.

The Asp belongs properly to South-eastern Europe, but is also common in the central parts of this continent. In Switzerland and Western Europe, even in Denmark, it is wanting. It is most frequently found, however, only in large lakes and rivers, but does not shun the brackish water on the coast, e. g. in the Haffs of Northern Germany and Lake Dassower (the mouth of the Trave). In Sweden its range is almost confined to the Mälar valley and the basin of Lake Wener. It also occurs, however, in the Dal Elf (at least in Lake By, a broad on this river in the south-east of Dalecarlia[b]), in the Em (Calmar), and, according to MALM[c], in the Helge (Christianstad). In Lake Wetter and the neighbouring waters it has never been found. That it also inhabits the Baltic island-belts, is more than probable, for the large female represented in our figure was taken at Sjötullen outside Stockholm. MÜLLER[d] assigned it to the Norwegian fauna under the name of *Blaa-spol;* but, according to COLLETT, the only Norwegian waters inhabited by this species are Lake Öjeren, from which it ascends in spring the Lersundselv and Nitelv, and that part of the Glommenelv which is below Lake Öjeren. In Finland the Asp is known with certainty only from the extreme south-west, but according

[a] Sometimes only 4, according to DYBOWSKI.

[b] According to information received from Dr. STEFFENBURG by LILLJEBORG. See also the above-cited report of the Swedish Fisheries Commission.

[c] See also RETZIUS, *Fn. Suec. Lin.*

[d] *Zool. Dan. Prodr.*, p. 51.

to MELA, occurs, though seldom, in the vicinity of Kuopio.

The Asp, as we have mentioned, is a fish of marked predatory habits, resorting to vegetable food only by accident, or when reduced by necessity. It is therefore lacking in the sociability of our other Cyprinoids, a feeling it evinces only in the spawning-season and perhaps during its winter sleep. "His name" (Germ. *Proppe*, Lat. *rapax*), writes GESNER, "is derived from his voracity, for he ranges the waters like a formidable pirate, to other fishes a no less dangerous, but rather a more destructive foe than the Sheatfish or the Pike. In headlong chase of his flying victims, which in terror leap on dry land, he sometimes runs ashore himself." Bleak and Smelt are its commonest prey; but it does not shrink from assailing larger fish or even water-rats, nor does it disdain smaller and lower animals, such as worms, mollusks, and the like. It is not very tenacious of life, dying soon on dry land. Its favourite haunts are clear lakes or gentle streams with clean, sandy or gravelly bottom. As long as the water is clear, it cunningly avoids all snares, and is difficult to take with net or seine; but a Minnow set on a trolling hook and cast enticingly before its nose is too tempting a bait to be resisted. When the water is thick, it may be more easily netted. Such are its habits in summer; but they assume a different aspect under the influence of sexual excitement.

The spawning-season of the Asp begins early in spring, soon after the breaking up of the ice, in Sweden in April or May. The males are then marked by the usual dermal eruption of small round tubercles on the head, the pectoral fins, and the dorsal scales back to the tail. The fish assemble in shoals, which ascend the rivers, or proceed to shallow parts of the lakes, where the roe is attached to stones or weeds, or simply deposited on the bottom. A middle-sized female contains, according to BENECKE, 80,000—100,000 eggs. The large gravid female of which we give a figure, measured 75 cm. from the tip of the snout to the end of the caudal lobes, and when taken off Stockholm on the 22nd of April, 1886, had nearly the whole of the abdominal cavity under the air-bladder and forward to the diaphragm filled by the two ovaries with their three or four lobes. The eggs were about $1^{2}/_{3}$ mm. in diameter, and their number was computed to be about 300,000. Of the growth of the fry NORBÄCK states[a] that during the first year they attain a length of 9 cm., and LILLJEBORG assumes specimens 15 cm. long, taken at the beginning of May, to be one year old.

The flesh of the Asp is white and fat, but bony and difficult of digestion. It shows a tendency in process of boiling to separate into flakes (the muscular sections, *myomeres*), which may be obviated, however, by putting it on the fire in cold water. Large and fleshy as the fish is, it is one of the most important Cyprinoids, and the head is considered a delicacy by many. Except during the spawning-season, however, no large catches of Asp are made in Sweden. Solitary specimens appear in the fishmarkets of Stockholm about Christmas; but the true season for Asp is from February to June. The Asp is taken chiefly in nets or traps. Still it affords good sport to the angler, who should prefer a bait of live fish, though worms may also be used.

GENUS LEUCASPIUS[b].

Scales middle-sized and deciduous. Lateral line incomplete. Lower jaw distinctly projecting, with the point fitting into a shallow indentation at the tip of the snout. Lobes of the caudal fin pointed. Length of the base of the anal fin more than 19 % of the distance between this fin and the tip of the snout, and more than $1^{1}/_{2}$ times the least depth of the tail. Beginning of the dorsal fin situated at the middle of the body or farther back, and the distance between it and the tip of the snout more than 86 % of that between the anal fin and the same point.

An intermediate form between *Aspius* and *Alburnus*, *Leucaspius* is nearly allied to the following subfamily. One of the most unmistakable signs of this is the relative position of the dorsal fin to the anal. In none of the preceding Leuciscines — except in young males of *Phoxinus* — have we found the distance between

[a] *Handl. Fisker., Fiskafe.*, p. 439.
[b] HECKEL, KN., l. c., p. 145.

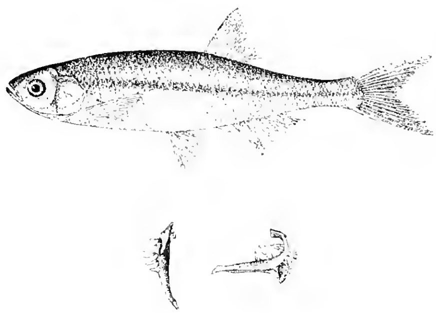
the dorsal fin and the tip of the snout to measure more than 86 % of that between the anal fin and the same point, as is generally the case in the Bleak, Bream, White Bream, and "Ziege". The fry of the Rudd and a few males of the same species, however, approach the line of demarcation very closely; but *Leucaspius* is easily distinguished from all the Leuciscines that have scales of moderate or some considerable size, by its incomplete lateral line, which seldom extends behind the tip of the pectoral fins. Only one species of the genus is known.

THE OWSIANKA (SW. GROPLÖJAN[a]).

LEUCASPIUS DELINEATUS.

Fig. 195.

Coloration silvery like that of the Bleak, with a steel-blue band along the sides of the body. Pharyngeal teeth slender, hooked at the tip, pectinated, and set in one or two rows: 5—4(5) or 4(2). 5—4. 4(2).



a b

Fig. 195. *Leucaspius delineatus*, natural size, taken at Landskrona on the 4th August, 1871 by LILLJEBORG, together with the left pharyngeals magn. 5 diam. *a* and *b* as in the preceding figure.

R. br. 3; *D.* $\frac{3}{8}$; *A.* $\frac{3}{11—13}$[b]; *P.* $\frac{1}{12\ \ 14}$; *V.* $\frac{1(2)}{7—8}$; *C.* $x + 1 + (16)17 + 1 + x$; *L. lat. squ.* 44—50 (7—13 perfor.); *L. tr.* 12 13; *Vert.* 36[c].

Syn. *Aphya (Mutterlosecken)*, SCHONEV., *Ichthyol. Slesv. Holst.*, p. 16.
Squalius delineatus, HCKL, *Russeggers Reisen*, vol. I, pt. 2, p. 1041; HCKL, KN., *Susswasserf. Östr. Mon.*, p. 193; SIEB. (*Leucaspius*), *Susswasserf. Mitteleur.*, p. 171; GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 319; LILLJ., Öfvers. Vet.-Akad. Förh. 1871, p. 815, tab XVII, A; MALM, *Gbgs, Boh. Fn.*, p. 568, not.; FEDDERS., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 90; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 131.
Leuciscus stymphalicus, CUV., VAL., *Hist. Nat. Poiss.*, vol. XVII, p. 295, tab. 498.
Aspius owsianka, CZERNAY, *Bull. Soc. Natur. Mosc.*, tom. XXIV, part. 1, p. 281, tab. VII; pt. 2, p. 259; MASLOW., ibid., tom. XXVII, pt. 1, p. 442.
Leucaspius abruptus, HCKL, KN., l. c., p. 145; DYB., *Cypr. Liel.*, p. 147 + *Owsianka Czernayi*, ibid. et p. 140.

The Owsianka is one of the smallest Cyprinoids. Its usual length is about 6—8 cm., measured to the tip of the caudal lobes, the former in the males, the latter in the females. Sometimes, however, according to BENECKE, it may attain a length of 12 cm. Its size is thus equal as a rule to that of the Minnow, but the form of its body is quite different, being more compressed, like that of the Bleak, which it also resembles in coloration.

The body is well proportioned, with regular dorsal and ventral curves, the latter being the sharper. The greatest depth of the body is about 20—22 % of its

[a] LILLJEBORG, l. c.
[b] Sometimes 14, according to DYBOWSKI.
[c] According to MASLOWSKY.

length to the end of the middle caudal rays, and the greatest thickness is about half the greatest depth. The least depth is about 8 % (7·8—8·2 %) of the length. The back is broad and convex, the belly more compressed, forming between the ventral fins and the anal aperture a sharp carina, covered with a row of curved scales.

The length of the head is about 23—21 % of that of the body. It is apparently a general rule that in the young and the males the length of the head is greater, in adult females less, than the greatest depth of the body. In form the head is almost exactly similar to that of the Bleak, but in old specimens its upper surface, along the middle of the forehead and the crown, is depressed and plane. The eyes are vertically set, rather large, and situated almost entirely in the anterior half of the head, the postorbital part measuring about 43 or 44 % of the entire length of the head. In specimens 5—8 cm. long the longitudinal diameter of the eyes, which is slightly greater than or equal to the vertical diameter, measures about 33—31 % of the length of the head, and is always perceptibly greater than the length of the snout. The tip of the snout is sharp (shallow), but broad (truncate), with a shallow sinus to receive the point of the lower jaw. The cleft of the mouth is turned sharply upwards and rather large; but in consequence of its obliquity the hind extremity of the maxillaries scarcely extends, when the mouth is closed, to the perpendicular from the anterior margin of the eyes. The lips are thin. The length of the upper jaw from the middle of the tip of the snout is about 7 % (6·6—7·2 %) of that of the body, or about 30 % (29·2—32·2 %) of that of the head. The length of the lower jaw, which is generally about equal both to the breadth of the interorbital space and the length of the suture between the suboperculum and the operculum, measures about $8^2/_3$ % (8·5—8·7 %) of the length of the body, or about $38^1/_2$ % (37·5—40 %) of that of the head. The nostrils lie rather near the upper anterior corner of the orbits. The gill-openings are fairly large, the branchiostegal membranes coalescing with the isthmus in about a line with the hind margin of the preoperculum. The outer row on the front of the first branchial arch contains 11—13 pointed gill-rakers, small and close-set below, larger and more scattered above. The pharyngeal teeth are slender and almost straight, with hooked tip and pectinated masticatory surface. They are sometimes set, according to Heckel, Maslowsky, and Siebold, in two rows; but in all the specimens examined by us they formed a single row. The pharyngeal cartilage is elliptical, but its hind (lower) extremity is raised, as in the preceding Leuciscines, in an inverted canaliculate form.

The fins are of the normal Leuciscine type. The dorsal fin begins at a distance from the tip of the snout measuring about half (49—52 %) of the length of the body. The length of its base is about $^1/_9$ (12—11 %), and its height about $^1/_7$ (16—$13^3/_4$ %), of the same length. The anal fin is perceptibly longer and, especially in old specimens, lower, and begins further back in the females than in the males. The distance between it and the tip of the snout measures in the males about 55 or 56 %, in the females about $57^1/_2$—$59^1/_2$ %, of the length of the body. Its base is about 16—14 % (in exceptional cases 13 %), and its height in young specimens about 14 %, in old 13—12 %, of the same length. Its length marks the approximation to the Abramidines, for whereas in all the preceding Cyprinoids the least depth of the tail is more than $^2/_3$ of the length of the base of the anal fin — though exceptions may occur among young Minnows — in *Leucaspius delineatus* the said ratio is less than $^2/_3$ (about 50—61 %). The caudal fin undergoes a similar change of growth, the length of the middle caudal rays being in young specimens about 12 %, in old about 10—$9^1/_2$ %, of that of the body. The longest caudal rays (in the inferior lobe) measure about 22 or 23 % of the length of the body. This fin is also subject to individual variation, an exceptional circumstance among the Cyprinoids, the number of the branched rays being either 16 or 17. The pectoral fins are obliquely pointed and comparatively short (16 or 15 % of the length of the body). The ventral fins are almost triangular, and their length is about 14 or 13 % (in exceptional cases 11 %), of that of the body. The distance between the ventral fins and the tip of the snout measures about 41—45 %, the preabdominal length about 20—$22^1/_2$ %, and the postabdominal length about 14 or 15 % (♂)—17 or 18 % (♀), of the length of the body.

The anal aperture calls to mind the corresponding organ in the Minnow and the 'Bitterling' (see above). It is more prominent and tubiform than in the Minnow, especially in the females, and is furnished on each side with an oblong, compressed papilla.

The scales are thin, deciduous, and rather large, their number in an oblique transverse row above the ventral fins being only 11—13. In form and structure they show most resemblance to those of the common Bleak, being deeper than long (of broad elliptical shape, with longitudinal axis set across the body), with few and indistinct radiating grooves, and with the nucleus nearer to the anterior margin than to the posterior. In young specimens only few scales (3—4 or even none) are pierced by the lateral line as it descends in a curve from the temporal region, while in old specimens this number is generally between 7 and 13.

The coloration too is mainly that of *Alburnus*. The dorsal side is olive green, more or less dark (brownish). The sides of the body are of a silvery lustre, with a steel-blue band, over which the silvery lustre extends, from the upper part of the gill-openings to the middle of the base of the caudal fin, towards which point it grows more distinct. The scales are dotted with brown, especially on the upper part of the sides in front. The fins are transparent and almost colourless, the dorsal and anal shading into grayish green, the pectorals into grayish white, the ventrals and anal into faint yellow.

The Owsianka, as we have mentioned, is one of LILLJEBORG's discoveries in the Scandinavian fauna. In 1871 his attention was directed by Mr. AHLBOM, late Collector in the Customs' Department, to a "variety of Bleak" that inhabited a small, but deep pond with peaty bottom, in a field near Landskrona. The fish would occasionally seem to have vanished from the pool, but usually re-appeared in great numbers during the spring, in the month of May. LILLJEBORG recognised this Bleak as *Leucaspius* (*Squalius*) *delineatus*, a form described first by HECKEL; and since then it has been met with in many other peat-haggs in Southern Scania between Landskrona and Ystad. But in Sweden, as in its true habitat, the species has been found in running water, even before LILLJEBORG's discovery, though it was not correctly determined until then. MALM states in *Gbgs. Boh. Fn.* that in September, 1868 he found it in the Kjeflinge near the railway-station of Örtofta, where it kept to shallow water near the grassy bank of the river; and according to TRYBOM it occurs both in broads along the course of the same stream and in Lake Vomb, the waters of which are discharged by this river, being so plentiful that it is often used as bait. In Denmark FIEDLER and FEDDERSEN have taken the species in small pools on the island of Zealand.

In Germany, as SIEBOLD has pointed out, the Owsianka has long been known under the names of *Mutterlosecken* (motherless), *Moderliesken*, etc. Its sudden appearance in peat-haggs and other small collections of water, which excited AHLBOM's attention in Sweden, had given rise in SCHONEVELDE's time to the belief that it came into being without parents (*aphya*). In Germany too it has been found both in peat-haggs and small streams. BLASIUS met with numerous specimens at Brunswick; BENECKE states that it occurs in the Kurische Haff. The French Expedition to the Morea found the species in Lake Zaraco, the famed Stymphalian Lake of Greek mythology. It seems to be most common, however, in Southern Russia, where it bears the name of *owsianka*, and according to CZERNAY, is used as food, in spite of its small size, and considered fairly good eating.

The Owsianka, like the great majority of our Cyprinoids, spawns in spring, the usual month in Sweden being May, in Germany April. It is a lively fish, in temperament resembling the Bleak, and also feeding on small insects. It dies soon after it is taken out of the water. Its apparently periodical disappearance from the peat-haggs — in Southern Russia too, according to MASLOWSKY, it is caught in the small streams only from September to April — may probably be explained either by some migration after the spawning-season, should any egress be open to the fish, or on the assumption that at certain seasons it keeps to the bottom of the deep pools, appearing at the surface when the water is disturbed. In Sweden it is sometimes fried and made into 'fish-cake' like other small fishes, but this is the only form in which it is eaten.

Subfamily ABRAMIDINÆ.

Dorsal fin much shorter than the anal, the base of the former measuring as a rule less than $^2/_3$[a] *of that of the latter, which is more than 16 % of the length of the body. Length of the head less than half the distance between the dorsal fin and the tip of the snout. No spinous ray in the dorsal or the anal fin. Ventral margin between the ventral fins and the anal aperture sharp, but generally naked (not covered with curved scales) in the median line. Mouth without barbels. Length of the lower jaw as a rule less than 47 % of that of the base of the anal fin. Pharyngeal cartilage oval or elliptical, with the anterior (upper) extremity more or less obtusely pointed.*

These characters are accompanied by the well-known Abramidine form, a deep and compressed body with strongly compressed or even sharp margins, along which the scales are shed at certain parts of the median line, the two outermost rows of scales being thus juxtaposed edge to edge, or leaving the skin at these parts naked. This is always the case, even in *Alburnus* and, at least partially, in *Spirlinus*, along the ventral margin between the ventral fins and the anal aperture; and in the true Breams the denudation extends, though with varying distinctness, to the anterior part of the dorsal margin behind the occiput.

It was not without reason that NILSSON proposed to unite all the Scandinavian Abramidines into one genus. Great as the difference may appear between a Bleak and a Bream, we find intermediate forms between them composing an almost unbroken series. A species found in Denmark and further south, *Spirlinus bipunctatus*, has also been referred by some, for example by GÜNTHER, to the genus *Abramis*, by others, for example HECKEL and SIEBOLD, to *Alburnus*. The near relationship of this subfamily to the preceding one, a relationship which in its intermediate forms and hybrids defies every attempt by fixed characters to define the limits between these two groups, has caused a like diversity of opinion, the Bleak being referred by AGASSIZ, KRÖYER, NILSSON, and LILLJEBORG to the same genus as the Asp. If the systematic classification of forms so closely allied is to be based on natural grounds, we are compelled for the sake of consistency to employ as generic characters relations which elsewhere seem to be of comparatively little weight. Hence FATIO established his new genus *Spirlinus*, and for the same reason we are obliged to divide the genus *Abramis*, with a view to obtaining an expression for the points of resemblance between the 'Zärthe' and preceding forms and the respects in which it differs widely from the true Breams.

The genera belonging to the Scandinavian fauna may be distinguished as follows:

I: Length of the head more than $^1/_3$ of the distance between the dorsal fin and the tip of the snout.
- *A:* Base of the anal fin less than $^1/_5$ of the length of the body and shorter than the head.
  - *a:* Lower jaw most prominent. Pectoral fins longer than the longest ray in the dorsal fin .... Genus *Alburnus*.
  - *b:* Jaws about equally prominent. Pectoral fins shorter than the longest ray in the dorsal fin ... Genus *Spirlinus*.
  - *c:* Tip of the snout most prominent. Pectoral fins shorter than the longest ray in the dorsal fin Genus *Leucabramis*.
- *B:* Base of the anal fin more than $^1/_5$ of the length of the body and as a rule longer than[b] the head...... Genus *Abramis*.

II: Length of the head less than $^1/_3$ of the distance between the dorsal fin and the tip of the snout .... Genus *Pelecus*.

[a] Invariably less than 72 % in all the specimens measured by us.

[b] In White Bream and young Bream exceptionally equal in length to the head.

Genus ALBURNUS.

Beginning of the dorsal fin situated at a distance from the tip of the snout less than three times the length of the head. Length of the base of the anal fin less than $^1/_5$ (between 16 and 18 %) of that of the body, and also less than that of the head. Pectoral fins longer than the longest ray in the dorsal fin. Point of the lower jaw projecting distinctly beyond the tip of the snout. Scales thin and deciduous; nucleus situated in the anterior half of the scale.

The genus of the Bleaks, according to GÜNTHER'S *Catalogue*, contains 15 recognised species from Europe and Southwestern Asia, most of them described by HECKEL from the latter region, which thus seems to be the true home of the genus. They are small, but lively fishes, readily attracting attention in rivers and lakes, where they sport at the surface in chase of insects, or in eager contest for every breadcrumb thrown to them.

They are distinguished from the other genera of the subfamily, with the exception of the "Ziege", by their comparatively low dorsal fin, generally lower even than in the preceding subfamily, excluding the Minnow. But on comparing the height of the dorsal fin with the length of the pectorals — a relation which is not without importance in preserving the equilibrium of the body — we find that in this respect the Bleaks and the Ziege rank with the adult Leuciscines, except the Roach, where, as in young specimens of the Scandinavian Leuciscines in general, the length of the pectoral fins is less than that of the longest ray in the dorsal fin. The majority of the Scandinavian Abramidines, on the other hand, thus retain, like the Roach, in this respect one of the characters of youth among the Leuciscines.

The name of the genus dates even from the time of AUSONIUS[a]. LINNÆUS employed it in a specific signification; but HECKEL restored it to the generic rank it had occupied in RONDELET[b], and separated[c] the Bleaks under this name from the other Cyprinoid genera. RONDELET'S *Alburnus*, however, was evidently distinct from this genus.

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[a] The continuation of the lines quoted above (p. 751) from the *Mosella* of AUSONIUS runs:

"Et *Alburnos* praedam puerilibus hamis?"

"And Bleak, an easy catch for angling boys."

[b] *De Pisc.*, part. II, p. 208.

[c] *Russeggers Reisen*, 1 Bd., 2 Th., p. 1036.

THE BLEAK (SW. LÖJAN).

ALBURNUS LUCIDUS.

Plate XXXVI. fig. 3.

Scales in the lateral line about 50 (46—54), branched rays in the anal fin about 17 (16—20). Sides of the body of a plain, lustrous, silvery white. Pharyngeal teeth slender, hooked at the tip, pectinated, and set in two rows: 2, 5—(4)5, 2.

Fig. 196. Left lower pharyngeals of *Alburnus lucidus*, *a*, seen from above, *b*, from without, both figures twice the natural size; *c*, the middle tooth in the inner row, three times the natural size.

R. br. 3; *D.* $\frac{3}{8-9}$[a]; *A.* $\frac{3}{16-20}$[b]; *P.* $\frac{1}{14-15}$[c]; *V.* $\frac{2}{8}$[d]; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* 46—54; *L. tr.* $\frac{8}{3(4)}$[e] 1; *Vert.* 42[f]—44.

Syn. Albula minor, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 11. *Cyprinus* quincuncialis, pinna ani ossiculorum viginti, ART., *Ichthyol.*, *Gen. Pisc.*, p. 6; *Syn. Pisc.*, p. 10; *Descr. Spec. Pisc.*, p. 17; LIN., *Fn. Suec.*, ed. 1, p. 124.

Cyprinus Alburnus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 325; BL., *Fisch. Deutschl.*, pt. 1, p. 54, tab. VIII, fig. 4; RETZ., *Fn. Suec. Lin.*, p. 359; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 321; EKSTR. (subg. *Abramis*, ex. CUV.), Vet.-Akad. Handl. 1830, p. 187; NILSS., *Prodr. Ichthyol. Scand.*, p. 31; AGASS. (*Aspius*), Mem. Soc. Sc. Nat. Neuch., tom. I, p. 38; SCHAGERSTR. (*Cyprinus*), Physiogr. Sällsk. Tidskr. 1837, p. 295; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, tom. XVII, p. 272 (+ *Leuc. ochrodon* (ex. AGASS.), p. 249 + *L. alburnoides* (ex SELYS), p. 250); FR., EKSTR., v. WR. (*Cyprinus*, subg. *Aspius*), *Skand. Fisk.*, ed. 1, pp. 58 et 203, tab. 51; KR. (*Aspius*), *Danm. Fisk.*, vol. 3, p. 485; NILSS. (*Abramis*, subg. *Aspius*), *Skand. Fn., Fisk.*, p. 337; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Sällsk. Handl. 1855, p. 81; WIDEGR., *Fiskfn., Fiskev. Norrb. L.* (1860), pp. 7 et 13; LINDSTR. (*Abramis*), *Gotl. Fisk.*, Gotl. L. Hush. Sällsk. Årsber. 1866, p. 18 (sep.); OLSS. (*Abramis*), Öfvers. Vet.-Akad. Förh. 1876, No. 3, p. 131; FEDDERS. (*Aspius*), Naturh. Tidskr., Kbhvn, ser. 3, vol. XII, p. 90; REUT., SUNDM., *Finl. Fisk.*, tab. XIV; LILLJ., *Sv., Norg. Fn., Fisk.*, vol. III, p. 253.

Alburnus lucidus, HCKL (+ *Alb. obtusus* + *A. acutus*), *Russegg. Reis.*, l. c.; HCKL, KN., *Süsswasserf. Östr. Mon.*, p. 131 (+ *Alb. breviceps*, p. 134); DYBOWSKI, *Cypr. Livl.*, p. 165; SIEB., *Süsswasserf. Mitteleur.*, p. 154; BLANCH., *Poiss. d. eaux douces Fr.*, p. 364 (+ *Alb. mirandella*, p. 369 + *A. Fabraei*, p. 370); GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 312; COLL., Forh. Vid. Selsk., Chrnia 1874, Tillægsh., p. 184; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 403; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 127; MELA, *Vert. Fenn.*, p. 336, tab. X; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 198, tab. CXXXVII, fig. 1; MÖB., HCKE, *Fisch. Osts.*, p. 119; FAT., *Fne Vert. Suisse*, vol. IV, p. 414.

Alburnus Linnei, MALM, *Gbgs, Boh. Fn.*, p. 568.

The Bleak is one of the smaller Cyprinoids. Its ordinary length, including the caudal fin, is 13—15 cm. In Sweden it seldom measures 18 cm.; but BENECKE states that in Prussia it attains a length of 20 cm.[g]

The body is rather elongated and laterally compressed, the greatest depth being occasionally $^1/_4$, but generally between $18^1/_2$ and 23 %, of the length to the end of the middle caudal rays, and the greatest thickness at most about $^1/_2$ the greatest depth. The least depth of the tail measures on an average about 8 % (7·4—8·2 %) of the length of the body. The dorsal margin is convex throughout its length. The belly is flat in front, carinated from the ventral fins to the anal aperture. The dorsal line is often nearly straight, being, at least in front, much less curved than the ventral.

[a] 7—9, according to FATIO.
[b] Sometimes 15, according to FATIO.
[c] „ 18, „ „ „
[d] „ 7, „ „ „
[e] $\frac{7-9}{3-4}$ according to FATIO.
[f] Sometimes 41, according to FATIO.
[g] According to BLOCH the Prussian Bleak may attain a length of 8—10 in. (20—26 cm.).

The length of the head varies between 19 and 21 % of that of the body, its size being thus somewhat below the average among the Scandinavian Cyprinoids. It is rather pointed, of uniform thickness, and compressed, at the top convex, with fairly parallel cheeks. The facial line is straight from the occiput to the tip of the snout. The breadth of the interorbital space measures about $^{3}/_{10}$ of the head, and is generally somewhat greater than the longitudinal diameter of the eyes, but sometimes equal to this diameter, which also differs only slightly from the length of the snout. The nostrils lie on a level with the upper margin of the eyes, nearer to the eyes than to the tip of the snout; and the distance between the anterior nostrils is equal to that between either of them and the middle of the tip of the snout. As usual in this family, the two nostrils of each side are separated by a narrow dermal ridge, raised in a lobate form, and the shape of the nostrils varies with the position of this ridge: when it is thrown back, the anterior is round, the posterior crescent-shaped. The situation of the eyes is such that the postorbital length of the head is as a rule somewhat less, but sometimes rather more, than half (44—52 %) of its entire length. The mouth is turned sharply upwards, its entire cleft lying in front of the perpendicular from the nostrils, which line, when the mouth is closed, touches the hind extremity of the maxillary bones. A small notch in the sharp tip of the snout, which is formed by the intermaxillaries (the margin of the upper lip), receives the blunt and rather prominent point of the lower jaw. The length of the upper jaw from the middle of the tip of the snout is often almost equal to the length of the snout, measuring 29—26 % of that of the head. The length of the lower jaw is 35—40 % of that of the head. The gill-openings are fairly large, the branchiostegal membranes coalescing with the isthmus almost beside each other, a little in front of the perpendicular from the hind margin of the preoperculum. The gill-rakers are close-set: in the outer row on the front of the branchial arch (16 or 17 in number) they are slender and wand-shaped, while in the inner row on this arch and in both rows on the other arches and on the outer anterior margin of the pharyngeals they are short and of a pointed triangular form. The pseudobranchiae are well developed. The pharyngeal teeth are distinguished, here as in the Rudd, by the pectination of the masticatory surface, at least before it is worn smooth, in the case of the three or four posterior teeth in the inner row. The two anterior teeth or at least the first tooth in this row, are as usual more conical, the second with or without pectinated masticatory surface, or with this surface worn smooth. Such is also the form of the two small teeth in the outer row. The pharyngeal cartilage is oval, with grooves obliquely crossing the masticatory surface, as in the majority of the Leuciscines described above, and with the hind (lower) extremity somewhat raised, a trace of the inverted canaliculate form more highly developed in the larger Leuciscines.

The dorsal fin begins at about the middle of the length of the body[a] or a little further back. It is of almost the same trapezoidal form as in the Leuciscines, with the length of the last ray at least rather more than $^{1}/_{3}$ of that of the longest ray, which here seems hardly to exceed 15 %[b] of the length of the body. The base of the dorsal fin measures about $^{1}/_{11}$[c] of the length of the body. The anal fin begins below the posterior part of the dorsal[d]. It is long[e], low behind, and forms a slight arch at the concave inferior margin. The first ray is hardly perceptible, the second half as long as the third, the fourth the longest and, like the following rays, branched at the tip. The caudal fin is deeply forked, the lower lobe being somewhat longer than the upper, and measuring somewhat more than $^{1}/_{5}$ of the length of the body.

The pectoral fins are obliquely and bluntly pointed. Their length is about $^{1}/_{6}$ ($16^{1}/_{2}$—$17^{1}/_{2}$ %) of that of the body. The ventral fins are much shorter, measuring about 12—13 % of the length of the body. Their position is such that the distance from the tip of the snout to their insertion[f] does not seem to exceed

[a] At a distance from the tip of the snout measuring 50—$52^{1}/_{2}$ of the length of the body; the latter percentage in our oldest female specimens.

[b] Varying, according to our measurements, between $13^{1}/_{2}$ and $14^{4}/_{5}$ %.

[c] According to our measurements 8·7—9·7 %.

[d] At a distance from the tip of the snout measuring about 59 % (57·4—59·3 %) of the length of the body.

[e] The base of the anal fin measures about 17 % (16·4—17·6 %) of the length of the body.

[f] About 11 % (11·8—10·5 %) of the length of the body.

[g] 40—43 % of the length of the body.

$82\frac{1}{2}$ %[a] of that from the same point to the dorsal fin. The preabdominal length measures on an average $22\frac{1}{2}$ %, and the postabdominal length $18\frac{1}{2}$ %, of the length of the body.

The texture of the thin scales has already been remarked. It is fairly characteristic of the Bleaks and their nearest relatives, in the dense, concentric striæ, most dense in the anterior (covered) part of the scale, around the eccentric nucleus, which also lies in the covered part. Towards the nucleus run a few (on the scales of the sides commonly 4, on the dorsal scales as many as 10) scattered grooves, extending forward for a greater or less distance from the hind margin of the scale. The scales are generally of a broad elliptical shape (those of the lateral line more quadrilateral, with the posterior part rounded), the longitudinal axis of the ellipse pointing up and down. They are rather large, but deciduous. The inner surface of their posterior part is lined with a dense layer of long, almost filiform crystals, which give them their silvery lustre.

The colour of the back and the upper part of the head is greenish gray. The rest of the body is silvery. The iris is also silvery, but above the pupil yellowish, with dense, confluent spots of gray. The pectoral, ventral, and anal fins are white, the first pair faintly tinged with green at the anterior margin. The dorsal and caudal fins are gray.

The Bleak is spread over the whole of Europe north of the Alps, with the exception of Scotland and Ireland[b]. In Sweden it is common enough, under the names of *Löja*, *Löga*, *Benlöja*, *Pjön*, *Pyn*, etc., up to the neighbourhood of Quickjock[c] (lat. 67° N.). It does not seem to thrive, however, in the highlands, for it is rare in Lapland, and in Western Jemtland, according to Olsson, it is wanting[d]. In Finland, where it is called *Salakka*, a name which at Torneå is altered, says Widegren, to *Salk*, its range extends, according to Mela, to 68° 20′ N. lat. In Norway, a country not very rich in Cyprinoids, the Bleak is found only in the south-east, no further north, according to Collett, than Lake Mjösen. It lives in the great lakes, in clear rivers and streams, and also in the inner part of the Baltic island-belt, as well as in Gothland and round the coasts of that island. According to Schagerström it also occurs in the Sound, at least off Landskrona.

The Bleak lives in shoals, solitary specimens being never met with, and prefers clear, running water with a stony or sandy bottom. It is consequently found but seldom in small lakes with a bottom of weeds or mud. Sportive and lively in temperament, it always keeps to the surface from spring to autumn, and catches the insects that drop into the water. It loves sunshine and calm, and in rainy and stormy weather makes for sheltered shores. At such times it probably descends some way below the surface, but it does not stay there long, and is never found at the bottom, except in autumn, when, like the other Cyprinoids, it retires to its winter-quarters in the depths. Less shy than timid, it soon returns to the spot whence it has been driven away by some noise. On the other hand, it is voracious, and instantly seizes any small substance thrown into the water. If it finds the morsel unfit for food, it again disgorges its prize. Its food consists principally of insects, small crustaceans, and worms.

At the end of May or beginning of June the Bleak assembles in large shoals to spawn in shallow water with a stony or sandy bottom. The shoal presses in serried array close to the shore, and seems like a dark cloud in the water. The spawning now begins; the fish leap time after time, at brief intervals, above the surface, and meanwhile deal frequent and rapid blows with the tail on the water, thus producing a hissing sound like that heard when a piece of cloth is suddenly torn in two. The roe attaches itself to stones or twigs at the bottom. How soon the eggs are hatched under ordinary circumstances, we cannot state with certainty, the time allotted by different statements to this process varying between 24 hours and as many days; but it undoubtedly varies according to the temperature of the water. Of the growth of the fry we learn from Malm that in the middle of September he caught young Bleak 18—23 mm. long in the Höje (a stream in Seania); and in Lake Mälar Lilljeborg

[a] According to our measurements 79—82·2 %.

[b] Day, l. c.

[c] According to Löwenhjelm, Vet.-Akad. Handl. 1843, p. 411. The statement is, however, somewhat dubious, for the spawning-season is said to occur in September.

[d] According to Fatio it ascends in the Swiss lakes to a height of about 700 m. above the level of the sea.

took specimens 20—25 mm. long at the beginning of October. Fishermen in general believe that the Bleak spawns three times a year at short intervals; and from Lomma (Scania) we are told by ÅSTRÖM[a] that at Whitsuntide three shoals of Bleak generally enter the stream from the Sound, and spawn one after the other at intervals of about a week. But the true explanation of this fact is that the difference in the spawning-season depends on the different ages of the fish, for the Bleak that spawn first are always larger than those which spawn later. Bleak are taken in numbers only during the spawning-season. The tackle most employed consists of a small and fine-meshed seine, constructed especially for this purpose, and called *löjnot* or *löjsköte* (Bleak-seine or Bleak-net), or a large circle-net (Sw. *grip*), which is cast over the shoal while spawning. In summer the Bleak may also be taken in small-meshed nets and in traps; but the catch is seldom large. After the spawning-season it takes a bait freely, a fly being an especially tempting morsel.

As the Bleak is small, and is only seldom taken in large numbers, it cannot possess any great importance as an article of food. It is generally eaten fresh, its flavour, when fried, being not unlike that of the Baltic Herring. When salted or dried it entirely loses its flavour. It is most useful to the fisherman as bait, for which purpose it is excellent, though not as live bait, its tenacity of life being small. It is eagerly sought after by terns and gulls, which generally flock to the places where Bleak are to be found, and it is one of the most important foods of our best and most valuable predatory fishes. When pursued by them, it may often be seen leaping in companies out of the water. In an aquarium it is a lively, playful, and amusing pet.

In France the Bleak has been much in request since the year 1680[b], when a manufacturer of beads, JACQUIN by name, discovered a method of applying the silvery pigment from its scales to practical use. With this substance, the so-called *essence d'orient*, he coloured the inner surface of hollow glass beads, which were then filled with wax, an excellent imitation of the genuine pearl being thus produced. Millions of Bleak were used in this way, and great quantities of Bleak scales imported to Paris, the chief seat of this manufacture. It is estimated, according to BLANCHARD, that about 4,000 Bleak yield half a kilogramme of scales, and that the proportion of the colouring matter to the total weight of the scales is as 1 to 7.

Central Europe is inhabited by three forms whose signification was difficult to explain, until SIEBOLD's suggestion that they were hybrids between the Bleak and other species, was generally accepted. One of them is the form described by HOLANDRE[c] in 1836 from the Moselle under the name of *Leuciscus dolabratus*, and by GÜNTHER from the Neckar, first[d] under the same name, subsequently[e] under that of *Alburnus dolabuloides*. This variety was elucidated by SIEBOLD[f] as a hybrid between the Chub and the Bleak, and belongs to the basins of the Maas, Rhine and Danube. It is usually as small as a Bleak and also of the same appearance, though with less ascending mouth, less prominent lower jaw, and shorter anal fin with straight or rounded (convex) margin. But it sometimes attains a length of at least 31 cm., and is then more like a Chub, with the scales pigmented at the hind margin with black. The pharyngeal teeth resemble those of the Bleak.

Another similar form has been described by JÄCKEL[g] from Bavaria under the name of *Alburnus Rosenhaueri*, and by BENECKE[h] from Deutsch-Eylau (Prussia) under that of *Scardiniopsis alburniformis*. Both these authors interpret it as a cross between the Rudd and the Bleak. Its body, according to BENECKE, is deeper[i] than that of the Bleak, its scales are coarser and generally fewer (45—47 in the lateral line), the anal fin

[a] *Några iakttagelser rörande de vertebrerade djur, som förekomma i trakten af Lomma.* disp. Lund 1859, p. 27.

[b] See BLANCHARD, l. c. In RÉAUMUR — Hist. de l'Acad. Roy. d. Sciences, An. 1716, p. 229 — the discovery is said to have been made in 1656.

[c] *Faune du Département de la Moselle*, p. 248.

[d] Jahresb. Ver. Vat. Naturk. Würtemb., Jahrg. IX (1853), p. 314.

[e] „ „ „ „ „ „ XIII (1857), p. 51, taf. II.

[f] *Süsswasserf. Mitteleur.*, p. 164.

[g] Zool. Garten 1866, p. 20.

[h] Zool. Anzeiger 1884, p. 228.

[i] 22 % of the length of the body to the end of the lower caudal lobe corresponds to 24 % of the length to the tip of the middle caudal rays, and is a measurement by no means uncommon, at least in gravid females of the common Bleak.

is shorter with fewer rays[a], the caudal less deeply forked, the silvery lustre not so bright, and the pectoral, ventral, and anal fins sometimes show a reddish tinge. But the most convincing proof of its hybrid nature lies, it is stated, in the outer row of pharyngeal teeth, which is frequently composed of 3 teeth, the regular number in the Rudd, and in the sharp median line of the ventral edge between the ventral fins and the anal aperture, which is generally covered by a row of bent scales, but sometimes scaleless as in the Bleak. In the last respect this form consequently resembles the following species (*Spirlinus bipunctatus*); and in the common Bleak too we sometimes find that the scales at the sharp ventral edge behind the ventral fins bend at an angle over the median line. In Scandinavian Bleak, however, three teeth have never been found in the outer pharyngeal row.

The third of these forms was seen by SIEBOLD[b] in the fishmarket at Königsberg. On the assumption that it is a hybrid between the White Bream and the Bleak, he gave it the name of *Bliccopsis alburniformis*.

(EKSTROM, SMITT.)

GENUS SPIRLINUS.

Beginning of the dorsal fin situated at a distance from the tip of the snout less than 3 times the length of the head. Length of the base of the anal fin less than $^1/_5$ *(between 16 and 18 %) of that of the body, and also less than that of the head. Pectoral fins shorter than the longest ray in the dorsal fin. Point of the lower jaw situated in a line with the the tip of the snout when the mouth is closed. Scales thin and deciduous; nucleus situated in the anterior half of the scale.*

These characters apply to only one known species, which is also so nearly allied to the preceding genus that it was not separated therefrom until 1882 (by FATIO). But this resemblance is coupled with so close an approximation to forms treated of below that GÜNTHER referred the species to the genus *Abramis*. The generic limitation is in many cases hardly more than a matter of taste: its object here is among the genera to mark the different stages in the gradual transition from the Leuciscines to the Abramidines.

[a] 15 branched rays. This number falls, however, according to FATIO, between the limits of variation in the Bleak (see above).
[b] *Süsswasserf. Mitteleur.*, p. 168.

THE SPERLIN-BLEAK (SW. BRAXENLÖJAN).

SPIRLINUS BIPUNCTATUS

Fig. 197.

Scales in the lateral line about 50 (44—52). Branched rays in the anal fin about 15 (14—16). Lateral line included between two black streaks: sides also marked with scattered black spots. Pharyngeal teeth compressed, hooked at the tip, with smooth masticatory surface, and set in two rows: 2, 5(4)—4(5), 2.

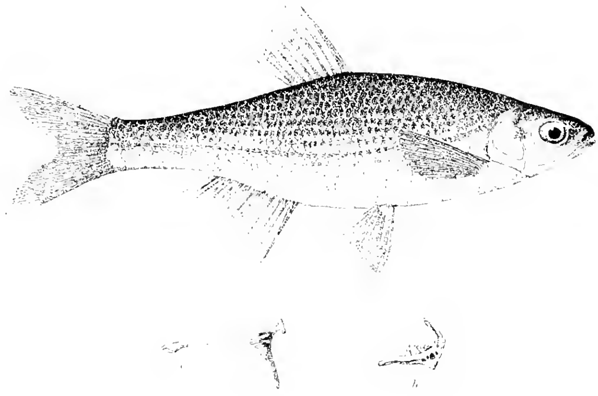

Fig. 197. *Spirlinus bipunctatus*, natural size. From the Lake of Zurich. *a*, left inferior pharyngeal seen from above, *b*, same bone seen from without, both figures twice the natural size; *c*, the middle tooth in the inner row, three times the natural size.

R. br. 3; *D.* $\frac{3}{7-8}$; *A.* $\frac{3}{14-16}$[a]; *P.* $\frac{1}{13-15}$; *V.* $\frac{2}{7-8}$; *C.* $x+1+17+1+x$; *L. lat.* 44—52; *L. tr.* $\frac{9}{4}$[b] 1; *Vert.* 38—40[c].

Syn. *Cyprinus bipunctatus*, BL., *Fisch. Deutschl.*, pt. I, p. 50, tab. VIII, fig. 1; AGASS. (*Aspius*), Mém. Soc. Sc. Nat. Neuch., tom. I, p. 38; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, tom. XVII, p. 259 (+*Leuc. Baldneri*, p. 262); BONAP. (*Alburnus*), *Cat. Met. Pesc. Eur.*, p. 33; GTHR (*Abramis*), Jahresb. Ver. vaterl. Naturk. Würtemb., Jahrg. IX, p. 307; HECKL, KN. (*Alburnus*), *Susswasserf. Oestr. Mon.*, p. 135; DYB., *Cypr. Livl.*, p. 161; SIEB., *Susswasserf. Mitteleur.*, p. 163; BLANCH., *Poiss. d. eaux douces Fr.*, p. 371; FEDDERSEN (*Aspius*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 91; BNCKE (*Alburnus*), *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 128; FATIO (*Spirlinus*), *Fne Vert. Suisse*, vol. IV, p. 392; LILLJ. (*Abramis*), *Sv., Norg. Fn., Fisk.*, vol. III, p. 322.

The Sperlin-Bleak never exceeds the average size of the common Bleak. According to FATIO it may attain in Switzerland a length of 15 cm.; but the ordinary length of adult specimens, including the whole caudal fin, lies between 10 and 13 cm.

In form this species is deeper than the preceding one, and consequently shows greater lateral compression, the greatest depth being at least about $\frac{1}{4}$[d], the least depth about $\frac{1}{11}$[e], of the length of the body to the end of the middle caudal rays, and the greatest thickness (across the opercula) at most about $\frac{2}{5}$, on an average 36 %, of the greatest depth.

In most other respects it resembles the Bleak; but the mouth does not ascend so sharply, and the

[a] Sometimes 17, according to FATIO; sometimes 18, according to GÜNTHER.

[b] $\frac{8-10}{3-5}$ according to FATIO.

[c] According to GÜNTHER and FATIO.

[d] 24·7 %—26·7 % according to our measurements.

[e] 8·8 %—9·4 % according to our measurements.

point of the lower jaw, though it fits into a shallow indentation at the tip of the snout, and projects distinctly beyond the latter when the mouth is open, is not prominent when the mouth is closed. The jaws are somewhat larger, the length of the upper jaw from the tip of the snout measuring about 31—35 % of that of the head, and the length of the lower jaw about 41—45 % of the same. The dorsal fin is situated as a rule somewhat farther forward, its beginning lying at a distance from the tip of the snout of about 50—47 % of the length of the body, and the distance between the tip of the snout and the ventral fins being about 85—90 % of that between the same point and the dorsal fin. This fin is also both higher — its longest ray measures about 19 or 20 % of the length of the body — and longer, the length of its base being about $^1/_9$ (11·8—11·3 %) of that of the body. The anal fin is also higher; its longest ray measures about 15—14 % of the length of the body.

The most striking difference from the Bleak appears, however, in the coloration. The ground-colour is indeed the same; but the lateral line, which during life is itself more or less red, is included between two black streaks running along and close to it. These streaks are formed by two small, elongated, black spots on each scale in the lateral line, one above and one below the opening duct. At the base of the scales on the sides of the body too, at least for 3 or 4 rows above and sometimes also below the lateral line, there appear somewhat larger, triangular spots, one on each scale, apparently forming longitudinal streaks along the sides.

The continental range of the Sperlin-Bleak in Central Europe is about the same as that of the Bleak, and the species occurs in similar localities, but not in such numbers. The Germans call it *Alandblecke*, *Schusslaube*, *Schneider*, etc.; in France it is most commonly known as the *Spirlin* (*Eperlan de Seine*). It has only once been found within the limits of the Scandinavian fauna: FEDDERSEN records (l. c.) the taking of a specimen in Lake Scanderborg (Jutland) in July, 1877.

GENUS LEUCABRAMIS.

Beginning of the dorsal fin situated at a distance from the tip of the snout less than three times the length of the head. Length of the base of the anal fin less than $^1/_5$ ($17^1/_2$—19 %) of that of the body, and also less than that of the head. Pectoral fins shorter than the longest ray in the dorsal fin. Tip of the snout projecting in front of the mouth. Scales firmly attached, Leuciscine in texture.

Among the Abramidine species hitherto described from Europe there are two — probably, however, varieties of the same species — *Abramis rimba* and *Abramis elongatus* (*melanops*), which seem to be assigned by the development of the anal fin to a place beside *Alburnus*. The form of the dorsal fin — comparatively long and low — also divides them from the true Breams; but the most important difference consists in a carina, formed by the bent scales of the median line, at the dorsal edge of the tail behind the dorsal fin. One of these two species, if it is still to be regarded as such — SIEBOLD suggests that it should be interpreted as a variety due to a constant life in rivers, without migration to lakes or the sea — belongs to Russia and Germany (S. E. and N.). The second is our well-known

THE ZÄRTHE (SW. VIMMAN)

LEUCABRAMIS VIMBA.

Plate XXXV, fig. 3.

Scales in the lateral line about 60 (58—61). The dorsal fin begins at least a little in front of the middle of the body, and the distance between it and the tip of the snout (about 48—nearly 50 % of the length of the body) is less than $^3/_5$ of that between the anal fin and the same point. Height of the dorsal fin less than $^1/_5$ of the length of the body. Pharyngeal teeth not hooked, compressed, with smooth (terete or one-grooved) and almost terminal masticatory surface, and set in one row: 5—5.

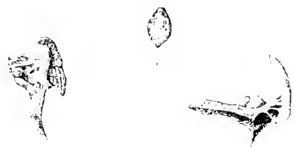

Fig. 198. Pharyngeal bones and pharyngeal cartilage of *Leucabramis vimba*, natural size: *a*, left pharyngeal seen from above; *b*, the same seen from without (the left); *c*, pharyngeal cartilage.

R. br. 3; *D.* $\frac{3}{8}$[b]; *A.* $\frac{3}{17-20}$[c]; *P.* $\frac{1}{15-17}$; *V.* $\frac{2}{9}$[d]; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 58[a]—61; *L. tr.* $\frac{10-11}{5-6}$ 1; *Vert.* 46.

Syn. Capito anadromus, GESN., *Hist. Anim.*, lib. IV, Paralip., p. 11. *Nasus*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 52. *Cyprinus* Capito anadromus dictus, ART., *Ichthyol.*, *Syn. Pisc.*, p. 8. *Cyprinus* rostro nasiformi, dorso acuminato, pinna ani ossiculorum viginti quatuor, ART., ibid., *Gen. Pisc.*, p. 6; *Syn. Pisc.*, p. 14; *Descr. Spec. Pisc.*, p. 18; LIN., *Fn. Suec.*, ed. I, p. 123.

Cyprinus Vimba, LIN., *Syst. Nat.*, ed. X, tom. I, p. 325; BL., *Fisch. Deutschl.*, pt. I, p. 38, tab. IV; RETZ., *Fn. Suec. Lin.*, p. 359; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 322 (+ *Cypr. carinatus*, p. 323); EKSTR. (subg. *Abramis*), Vet.-Akad. Handl. 1830, p. 184; NILSS., *Prodr. Ichthyol. Scand.*, p. 31; CUV., VAL. (*Abramis*), *Hist. Nat. Poiss.*, vol. XVII, p. 65; KR., *Danm. Fisk.*, vol. III, p. 400; NILSS., *Skand. Fn.*, *Fisk.*, p. 322; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Sällsk. Handl. 1855, p. 82; HCKL., KN. (*Abramis*), *Süsswasserf. Östr. Mon.*, p. 109; WIDEGR. (*Cyprinus*), *Fiskfn.*, *Fisker. Norrb. L.*, Landtbr. Akad. Handl. 1861, p. 7 (sep.); DYB. (*Abramis*), *Cypr. Livl.*, p. 183; SIEB., *Süsswasserf. Mitteleur.*, p. 125; MGRN, *Finl. Fiskfn.* (disp. Helsingf. 1863), p. 41; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 303; MALM, *Gbgs. Boh. Fn.*, p. 566; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 120; MELA, *Vert. Fenn.*, p. 329, tab. X; MOB., HCKE, *Fisch. Osts.*, p. 117; REUT., SUNDM., *Finl. Fisk.*, tab. I; LILLJ., *Sv.*, *Norg. Fn.*, *Fisk.*, vol. III, p. 304.

In Sweden the 'Zärthe' attains a length of at least 37 cm., including the whole of the caudal fin. Specimens of this size have been forwarded to the Royal Museum from Norrköping on the Motala River.

The body is deeper than in *Alburnus*, but shallower than in *Abramis*, the greatest depth, at the beginning of the dorsal fin, varying between about 26 and 32 % of the length to the end of the middle caudal rays, and the least depth (least depth of the tail) between about 9 and $10^1/_2$ % of the same. It is rather strongly compressed, with almost vertical sides; the greatest thickness of the head is about $^2/_3$ of the greatest depth of the body, which is generally not much thicker, though in gravid females the thickness of the abdominal region may be half as great as its depth, or a little more. The dorsal profile shows a more or less distinct break at the occiput, and at this point rises in a faint curve which soon passes into an almost straight line, interrupted only by a slight elevation at the beginning of the dorsal fin. The upper and lower profiles of the head converge in front with fair regularity at an angle of about 60°. The ventral profile is more curved in front and behind than the dorsal; but at the middle, in front of and behind the ventral

[a] Sometimes 54, according to MÖBIUS and HEINCKE.

[b] 7—9, according to KRÖYER.

[c] Sometimes 21, according to KRÖYER.

[d] Sometimes 8, according to DYBOWSKI; sometimes 10, according to SIEBOLD.

fins, to the beginning of the anal fin, it is straight. The forepart of the back, as well as the top of the head, is transversely convex; but towards the beginning of the dorsal fin it grows more and more compressed, while behind this fin the dorsal margin is again convex or even flat. Along the median line of the dorsal margin there runs, however, interrupted only by the dorsal fin, "a thin keel, with the appearance of a coarse thread laid under the skin. This keel begins on the head vertically above the anterior margin of the eyes, and ends at the caudal fin" (Ekström). The anterior part of the keel, almost to the dorsal fin, is naked; but at this point one or two scales generally begin to overlap the margin with their lateral part. Behind the dorsal fin, on the other hand, the keel itself consists of curved scales. The belly in front of the ventral fins is convex or flat underneath, but between these fins and the anal aperture sharp, with the median line scaleless. At the sides of the straight base of the anal fin the lowest scales project, forming a groove in which this fin may be partially concealed.

The length of the head measures in adult specimens (19—34 cm. long) about $22\frac{1}{2}$—$21\frac{1}{2}$ % of that of the body. Just in front of the eyes it is more or less tumid; but the most characteristic point in its appearance is the prolongation of the snout, as in the Haddock or the Houting. The projecting tip of the snout is obtusely rounded, and the length of the snout measures in young specimens about 29 % of that of the head, in old as much as 35 % of the same, being less in the former than the breadth of the interorbital space, but in the latter at least equal to or, generally, somewhat greater than this breadth. In the former too the length of the snout is somewhat less, but in the latter perceptibly greater, than that of the upper jaw from the middle of the tip of the snout. The mouth thus acquires a position quite ventral and almost horizontal, but is fairly large, so large, according to Artedi, that the middle finger may be inserted with ease into the mouth of large specimens, the upper jaw being then protruded as if from a thumb-stall. The lower jaw, which articulates below the centre of the eyes, measures about 36—33 % of the length of the head. The lips are rather thick. The eyes are of moderate size, their longitudinal diameter varying in the above-mentioned adult specimens between $23\frac{1}{2}$ and 18 % of the length of the head, or between $\frac{1}{2}$ and $\frac{2}{3}$ of the postorbital length of the same. The postorbital part occupies between 44 and 50 % of the entire length of the head, the eyes being thus situated sometimes entirely, and always principally, in the anterior half of the head. The nostrils, set almost on a level with the upper orbital margin, are farther from the eyes than in the preceding forms; but the distance between the posterior nostril and the eye is never more than half of that between the anterior and the tip of the snout. The gill-openings are large, the branchiostegal membranes coalescing with the isthmus close beside each other and in about a line with the posterior margin of the eyes. The gill-rakers in the outer row on the first branchial arch are not very close-set (15 or 16) and triangular in shape, the upper and lower ones pointed, the middle ones blunter and with a tendency to ramification at the tip. The outer anterior margin of the pharyngeals is set with 10—12 small spines. The pharyngeals are comparatively short, and their anterior (lower) arm is deeply grooved (bilobate) at the inferior margin. The pharyngeal teeth, which have been described above, are in other respects, both in form and arrangement, not unlike those of the Roach.

The shape of the dorsal fin also reminds us most of the Roach, but it is somewhat more pointed, as in *Abramis*, and the base is comparatively shorter. Its position is given above. The base measures about $\frac{1}{10}$ (10—10·6 %), and the height about 19—$16\frac{1}{2}$ %, of the length of the body. The distance between the anal fin and the tip of the snout occupies in young specimens about 62 %, in old sometimes nearly 66 %, of the length of the body. The base of this fin measures in all our specimens 18—19 % (according to Dybowski sometimes only $17\frac{1}{2}$ %) of the length of the body, and its greatest height in the males about $\frac{1}{9}$, in the females about $\frac{1}{10}$, of the same. The caudal fin is deeply forked, its middle rays measuring about $7\frac{1}{2}$—$6\frac{1}{2}$ % of the length of the body, and about $\frac{1}{3}$ of that of the longer (the inferior) caudal lobe.

The pectoral fins are obtusely pointed, the second or third ray being the longest. Their greatest length is about 15 or 16 % (in a few males nearly 17 %) of the length of the body. The preabdominal length is about 22—24 % (in a few females $24\frac{1}{2}$ %), and the postabdominal length about 20—$20\frac{1}{2}$ % (in a few females 21 %), of the length of the body. In percentage of the same length the distance between the ventral fins and the tip of the snout is about 43—45 (in a few females nearly 46), and the length of these fins in the females between 14 and 15, in the males between 15 and 16 [a]. In relation to the dorsal fin they lie so far back that the distance between their insertion and the tip of the snout is as a rule perceptibly more than 87 % ($87^{1}/_{3}$—$91^{1}/_{2}$ %) of that between the dorsal fin and the same point.

The scales are middle-sized, deeply embedded in the skin, and imbricated. They are of an irregular quadrilateral shape and rounded, with almost central nucleus, dense concentric striæ, and numerous and well-defined radiating grooves, the latter alternating, both in front (finer) and behind (coarser and more regular), in their greater or less extent towards the nucleus.

In coloration two varieties are distinguished [b], *blekrimma* (Pale Zärthe) and *svartrimma* (Black Zärthe), the latter being probably no more than the spawning dress. Both on the head and the back the coloration is above blue or greenish brown, at the top of the sides of the body silvery with a dash of blue, fading below into the pure silvery white of the belly. On the sides of the head the dark blue tint extends down to the upper part of the gill-cover, and the silvery lustre shows stronger or fainter traces of a brassy colour. In Germany its dark snout has gained for the Zärthe the name of *Blaunase* or *Russnase*. All the fins are light, gray or grayish blue, more or less tinged, especially the caudal, with orange at the base. The iris is of a pale brassy yellow, shading into greenish above the pupil. Our figure, which is coloured from a sketch by W. v. WRIGHT, represents the Zärthe in this dress of almost pure silver. On weedy bottoms or in dark water the colours of the fish are greener with a more powerful brassy lustre. SIEBOLD has described the dark spawning dress, in which the sides of the body, even below the lateral line and close to the ventral and anal fins, acquire a singular silky lustre, this being caused by a deep black pigment from which the ventral side itself, from the lips to a narrow strip at the margin behind the anal fin, stands off sharply with its deep orange hue. The latter colour also extends to the paired fins and the base of the anal fin; the dorsal and caudal fins, the upper margin of the pectorals, and the lower margin of the anal fin being, on the other hand, blackish. In addition to this spawning dress, which is common to both sexes, the males are distinguished at this season by the usual dermal eruption, consisting of small round tubercles on the occiput, the opercula, the margins of the scales, and the inner surface of the paired fins.

The Zärthe is properly a marine fish, but also lives in the great lakes, and ascends rivers in order to spawn, being thus a so-called anadromous species. Its geographical range comprises Eastern Europe from Finland, Sweden, North-western Germany, and the watershed of the Danube to the Black Sea with its Russian river systems and the Sea of Azov. It makes its way up the Elbe and Weser from the North Sea, but is wanting in the Rhine. In Finland, where it is common among the southern islands and, to the east, in Lake Ladoga, it does not go farther north, according to MELA, than the sixty-third degree, being very rare even in that latitude. From the Swedish coast of the Gulf of Bothnia we are told by WIDEGREN (l. c.), though his statement is perhaps questionable, that the Zärthe occurs in the lower course of the Lulea Elf (nearly 66° N. lat.). The northernmost locality in Sweden to which we can with certainty assign this species, is the neighbourhood of Hudiksvall (about 62° N.), from which region Mr. WISTRÖM has sent to the Royal Museum a specimen 24 cm. long, taken in the fjord of Lingarö on one of the last days in September, 1882. In the same neighbourhood, we are told, it sometimes, though seldom, ascends the River Dekanger in spring. Ever since NILSSON'S time the Zärthe has been known in Blekinge; but in Scania it has never been found. It is commonest in the Mälar Valley and the Baltic island-belt with the streams that fall into this part of the Baltic. In Lake Wener it is also found, and is sometimes caught, "especially in the months of May and June" (MALM) in the River Gotha at Gothenburg. In Norway, Denmark, and the west of the Baltic the species is unknown; but from the Elbe it was described even by GESNER and SCHONEVELDE. From the Baltic it enters the German Haffs to spawn. According to DYBOWSKI (l. c.) and SEIDLITZ [c] it occurs in all the rivers of the Baltic Provinces of Russia. Its Baltic range being of such extent, we might well expect to find it both off Gothland and Bornholm; but is has not yet been observed in either of these localities.

[a] According to DYBOWSKI the same sexual distinction was present in his specimens; but the percentages are somewhat lower, this being probably due to a different manner of measurement.

[b] According to Mr. AROSENIUS, who forwarded to the Royal Museum specimens of these varieties from the Motala River (Norrköping) in 1834.

[c] *Fauna baltica*, p. 101.

EKSTRÖM has described the habits of the Zärthe in the neighbourhood of Mörkö. At the approach of spring it ascends the rivers, where it remains during the summer. Towards autumn it returns to the sea, where it passes the winter, in so deep water that it has never been caught at this time of year. It probably chooses its winter-quarters outside the island-belt. In the lakes too it retires to their deepest parts[a].

Cunning and shy, like most of the Cyprinoids, says EKSTRÖM, it is difficult to catch, except during the spawning-season, and dies soon after it has been taken out of the water. It seldom attains any considerable size. The flesh is white, but flabby and of poor flavour. In a female 31 cm. long and $^{7}/_{10}$ kilo. in weight BLOCH estimated the number of the ova at 28,800, whence it appears that the Zärthe multiplies quickly enough; but according to EKSTRÖM its growth is slow, and it thrives only in clear or running water with a stony or sandy bottom.

In the stomach of the Zärthe EKSTRÖM seldom found traces of other food than crustaceans, insects, worms, and, most often, the crushed shells of mollusks (*Neritina*): hardly ever of vegetable substances.

At the end of May — still according to EKSTRÖM — the spawning-season begins, and the Zärthe ascends such streams and rivers with stony bottom as fall into the sea or the great lake where it has passed the winter. The roe is deposited on and adheres to the stones, against which the spawning fish eagerly rubs itself in order to get rid of its burden.

In spring and autumn, as it roves to and from the spawning-place, small numbers of Zärthe are taken among other fishes with net and seine in Södermanland. During the spawning-season it is caught in a special kind of large hand-net.

In the localities affected by the Zärthe for the purpose of spawning, continues EKSTRÖM, where it may consequently be taken in numbers, it always appears on the labourer's humble board. It is generally but little esteemed, and indeed requires skilful preparation to suit a more delicate palate. EKSTRÖM found it best when fried.

GENUS **ABRAMIS.**

Beginning of the dorsal fin situated at a distance from the tip of the snout less than three times the length of the head. Length of the base of the anal fin more than $^{1}/_{5}$ (21—35 %) of that of the body, and greater as a rule than that of the head. Pectoral fins shorter than the longest ray of the dorsal fin. Tip of the snout projecting only slightly, if at all, in front of the mouth. Scales firmly attached, Leuciscine in structure.

This genus too is mainly European, and contains only a few species (4 determined and recognised with certainty, excluding hybrids). Still HECKEL[b] divided it into 3 genera: *Abramis*, *Blicca*, and *Ballerus*, the first with pharyngeal teeth set in a single row and the base of the anal fin comparatively little elongated, the second with two rows of pharyngeal teeth, the third with pharyngeal teeth set in one row and the base of the anal fin greatly elongated. The first two genera, however, so closely resemble each other in all other respects that their division even into separate subgenera must appear unnatural. The character drawn from the arrangement of the pharyngeal teeth in one or two rows has also been regarded by more recent authors as insufficient for the establishment of distinct genera. The great elongation of the anal fin should rather be employed for this purpose; but the species are so few that the division is destitute of practical importance.

The three Scandinavian species may be distinguished as follows:

A: Length of the base of the anal fin less than $^{3}/_{10}$ of that of the body.
  a: Length of the lower jaw less than $^{3}/_{4}$ of the least depth of the tail .... *Abramis blicca.*
  b: Length of the lower jaw more than $^{3}/_{4}$ of the least depth of the tail ... *Abramis brama.*
B: Length of the base of the anal fin more than $^{3}/_{10}$ of that of the body .... *Abramis ballerus.*

Besides these species, however, we must not forget three hybrids, which occur in Scandinavia as well as

[a] In Atter See (Austria) according to HECKEL and KNER, it keeps at a depth of 10 fthms., in winter even 20; and the shoals in which it is collected at this season betray their presence by rooting up the muddy bottom and discolouring the water.

[b] *Russeggers Reise*, p. 1032.

elsewhere, between the Breams and the Leuciscines. Instances of a Roach or a Rudd with more than 14 branched rays in the anal fin, of a Roach with pharyngeal teeth set in two rows, or of a White Bream with less than 18 branched rays in the anal fin, have been explained on the assumption that these forms are hybrids between the White Bream and the Roach or the Rudd. This explanation is indeed correct to all appearance; but its demonstration, which can be attained only by experimental methods, has still to be made by pisciculturists. These remarks also apply to the assumed hybrid between the Bream and the Roach. The last form is usually most like a Bream, but has only 15—18 branched rays in the anal fin.

THE WHITE BREAM OR BREAMFLAT (SW. BJÖRKNAN).

ABRAMIS BLICCA.

Plate XXXV, fig. 2.

Scales in the lateral line about 46 (45—50). Anal fin with 21—23[a] branched rays. Between the lateral line and the dorsal fin 9 or 10, in exceptional cases 11, rows of scales. Pectoral and ventral fins red or yellow at the base. Pharyngeal teeth set in two rows: (1)2(3), 5(6)—5,(1)2(3).

Fig. 199. Pharyngeal bones and pharyngeal cartilage of *Abramis blicca*, natural size: *a*, *b*, and *c* as in the preceding figure.

R. br. 3; *D.* $\frac{3}{8^{b}}$; *A.* $\frac{3}{21-23(24)}$; *P.* $\frac{1}{14-16(17)}$; *V.* $\frac{2}{8}$; *C.* $x+1+17+1+x$; *L. lat.* (43)45—50; *L. tr.* $\frac{9-10(11)}{5-6(7)}$ 1; *Vert.* 38—40.

Syn. Ballerus, RONDEL., *De pisc. lacustr.*, p. 155. *Blicca*, GESN., *Hist. Anim.*, lib. IV (Francof. 1620), p. 24 (+ (?) *Plestya*, p. 25, ex BELON.). *Cyprinus* quincuncialis, pinna ani ossiculorum viginti quinque, ART., *Gen.*, p. 3; *Syn.*, p. 13; *Spec.*, p. 20. *Cyprinus* pinnæ ani radiis viginti quinque, LIN., *Fn. Suec.*, ed. I, p. 124 (syn. nec descr.) = *Cyprinus Bjoerkna*, *Syst. Nat.*, ed. X, tom. I, p. 326 (syn. nec. descr.).

Cyprinus Plestya, LESKE, *Ichthyol. Lips. Spec.*, p. 69.

Cyprinus Blicca, BL., *Fische Deutschl.*, part. 1, p. 65, tab. X; EKSTR. (subg. *Abramis*), Vet.-Akad. Handl. 1830, p. 179; NILSS., *Prodr. Ichthyol. Scand.*, p. 31; FR., EKSTR., v. WR., *Skand. Fisk.*, ed. 1, p. 64, tab. 12; KR. (*Abramis*), *Danm. Fisk.*, vol. III, p. 389; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Sällsk. Handl. 1855, p. 82; GTHR. (*Abramis* subg. *Blicca*), *Cat. Brit. Mus., Fish.*, vol. VII, p. 306; FEDDERSEN, Naturh. Tids-kr. Kbhvn, ser. 3, vol. XII, p. 86; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 196, tab. CXXXVI; MÖB., HCKE, *Fisch. Osts.*, p. 118; LILLJ., *Sv., Norg. Fn., Fisk.*, vol. III, p. 313.

Cyprinus Laskyr, GÜLDENST. apud PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 326; — vide NORDM., *Voy. Russ. Mér.* (DEMIDOFF), tom. III, p. 504, tab. 22, fig. 1; — HCKL., KN. (*Blicca*), *Susswasserf. Östr. Mon.*, p. 123.

Abramis micropteryx et *Abr. erythropterus*, AGASS., *Mém. Soc. Sc. nat. Neuch.*, vol. I, p. 39 (cf. CUV., VAL., *Hist. Nat. Poiss.*, vol. XVII, pp. 44 et 58).

Abramis Bjoerkna, NILSS., *Skand. Fn., Fisk.*, p. 328; SIEB. (*Blicca*), *Susswasserf. Mitteleur.*, p. 138; MGRN, *Finl. Fiskfn.*, disp. Helsingf. 1863, p. 42; BLANCH. (*Abramis*, subg. *Blicca*), *Poiss. eaux douces Fr.*, p. 359; MALM (*Abramis*), *Gbgs. Boh. Fn.*, p. 565; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 398; BNCKE (*Blicca*), *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 123; FAT., *Fn. Vert. Suisse*, vol. IV, p. 358; MELA (*Abramis*), *Vert. Fenn.*, p. 333, tab. X; REUT., SUNDM., *Finl. Fisk.*, tab. IV.

Blicca argyroleuca, HCKL. KN., l. c., p. 120; DYBOWSKI, *Cypr. Livl.*, p. 202.

Obs. ARTEDI described this species with fair accuracy in *Descript. Spec. Pisc.* (p. 20, No. 9), under its Upland name of *Bjorkna*, and also included it in *Synonymia Piscium* (p. 13, No. 27) and *Gen. Pisc.* (p. 3, No. 3). But he failed to perceive that it was the species called *Ballerus* and *Blicca* by former ichthyologists, referring these names instead to his own *Blicca* (*Descr. Pisc.*, No. 11), to which LINNÆUS on his authority applied the specific name of *Ballerus*, which it has since retained. ARTEDI'S *Bjorkna* remained unknown to LINNÆUS, though the name is given both in the *Fauna Suecica* and

[a] Sometimes 24.

[b] 7—9, according to KLOYER.

[c] Sometimes 19, according to FATIO.

the *Systema Naturæ*. This is evident from the appended note in the *Fauna*, where LINNÆUS expressly states that he had counted 35 rays in the anal fin of the *Bjorkna* — a number which, among the species indigenous to Sweden, is to be found in *Abramis ballerus* alone. In RETZIUS's edition of the *Fauna Suecica* the error was not corrected, although BLOCH had already given a lucid description and a good figure, considering the date at which it was executed, of ARTEDI's species, under the name of *Cyprinus Blicca*, which it still retains. NILSSON was the first Scandinavian writer to restore the name of *Bjorkna* to its original signification, and to recognise BLOCH's nomenclature (see *Prodr. Ichth. Scand.*); but EKSTRÖM had previously (Vet.-Akad. Handl. 1830) expressed the same opinion on the strength of information privately supplied to him by NILSSON.

The White Bream is the smallest Scandinavian member of the genus *Abramis*. It never attains any considerable size. Its ordinary length is between 15 and 23 cm., rising, however, sometimes to 30 or, in exceptional cases, 35 cm., including the whole of the caudal fin.

In most respects the White Bream comes nearest our common Bream, and in appearance so closely resembles young Bream that it is frequently confounded with them, under the common name of *Braxenpanka*. In our description we shall therefore lay special stress on the differences brought to light by a comparison between them.

In the form of the body it is hardly possible to detect any constant difference between the White Bream and the Bream. The body of both is compressed and deep, though generally a little less so in the former. In White Bream preserved in the Royal Museum, and measuring between 106 and 239 mm. in length to the end of the middle rays of the caudal fin, the greatest depth of the body is between 31 % (in young specimens) and nearly 40 % (in old) of its length, and the greatest thickness (with more individual variations) between $1/3$ and $1/4$ of the greatest depth. The least depth of the tail increases during these changes of growth from 9·4 to 11·3 % of the length of the body. The back, which rises somewhat abruptly from the occiput, then ascends in a regular curve to the beginning of the dorsal fin, where it forms an obtuse angle, and afterwards slopes almost in a straight line to the caudal fin. Though carinated from the occiput to the dorsal fin, it is thicker and more convex than in the Bream. The belly is flat from the pectoral region to the ventral fins. From this point to the vent it is sharply carinated. The ventral profile is almost straight from the pectoral region to the anal aperture, where it forms an obtuse angle, more acute, however, than the dorsal angle, and advances in a somewhat incurved line to the caudal fin.

The head, the length of which is about $1/5$ ($21 1/2$—20 %) of that of the body, tapers uniformly forwards from above and below, but the snout is fairly thick and obtuse, projecting a little beyond the mouth. The forehead is broad and convex, the breadth of the interorbital space being about $7 1/2$—8 % of the length of the body, or $35 1/2$—$38 1/2$ % of the length of the head. The frontal profile is straight from the occiput to the nostrils, where it descends abruptly, and slopes towards the snout. The sides of the head are moderately compressed, the thickness being equal to the depth, measured at the anterior orbital margin. The mouth is small and ascends only slightly, but may be projected to some distance in a tubular form. The corner of the mouth falls short of the perpendicular from the anterior orbital margin. The length of the snout, which measures about 5—6 % of that of the body or about 23—31 % of that of the head, is as a rule equal in young specimens to the length of the upper jaw (from the tip of the snout), in old a little greater. The length of the lower jaw measures about $6 1/2$—7 % of that of the body, or about 32—34 % of that of the head, is less than that of the suture between the suboperculum and operculum, and also than 71 % (in the said specimens 70—57 %) of the least depth of the tail. The eyes, on the other hand, are comparatively larger than in the Bream, their longitudinal diameter varying in our specimens between about 34 and 27 % of the length of the head, while in young specimens it is perceptibly greater, in old slightly less, than the length of the snout. Their size is often so considerable that the White Bream may be at once distinguished thereby from the young Bream in its company. The position of the eye is such that the postorbital length of the head in young specimens is less, in old somewhat more, than half its entire length. The nostrils are set much as in the Zärthe, the distance between the posterior nostril and the upper anterior part of the orbital margin being about $2/5$ of that between the anterior nostril and the tip of the snout. The anterior nostril is smaller than the posterior, but circular; while the latter is obliquely set and elliptical or crescent-shaped. The gill-openings are smaller than in the Zärthe, the branchiostegal membranes coalescing below with the isthmus at a greater distance from each other and farther back, in a line with the hind (vertical) margin of the preoperculum.

The gill-rakers are short and scattered, the outer row on the front of the first branchial arch containing 14 or 15, and the outer anterior margin of the pharyngeals being furnished with almost as many (13). The pharyngeals are armed as a rule with two rows of teeth (fig. 199), the inner row being always composed of 5 compressed and nearly straight teeth, with distinctly hooked tips in most cases only in the hindmost (uppermost) tooth and the middle one, the outer generally of two (in exceptional cases one or three) smaller, more cylindrical teeth. According to EKSTRÖM the outer row is often wanting, which probably depends on the shedding of the teeth, when the pharyngeal teeth readily drop out, or lie loose in the gums[a].

The dorsal fin lies on the hind arm of the angle formed by the dorsal profile, so high that the first rays occupies the apex of the back. The distance between it and the tip of the snout measures more than half (about 51—54 %) of the length of the body, but less than 88 % (81—87 %) of the distance between the tip of the snout and the anal fin. Its height is about twice its length, the longest ray measuring about 22—26 % of the length of the body, and the base about 11—12 % of the same. The fin is pointed in front, with the upper posterior margin obliquely truncate, the height behind being only $^1/_3$ of that in front. The anal fin, in consequence of its length, is not so obliquely truncate, but more deeply concave at the margin. The distance between it and the tip of the snout is about 58—64 %, the length of the longest ray about 15 (exceptionally 14)—18 %, and its base about 23 (exceptionally 21)—$26^1/_2$ %, of the length of the body. The caudal fin is deeply forked, with the lower lobe somewhat longer than the upper. Its middle rays measure about 9 or 10 % (exceptionally $8^1/_2$ or 11 %) of the length of the body, or rather less than $^2/_5$ of that of the longest ray in the lower lobe.

The pectoral fins are normal in form, but comparatively short, always shorter than the preabdominal length. Their length is about 17 ($16^1/_2$)—18 ($18^1/_2$) % of that of the body. The ventral fins are inserted at a distance from the tip of the snout measuring about 40—45 % of the length of the body, and less than 87 % ($77^1/_2$—$86^1/_2$ %) of the distance between the dorsal fin and the same point. Their length is about 15 ($14^1/_2$)—18 % of that of the body. Both the preabdominal length and the postabdominal, the latter as a rule rather less than the former, measure about $^1/_5$ (20—23 or 24 %) of the length of the body.

The body is covered with large, striated, and imbricated scales, very like those of the Roach, and with more distinct striæ than those of the Bream. This peculiarity combined with their relative size, is especially characteristic of the White Bream, and renders it easily recognisable, if only attention be paid hereto. The most trustworthy standard of the size of the scales, however, is their number. In the lateral line, which lies rather low, nearer to the belly than to the back, we generally find only 46 scales — the ordinary variations lie between 45 and 48 — and above the lateral line only 8 or 9 large rows and one smaller row, the latter at the very base of the dorsal fin (the Bream has at least 12 such rows). Between the lateral line and the insertion of the ventral fin we usually find 6 rows of scales. The distribution of the scales on the anterior part of the dorsal margin and on the ventral margin behind the ventral fins has already been described.

The coloration of the White Bream changes somewhat with age and according to the season of year. The young are of a lighter colour and have paler fins. In spring during the spawning-season, or as shown in our figure, the ground colour of old specimens is silvery white with a strong dash of yellow, darker above and gradually passing into the olive gray of the back. The sides of the head are bright with a play of many handsome colours. The iris is of a faint golden yellow, densely punctated with fine, dark green dots, collected, especially above, into a broad, dark band. The dorsal and caudal fins are of a plain olive gray. The pectoral, ventral, and anal fins are pale, with more or less ruddy rays and a reddish tinge at the base. By this red or orange hue of the inferior fins it is always easy to distinguish the White Bream from young Bream, in which these fins are pale and colourless. On the conclusion of the spawning the sides of the body resume their dress of silvery white.

In the White Bream, says FATIO, the back and the sides of the body are often strewn with some roundish, black spots. In normal Scandinavian specimens we have never found such spots; but in a variety (hybrid) which

[a] Unless it be the case that EKSTRÖM met with hybrids between the White Bream and the Bream, with the external characters of the former and the dentition of the latter.

occurs in the River Helge, and of which we shall have more to say below, these spots, according Mr. SVENSSON, Preparator at the Royal Museum, are very common. To judge by their appearance in one stuffed specimen, however, they seem to be morbid symptoms, concretions of pigment on abraded scales or more or less injured fin-rays.

The White Bream — the German *Blicke* or *Guster*, the Danish *Flire*, *Blege*, or *Blaafinne*, and the French *Bordelière*[a] — has an extensive range in fresh water north of the Alps, from Ireland eastwards throughout Russia-in-Europe[b]. In Finland, according to MELA, it goes north to lat. 63° 40'. In Norway it has not been found. It is common in most of the lakes of Southern Sweden and in the inner part of the Baltic island-belt. As it is a species generally despised, and while confounded by most fishermen with young Bream, goes by different names in most of the localities where it occurs and is known to be a distinct form, we are as yet unable to fix the limits of its range in Sweden, especially to the north. We know that it is common in the Mälar Valley, Lake Wener, and the southern provinces. NILSSON found it in the Dal Elf at Söderfors in 1829. WISTRÖM supplied LILLJEBORG with information of its occurrence in the fjords near Hudiksvall (about 62° N. lat.), and STEFFENBURG of its presence in the basin of the Dal Elf up to Lake Öje in Dalecarlia (61° N. lat.). According to MALM it is pretty common in Bohuslän, according to NILSSON common in Scania. It is known by many names, e. g. *Bjälke*, *Blecka*, *Björkfisk*, *Björkare*, *Kjärta*, *Panka*, *Blapanka*, with several different dialectic pronunciations of these words.

The White Bream thrives best in lakes and rivers with a clayey and sandy bottom overgrown with weeds. Early in spring it repairs to shallow and weedy shores, where it spawns periodically in June or even at the middle of May. In favourable weather each spawning lasts about three days, at longer or shorter intervals. The old fish spawn first, the young some time later. The roe is deposited on the weeds, to which it adheres. During the operation of spawning the fish plunge and splash about at the surface, where they are seldom seen on other occasions. The White Bream usually keeps to the bottom, sometimes swimming in mid water. Though shy and greatly afraid of noise at other times, it is tame and fearless during the spawning, when it may be caught with ease.

It passes the whole summer in shallow water, and does not retire to the depths until autumn, when it descends to its winter-quarters. It is one of the most voracious Cyprinoids, feeding on weeds, insects, and worms, and biting so freely that it is a nuisance to the fisherman, for it often secures the bait without being hooked. It has therefore received the nickname of *ätare* (glutton).

Though it thieves so greedily, and is always on the alert where there is anything to be got, it is always lean. As it is also of small size, and the flesh very bony, it is never in request, being eaten only for want of better fish or by the poor. Like most of the Cyprinoids, it is very prolific — BLOCH estimated the number of the eggs in a female weighing 117 grm. at about 108,000 — and thus yields quite a considerable supply of food to the larger and better flavoured fishes-of-prey.

No special fishery is carried on for the White Bream to the best of our knowledge; but as it is, so to speak, omnipresent, it is taken with most of the tackle employed for other fishes. The greatest quantity is caught in spring, at the approach of the spawning-season, in the baskets (Sw. *lanor*) set for Eel in rivers and large streams.

(EKSTRÖM, SMITT.)

As we have mentioned above, the difficulties of the systematist are increased by the occurrence in this family of forms whose characters incapacitate them for a place either within the Leuciscine or the Abramidine subfamily, though their whole nature distinctly indicates their near relationship to one or other of the species already described. These forms have been explained as hybrids; and in Southern Sweden (Scania and Blekinge) we find two of them, descended probably on one side from the White Bream and on the other from the Rudd

[a] "Because it always keeps to the shore" (RONDELET).

[b] GRIMM, *Fishing and Hunting in Russian Waters*, p. 15.

or the Roach. These forms were first discovered in Germany, and HECKEL, who did not regard them as hybrids, bestowed upon them the special generic name of *Bliccopsis*[a]. Much may be urged against this name as co-ordinating hybrids with true species and genera in the systematic nomenclature; and FATIO[b] therefore coined the compound names *Scardo-blicca Erythro-Bjorkna* and *Leucisco-Blicca Rutilo-Bjorkna*. But the forms have been most accurately defined in Bavaria by SIEBOLD and JACKEL, who have retained the Heckelian generic name.

BLICCOPSIS ERYTHROPHTHALMOIDES.

(HYBRID BETWEEN THE WHITE BREAM AND THE RUDD.)

Fig. 200.

Body deep as in the deepest Rudd, the greatest depth being 34—39 % of the length, with the forepart of the back convex and covered with scales in the median line. Dorsal fin with 8 or 9 branched rays[c], *anal with 15*[d] *or 16. Distance from the tip of the snout to the dorsal fin more than half the length of the body, and perceptibly greater than that to the foremost point in the insertion of the ventral fins. At most 10 scales in a transverse row above the lateral line. Pharyngeal teeth set in two rows and more or less distinctly pectinated.*

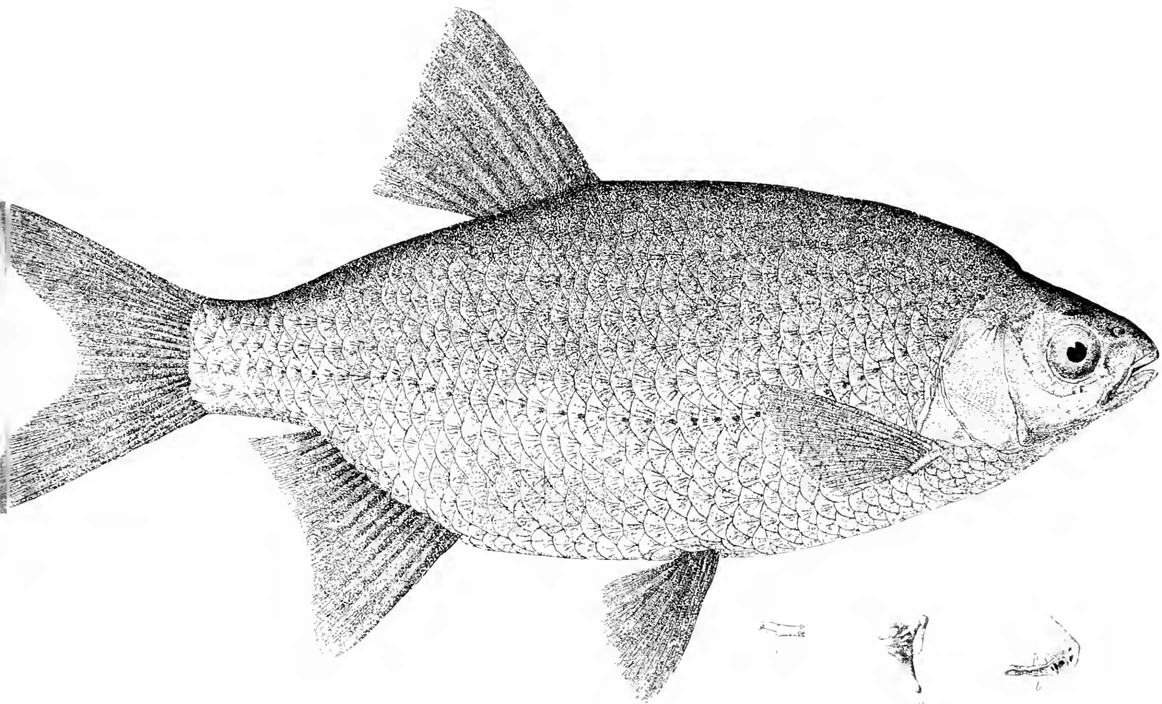

Fig. 200. *Bliccopsis erythrophthalmoides*, taken in a Herring-seine off Karlskrona, in May, 1876, by Mr. LUNDBERG, Inspector of Fisheries. Natural size. *a*, left pharyngeal, seen from above, natural size; *b*, the same, seen from without, natural size; *c*, the last tooth in the inner row, twice the natural size.

[a] *Russeggers Reisen*, Bd. 2, p. 1032.
[b] *Faune des Vertébrés de la Suisse*, vol. IV, pp. 376, 387.
[c] Sometimes 7, according to FATIO.
[d] Sometimes 12—15, according to FATIO.

R. br. 3; *D.* $\frac{3}{8^{a}-9}$; *A.* $\frac{3}{14-16^{b}}$; *P.* $\frac{1}{16-17}$; *V.* $\frac{2}{8-9}$;

C. $x + 1 + 17 + 1 + x$; *L. lat.* 42—46; *L. tr.* $\frac{9-10}{4-5}$ 1.

Syn. Bliccopsis Buggenhagii, p. p. HECKEL, l. c. (nec BLOCH); QVENNERSTEDT (*Cyprinus*), Öfvers. Vet.-Akad. Förh. 1877, No. 7, p. 13, tab. VII et VIII; MALM (*Abramidopsis*), Gbgs Naturh. Mus. Årsskrift, III (1881), p. 25.

Abramis abramo-rutilus, p. p., HOLANDRE, *Fn. Mos.*, vide SIEB. (*Bliccopsis*), *Susswasserf. Mitteleur.*, p. 142.

Bliccopsis erythrophthalmoides, JÄCKEL, *Fisch. Bay.*, Abh. Zool. Miner. Ver. Regensburg, H. 9 (1864), II, p. 49. Hybrid between Leuciscus erythrophthalmus and Abramis blicca, GTHR. *Cat. Brit. Mus., Fish.*, vol. VII, p. 233.

The hybrid assumed on the above grounds to exist between the White Bream and the Rudd attains in Sweden a length of at least 27 cm., including the whole caudal fin. It has the convex dorsal margin of the Rudd — though the dorsal profile, as in the White Bream, forms a sharper break at the occiput — the broad forehead of the Rudd — the breadth of the interorbital space sometimes about 45 % of the length of the head — and the comparatively low dorsal fin of the same species — the length of the longest ray less than $^{1}/_{5}$ of that of the body. But the length of the anal fin, which at least exceeds 16 % of that of the body, at once shows, apart from the number of the rays, that the fish cannot be referred to this species. The pharyngeal bones and teeth are also most like those of the Rudd; but the only essential difference in this respect between the Rudd and the White Bream lies in the more elongated form of the teeth, with longer and more lateral masticatory surface, and their more distinct pectination in the former. In the only specimen of this hybrid whose pharyngeal apparatus we have been able to examine, the teeth numbered 3, 5—5, 3.

In Sweden, as far as we know, this hybrid has been found only at two localities in Scania and one in Blekinge. It was first taken in 1864 by Prof. BERGGREN in Lake Ring; but Prof. QVENNERSTEDT was the first (1876) to notice and determine this find, describing at the same time two other specimens from the same locality, one procured through BERGGREN, the other taken by Prof. NAUMANN, who has also presented a specimen to the Museum of Gothenburg. In the meantime (1869) a specimen denoted by QVENNERSTEDT (l. c., p. 21) as 'Ex. 1', had been caught in the River Helge, and stuffed by Mr. SVENSSON for the Museum of Kristianstad. The original of our figure was taken at the beginning of May, 1876, by Mr. LUNDBERG, Inspector of Fisheries, among a haul of Herrings caught in a seine off Lagervik at Karlskrona. According to QVENNERSTEDT two more specimens have been found in Lake Ring, but not preserved, so that in all 8 examples have hitherto been met with in Sweden, most of them in fresh water, but one in the brackish water of the Baltic island-belt.

[a] Sometimes 7, according to FATIO.

[b] Sometimes 12—15, according to FATIO.

BLICCOPSIS ABRAMO-RUTILUS.

(HYBRID BETWEEN THE WHITE BREAM AND THE ROACH).

Fig. 201.

Body more elongated, deep as in the Rudd or Roach — greatest depth about 31 % of the length. Dorsal margin more compressed, but covered with scales, though not regularly arranged, in the median line. Dorsal fin with 9[a] branched rays, anal with 16[b]. Distance from the tip of the snout to the dorsal fin about half the length of the body, and only slightly greater than that to the foremost point in the insertion of the ventral fins. At most 10 scales in a transverse row above the lateral line. Pharyngeal teeth set in one or two rows and with smooth or only faintly pectinated masticatory surface.

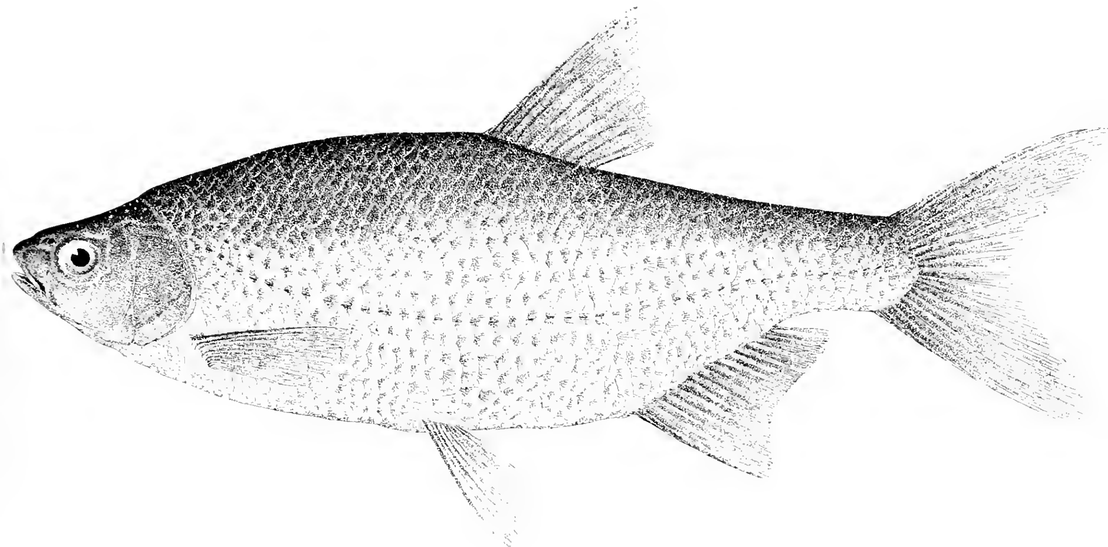

Fig. 201. *Bliccopsis abramo-rutilus*, ♂, taken at Kristianstad, 4th May 1872. $^3/_4$ of the natural size. From a stuffed specimen.

R. br. 3; *D.* $\frac{3}{9^a}$; *A.* $\frac{3}{16^b}$; *P.* $\frac{1}{16(15)}$; *V.* $\frac{2}{8}$; *C.* $x+1+17+1+x$; *L. lat.* 47[c]; *L. tr.* $\frac{10^d}{5-6}$ 1.

Syn. *Abramis (Bliccopsis) abramo-rutilus*, p. p., HOLANDRE, SIEBOLD — vide supra.

Abramis Buggenhagii, SEL.-LONGCH., *Fne Belge*, p. 216.

Bliccopsis abramo-rutilus, JÄCKEL, l. c., p. 53.

Hybrid between Abramis blicca and Leuciscus rutilus, GTHR., *Cat. Brit. Mus., Fish.*, vol. VII, p. 215.

In its most pronounced form, the form with the influence of the Leuciscine type most distinct, this hybrid most resembles a Roach with the anal fin considerably elongated and the forepart of the back extraordinarily compressed (carinated). It thus differs at the first glance from the preceding hybrid partly in the more elongated body, partly in the apparently greater size of the scales. These are not so densely

[a] According to FATIO 8, or more seldom 7.

[b] According to FATIO 11—15, more seldom 16.

[c] 41—46, according to FATIO.

[d] $\frac{8-9}{4-5}$, according to FATIO.

imbricated, and a greater part of their surface is thus left bare, the rule being that in this hybrid most of the scales, at least those on the middle of the sides of the body, have the free (hind), externally visible portion half (or more) as long as deep, while in the preceding hybrid, as in the Rudd and the White Bream, the length of the said part of each scale is less than half its depth. The same difference in the position of the dorsal fin as appears between the Roach on one hand, the Rudd and White Bream on the other, is also maintained here, the distance between the tip of the snout and the beginning of the said fin being less in this hybrid than half the length of the body. In the specimen examined, it is true, the dorsal fin contains 9 branched rays; but the last of them is slender and branched only at the tip, not, as is generally the case in the Cyprinoids, divided almost to the base. The pharyngeal teeth we have not been able to examine; the above remark on this head is taken from JÄCKEL, who found them to number: 0(1 or 2), 6(5)—5(6), 0(1 or 2).

This form, according to Mr. SVENSSON, is the most common hybrid in the River Helge and the lakes through which this river flows as it approaches the sea. Kristianstad Museum possesses three stuffed specimens, one of which we have been enabled to examine by the kindness of Lecturer WAHLSTEDT. It is a male, caught on the 4th of May, 1872, with the small, verrucose tubercles characteristic of the spawning season, on the sides of the head (thickest on the gill-covers), the lateral scales on the forepart of the body, and the inner surface of the pectoral fins. The coloration seems to have been that typical of the Roach, the front part of the anal fin, however, being of the black colour frequently present in the White Bream. The entire length to the tip of the lower caudal lobe is 29 cm., but to the end of the middle caudal rays — the measurement constantly termed in this work, unless otherwise specified, the length of the body — only 256 mm. The greatest depth is 30·7 %, and the least depth 10 %, of the length of the body. The greatest thickness — in the stuffed specimen just in front of the dorsal fin — measures 37·6 % of the greatest depth. The length of the head is 20·7 % of that of the body, and the postorbital length of the same part half the entire length of the same. The distance from the tip of the snout to the beginning of the dorsal fin is slightly less than half the length of the body. The base of the dorsal fin measures 12·5 %, its longest ray 20·3 %, of the length of the body, and its last ray rather more than $^1/_3$ ($34^1/_2$ %) of the length of the longest ray. The beginning of the anal fin lies at a distance from the tip of the snout equal to 65·6 % of the length of the body; its base measures 16·8 %, its longest ray 15 %, of the same length. The length of the pectoral fins is 16 % of that of the body. The ventral fins are only slightly shorter than the pectoral, and the distance between them and the tip of the snout is 93 % of that between the dorsal fin and the same point. The length of the middle caudal rays occupies 9 % of that of the body. Apart from all the other resemblances to the Roach, the position of the ventral fins in relation to the beginning of the dorsal fin shows that one of the parent species of this hybrid must have been the Roach; while the length of the pectoral fins and the number of the scales admit of the assumption that the White Bream was the other parent species, but exclude the Bream from the possible progenitors of this hybrid.

From the same locality the Museum of Kristianstad has received two other hybrids, similar to each other, one of which is mentioned by QVENNERSTEDT (l. c.) under the head of "Ex. 2". The other (fig. 202) was caught on the 17th of March, 1869, and has been lent to me for the purpose of examination by Mr. WAHLSTEDT. It has the coloration of the White Bream, in particular the above-mentioned black spots[1] on the sides of the body, the dorsal, anal, and caudal fins, and the right ventral fin. Two similar spots of somewhat larger size, with the same symptoms of skin-disease, are situated on the right side of the head, the lower on the hind margin of the preoperculum, the upper on the front margin of the operculum. The specimen evidently has more White Bream blood in it, a cir-

[1] These spots, which are reproduced in our figure, cannot be minutely examined in a dried specimen, but are probably caused by *Holostomum cuticola* (NORDMANN, *Mikrographische Beiträge zur Naturgeschichte der wirbellosen Thiere*, Heft. I, p. 49, taf. IV, fig. 1—4), a flatworm occurring in the skin and eyes of many fishes, and belonging to the Trematod order — cf. for example fig. 211, p. 209 in MAX VON DEM BORNE, *Handbuch der Fischzucht und Fischerei*. The spots themselves are pure black; and the scales over which they extend are partially abraded. At the centre of some spots is a blister, concealing a cavity which was probably inhabited by the parasitic worm.

cumstance especially distinct in the form of the body and the situation of the dorsal fin. The fins are somewhat damaged; but the length to the tip of the lower caudal lobe was probably almost 23 cm. The length of the body (to the end of the middle caudal rays is 199 mm. Greatest depth 32·2 % of the length of the body, least depth 9·5 % of the same. Greatest thickness 39 % of the greatest depth. Length of the head 21·1 % of that of the body, postorbital length of the head 47·6 % of its entire length. Distance from the tip of the snout to the beginning of the dorsal fin 51·3 %, base of the dorsal fin 12·3 %, of the length of the body. Distance from the tip of the snout to the beginning of the anal fin 62·2 %, base of the said fin 17·1 %, of the length of the body. Pectoral fins equal in length to the base of the anal fin, ventral fins 15½ % of the length of the body. Distance between the latter fins and the tip of the snout 87·2 % of that between the dorsal fin and the same point. Length of the middle caudal rays 7·5 % of that of the body. Above the lateral line 10 scales, below it 6, in an oblique transverse row from the insertion of the ventral fin. Scales in the lateral line 47. Fin-formula identical with that of the preceding hybrid.

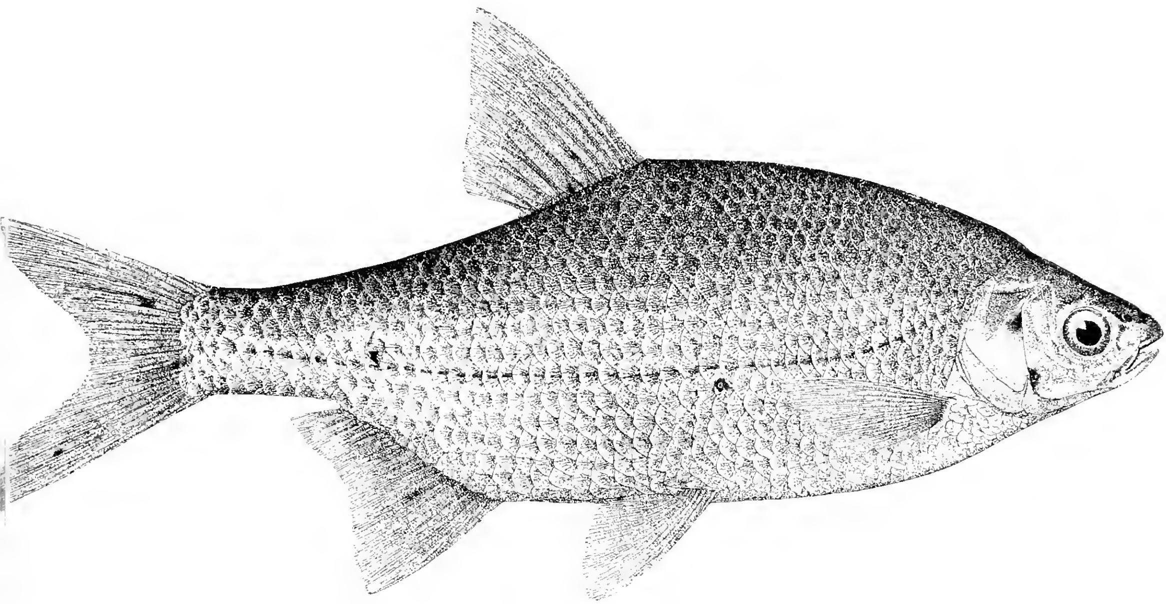

Fig. 202. *Bliccopsis rutilo-blicca* from the R. Helge at Kristianstad, taken April 17, 1869. Natural size. Among the stuffed specimens in the Museum of Kristianstad School.

This latter hybrid is thus distinguished from the White Bream mainly by a thicker body and a shorter anal fin.

THE BREAM (SW. BRAXEN).

ABRAMIS BRAMA.

Plate XXXIV, fig. 2.

Scales in the lateral line about 53 (51—56[a]). Anal fin with 25—27[b] branched rays. Between the lateral line and the dorsal fin 12—14 (in exceptional cases 11) rows of scales. Pectoral and ventral fins grayish white at the base. Pharyngeal teeth set in a single row; 5(6)—5.

Fig. 203. Pharyngeal bones of *Abramis brama*, *a* and *b* natural size: *a*, left pharyngeal, seen from above; *b*, the same, seen from without (the left); *c*, the last (uppermost) tooth, seen from behind, twice the natural size.

R. br. 3; *D.* $\frac{3}{8-9^{c}}$; *A.* $\frac{3}{25-27^{b}}$; *P.* $\frac{1^{d}}{16-18}$; *V.* $\frac{2}{8^{e}}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 51—56[a]; *L. tr.* $\frac{12-14}{6-7}$ 1; *Vert.* 43—45.

Syn. *Abramis*, BELON, *Nat.*, *Div. Poiss.*, p. 318. *Cyprinus latus sive Brama*, RONDEL., *De Pisc. Lacustr.*, p. 154; SCHONEV., *Ichthyol. Slesv. Hols.* p. 33. *Cyprinus* pinnis omnibus nigrescentibus, pinna ani ossiculorum viginti septem, ART., *Ichthyol.*, *Gen. Pisc.*, p. 6; *Syn. Pisc.*, p. 4; *Descr. Spec. Pisc.*, p. 20; LIN., *Fn. Suec.*, ed. I, p. 121.

Cyprinus Brama, LIN., *Syst. Nat.*, ed. X, tom. I, p. 326; BL., *Fisch. Deutschl.*, part. I, p. 75, tab. XIII; RETZ., *Fn. Suec. Lin.*, p. 360; PALL. *Zoogr. Ross. Asiat.*, tom. III, p. 325; EKSTR. (subg. *Abramis*), Vet.-Akad. Handl. 1830, p. 169; NILSS., *Prodr. Ichth. Scand.*, p. 30; EKSTR., v. WR., *Skand. Fisk.*, ed. I, p. 175, tab. 42; CUV., VAL. (*Leuciscus*), *Hist. Nat.*, *Poiss.*, tom. XVII, p. 9; KR. (*Abramis*), *Danm. Fisk.*, vol. III, p. 369; SUNDEV. (*Cyprinus*), Stkhlms L. Hush. Sällsk. Handl. 1855, pp. 81 et 173; NILSS. (*Abramis*), *Skand. Fn.*, *Fisk.*, p. 324; HCKL, KN., *Susswasserf. Östr. Mon.*, p. 104; WIDEGR. (*Cyprinus*), *Fiskfn.*, *Fisker. Norrb. L.*, 1860, pp. 7 et 13; DYB. (*Abramis*), *Cypr. Livl.*, p. 190; SIEB., *Susswasserf. Mitteleur.*, p. 121; MGRN, *Finl. Fiskfn.*, disp. Helsingf., p. 40; WIDEGR. (*Cyprinus*), Landtbr. Akad. Tidskr. 1863, pp. 201, 203, 207; GTHR (*Abramis*), *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 300; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 183; MALM, *Gbgs. Boh. Fn.*, p. 565; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 395; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 118; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 193, tab. CXXXV; MELA, *Vert. Fenn.*, p. 332, tab. X; MÖB., HCKE, *Fisch. Osts.*, p. 115; NORBÄCK, *Handl. Fisker.*, *Fiskafv.*, p. 433; REUT., SUNDM., *Finl. Fisk.*, tab. VII; LILLJ., *Sv.*, *Norg. Fisk.*, vol. III, p. 274.

Cyprinus Farenus, EKSTR., Vet.-Akad. Handl. 1830, p. 175; NILSS., *Prodr.*, l. c.: — juvenem hujus speciei judicarunt FRIES et EKSTR., *Skand. Fisk.*, ed. I, p. 57 (anno 1837).

Abramis vetula, HECKEL; *Abramis microlepidotus* + *Abr. argyreus*, AGASSIZ; *Abramis Gehini*, BLANCHARD, vide SIEBOLD, l. c.

Obs. After the determination given by FRIES and EKSTRÖM of ARTEDI'S *Faren*, later writers — NORDMANN (*Voyage of Demidoff*, 3, p. 503), VALENCIENNES, NILSSON, SIEBOLD, etc. — have adopted this designation as a synonym of *Abramis brama*. Here as elsewhere, however, the Swedish name proves the safest guide to the correct interpretation of ARTEDI'S species, though a slip of the pen (27 rays in the anal fin, instead of 37) has been overlooked both in *Syn. Pisc.* and the short diagnosis in *Descr. Spec. Pisc.* See the note to the following species.

[a] Sometimes 49, according to LILLJEBORG, or even 45 (in specimens 16 cm. long), according to VALENCIENNES; sometimes 63, according to DAY.

[b] 23—28, according to SIEBOLD. Sometimes 29, according to CZERNAY.

[c] Sometimes 7, according to KRØYER. Sometimes (in our largest specimen) 10, though here the last ray is not divided, in accordance with the general rule, to the base, and is besides slender, being thus best reckoned as a part separated from the ray in front of it.

[d] $\frac{1}{15}$, according to EKSTRÖM.

[e] Sometimes 7, according to KRØYER.

The Bream is one of the largest Swedish Cyprinoids. The ordinary length, including the whole caudal fin, is 23—35 cm.; but it is not very unusual to meet with Bream 5 dm. long, and according to the reports sent in to the Swedish Fisheries Commission of 1881—83 the species attains in many parts of Sweden a length of about 59 cm. and in Scania even of 74 cm. The weight, on the same authority, is sometimes $18\frac{1}{2}$ Sw. lbs. (nearly 8 kilo).

The body is compressed, thin, and deep, the greatest depth, which occurs at the beginning of the dorsal fin, being about 34—38 % of the length, and the greatest thickness about 27—36 % of the greatest depth. The least depth, just in front of the caudal fin, is about $9\frac{1}{2}$ (in young specimens sometimes $9\frac{1}{3}$) —$10\frac{1}{4}$ % of the length of the body. The dorsal profile, which rises more or less sharply from the occiput, most abruptly if the fish be fat, from this point forms a regular curve to the first ray of the dorsal fin, where it makes an obtuse angle, afterwards descending almost in a straight line to the base of the caudal fin. The back is compressed and thin, but not carinated, all the way to the dorsal fin; from this fin to the caudal it is somewhat plumper and convex. The belly, as usual, is flat to the ventral fins and carinated from this point to the anal aperture. From the isthmus to the ventral fins the ventral line is almost straight, but slopes a little towards the anal aperture, where it forms an angle more obtuse than the dorsal; from the vent it rises almost in a straight line to the end of the anal fin, between which point and the caudal fin it curves inwards.

The head is as a rule equal in size to that of the White Bream, measuring $21\frac{1}{2}$—20 % of the length of the body; but in young specimens, even those about 2 dm. long, its length may be 23 or 24 % of that of the body. It is so much compressed that the greatest thickness, across the opercula, is about equal to the postorbital length, which in young Bream is somewhat less, in old rather more, than half of its entire length. The forehead from the occiput to the nostrils is straight, broad, and convex, the breadth of the interorbital space being about 8—9 % of the length of the body or 36—41 % of the length of the head. Both on the forehead and the sides of the head the pores belonging to the system of the lateral line are quite distinct. From the occiput two parallel rows of pores (the frontorostral branches of the system, cf. fig. 104, p. 368) run along the forehead to a point almost vertically above the eyes; these pores are 8 or 9 in number, and the first two or three lie somewhat within the line, as if they composed an independent row. Another row of similar pores (the suborbital branch of the system), the number of which is still greater, also begins at the occiput, a little below the former. This row bends up towards the forehead above the cheek, then descends below the eye, and ends half-way between the tip of the snout and the nostrils. Similar pores also occur at the posterior and inferior margins of the preopercula and on the under surface of the lower jaw (the mandibular branch of the system). Above the nostrils lies the depression usually present in the Cyprinoids, terminating the mobile portion of the snout (see above), which is obtuse and projects only slightly beyond the mouth. The mouth is small and turned slightly upwards, but when it is opened, may be protruded to a considerable distance in a tubular form. When the mouth is closed, the upper jaw projects some way beyond the lower. The corner of the mouth lies in the perpendicular from the anterior margin of the nostrils. In this species too the length of the snout, which varies between about 6 and $7\frac{1}{2}$ or nearly 8 % of the length of the body, or between 28 and 38 % of that of the head, is as a rule in young specimens about equal to, in old somewhat greater than, the length of the upper jaw from the middle of the tip of the snout. The length of the lower jaw varies between about 8 and nearly 10 % of that of the body, or between about 35 and 45 % of that of the head, and is greater than that of the suture between the suboperculum and the operculum, and also more than 75 % of the least depth of the tail (76—95 % in our specimens, which are between 17 and 47 cm. long). The eyes are as a rule comparatively smaller than in the White Bream, their longitudinal diameter varying in our specimens between about 28 and 19 % of the length of the head. But this great reduction depends to a considerable extent on the fact that our largest Bream are more than twice the size of our largest White Bream. The position of the eyes, on the other hand, is essentially the same as in the White Bream. The nostrils, which in form are exactly like those of the White Bream, occupy in young Bream the same position as in the White Bream, but in old specimens are removed by the prolongation of the snout comparatively nearer to the eyes. The gills, the opercula, the branchiostegal membrane and rays, resemble those of the White Bream. The gill-rakers are more numerous than in the said species, their number in the outer row on the front of the first branchial arch being 22 or 23, on the outer anterior margin of the pharyngeals 15 or 16. The pharyngeal teeth (fig. 203) are always set in one row, except during the shedding of the teeth, when one or two may be found in the gums within the main row, which usually consists of 5 compressed teeth, obliquely truncate at the crown, with hollowed masticatory surface and slightly hooked tip. The pseudobranchiæ are distinct in young Bream, in old concealed.

The dorsal fin begins at the apex of the angle formed by the dorsal profile, almost vertically above the middle point in the postabdominal part, and at a distance from the tip of the snout which increases with age, measuring about 52—58 % of the length of the body, or (in our specimens) about 88—94 % of the distance between the tip of the snout and the anal fin. In this species too its height is about twice its length — longest (first branched) ray about 21—26 % (sometimes 27 %) of the length of the body, and the base about $11^1/_2$ (sometimes 11)—$12^1/_2$ % of the same. The upper posterior margin of the fin is so obliquely truncate that in front the height is more than three times as great as behind. The anal fin is of about the same form, and occupies about the same position as in the White Bream; but is generally somewhat longer. In proportion to the length of the body the distance between this fin and the tip of the snout is about 59—62 %, its base about $24^1/_2$ (sometimes 24)—27 %, and its height in front about 20—17 % (in our largest specimen $15^1/_2$ %). The caudal fin is deeply forked, the lower lobe being longer than the upper. The middle rays measure about 10—$7^1/_2$ % of the length of the body, or about $^1/_3$ of that of the longest ray in the lower lobe of the fin.

The tips of the pectoral fins extend (in the males and sometimes in the females) to the insertions of the ventrals or a little farther, the length of the former pair being about 20—$21^1/_2$ % of that of the body. The ventral fins are set at a distance from the tip of the snout measuring about 44—$42^1/_2$ % of the length of the body, or less than 83 % (82—74 %) of the distance between the tip of the snout and the dorsal fin. Their length is about 17 % (16—$17^1/_2$ %) of that of the body. The postabdominal length is always less than the preabdominal, the former varying between about 17 and 20 %, the latter between about 23 and 20 %, of the length of the body.

The scales are large, finely striated, broader than long, and of a rounded quadrangular shape, with the free (hind) part more than twice as deep as long, and the anterior (inserted) margin irregularly undulating or even smoothly rounded. They are densely imbricated in regular rows, and the lateral line runs much nearer to the belly than to the back.

The coloration, which varies greatly according to the age of the fish and the water in which it lives, is darker in old and fat specimens than in young and lean. In a full-grown fat Bream the upper parts of the head and the back are yellowish gray, suffused with a brassy lustre most distinct on the sides, which are lighter and become yellower towards the belly. The belly is of a more or less whitish yellow. The opercula and cheeks are yellowish white with a brassy lustre. The lips are white. During the spawning-season the scales of the milters are studded on the front part of the sides and the head with whitish tubercles. All the fins are blackish gray. The pectoral and ventral fins have lighter, almost white bases; but these parts, as well as the belly, become suffused with blood on the death of the fish (cf. above, on the Sheatfish). The iris is yellow, strewn with extremely fine, dark dots, and is divided from the pupil by a ring of still deeper yellow.

North of the Alps the Bream is more or less common in most of the great European lakes, in places where the water is clear, and where at least a few shelving, weedy shores are to be found. It also lives in large rivers where the current is not too strong. In such waters it occurs in all the provinces of Sweden save Gothland[a]. In Finland it is equally common, and according to Mela goes north to lat. 67° 25'. It does not thrive in the highlands, and in Lapland and even in Jemtland it is rare. In Norway, according to Collett, it occurs only in the south-eastern tracts of the country, hardly going north of lat. 61°. Though it does not attain the same size in salt water, it is found in the inner parts of the Baltic island-belts.

The favourite haunts of the Bream invariably lie in clear and moderately deep water with a weedy bottom, especially where it can find Merlin's-grass[b]

[a] Cf. *Underd. Bet. m. Forslag till Ny Fiskeristadga*, Stkhlm 1883, p. 154.

[b] Sw. *Braxengräs*, Bream-grass.

(*Isoetes lacustris*), which it roots up like the pig. Floating bits of this weed betray to the fisherman the resorts of the Bream. Though during summer the Bream stays in water of a moderate depth, adult individuals never ascend to the shores except in the spawning-season. Only small Bream repair to the shallows in early spring and remain there all the summer. Late in autumn, when the weather is very stormy, the Bream is sometimes driven into shallow inlets, and is then known by the fishermen as *Orädersbraxen* (Storm Bream). The individuals that ascend rivers during the spring spawning and in summer are generally young. Their habits also differ from those of their fellows in general, for the shoals of Bream do not move against the stream, but always swim with the current. As the autumn draws to a close, the Bream retires to deep water, and chooses its winter-quarters in the deepest place it can find. Here it lies packed in countless multitudes, and such places are called *Braxenstand* (Bream-stands). A famous pool of this description lies in Lake Hallbo in Södermanland, and has annually yielded a take, at the same spot and at a single haul, of 4,250—17,000 kgrm[a].

The Bream is cautious, cunning, gregarious, and very timid. It is seldom found alone, but almost always in large or small companies. The best proof of its cunning is its habit of burrowing in the mud or lying on one side that the seine may pass over it. Loud noises, thunder, the sound of bells, the report of firearms, etc., always drive it into deep water, from which it does not return for several days. Its tenacity of life is such that, embedded in grass, it may be conveyed alive for considerable distances. A method long employed in order to keep the fish alive during as long a transportation as possible, is to place in its mouth a bit of bread previously dipped in spirits.

The Bream may be planted in ponds, where it thrives well and grows fat if not stinted in food. In a state of nature the fish lives on weeds, mud, worms, and insects. In the stew it may be fed and fattened on brewers' grains, pellets of dough, and the like.

Like the other Swedish Cyprinoids the Bream is subject to great variations of form and colour, these depending on the age of the fish, the season of the year, the nature of the water, etc. The difference is often so great that some ichthyologists — as shown by our list of synonyms — have been in doubt whether these forms did not constitute distinct species. If the supply of food is plentiful, and the fish becomes fat, the body is always deeper in relation to its length than in specimens which are lean for lack of food. In the latter case the body is more elongated, with more pointed head, and the back usually rises in a less sharp curve. Young specimens are always much shallower than old, and more elongated in form. At this age they are regarded by the fishermen in certain localities as a distinct species, and are called *Panka, Blapanka, Flira, Svartspoling*, etc. The colouring too, as we have mentioned above, is much darker in fat Bream than in lean or young specimens.

At the end of May or beginning of June the Bream repairs to the shores in order to spawn. The spawning always takes place when the juniper is in flower, a circumstance which is duly observed by the fishermen. The first shoal to arrive at the spawning place, which is never changed, being the same from year to year, consists of males alone. The females come later to join their mates, and the spawning now begins, the silent hours of night being preferred for this purpose. The operation is accompanied with great noise, for the fish rove to and fro at the surface in dense shoals, lashing the water with their tails and displaying their activity in many ways. The roe is deposited on rushes and weeds, against which the female rubs her body while spawning. The ova are small and yellowish. The spawning last 3 or 4 days, according to the weather. The eggs are hatched in three weeks, and the fry grow quickly. When the old Bream have finished spawning, the young fish commence. If no convenient spawning-place can be found in a lake, the shoal ascends some large stream in quest of a suitable spot. In the latter case the choice always falls on some weedy bight at the side of the channel.

The Bream is very prolific. Bloch counted 137,000 eggs in a female weighing 6 lbs. (2,811 grammes), and Benecke estimates the number at 200,000—300,000 ova about $1^1/_2$ mm. in longitudinal diameter.

The flesh of the Bream, though bony, being of good flavour, the fisherman has many different methods of taking this species. During the spawning-season gill-nets are generally used, the seine being less suitable, as the fish are frightened by its use, and often disturbed

[a] Cf. Lloyd, *Scandinav. Advent.*, vol. I. p. 45.

in their spawning operations. The *katsa* (fig. 204), a fish trap set at the spawning-place or in the channels which the Bream must pass on its way thither, is a often caught, as we have mentioned, in ice-seines, when the winter-quarters of the fish have been discovered. In August and September the Bream is taken by ang-

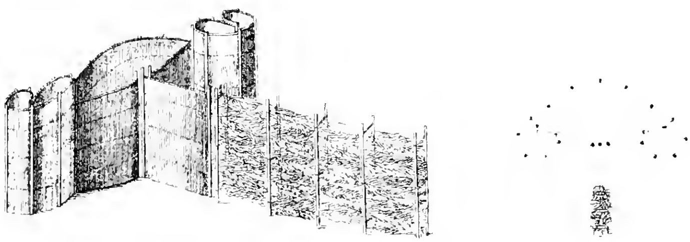

Fig. 204. *Katsa*, a fish trap in general use in Central Sweden, and chiefly employed in the taking of Cyprinoids. Seen obliquely from the side with the shore-arm to the right, and in the plan with the shore-arm turned downwards.

better kind of tackle, the fish being thus afforded an opportunity of depositing their roe on the shore-arm of the trap. In winter great numbers of Bream are ling in 6—12 fathoms of water, the bait used being the common earthworm.

(Ekström, Smitt.)

A form which has long been known, but was first recognised in scientific nomenclature by Bloch, the German *Leiter* and Yarrell's Pomeranian Bream, has been explained by Siebold and other later writers as a hybrid between the Bream and the Roach. For the sake of uniformity and on the analogy of *Bliccopsis*, however, Siebold gave this form the generic name of *Abramidopsis*. The most striking character — a comparatively short anal fin in conjunction with a Bream-like body — is common to *Abramidopsis* and *Bliccopsis*, and we therefore consider it most appropriate to compare this form in our diagnosis thereof with the said hybrids of the White Bream.

THE POMERANIAN BREAM.

ABRAMIDOPSIS BUGGENHAGII

(HYBRID BETWEEN THE BREAM AND THE ROACH.)

Fig. 205.

Body shallower than in the Bream, the greatest depth being about 31—33 % of the length. Dorsal margin in front of the dorsal fin compressed, but covered with scales in the median line. Dorsal fin with 10 branched rays, anal with 15—18. Distance from the tip of the snout to the dorsal fin slightly less than half the length of the body, but perceptibly greater than that to the foremost point in the insertion of the ventral fins. At least 10 scales in an oblique transverse row between the beginning of the dorsal fin and the lateral line. Pharyngeal teeth set in a single row, hooked at the tip, but with smooth masticatory surface: 6 or 5—5.

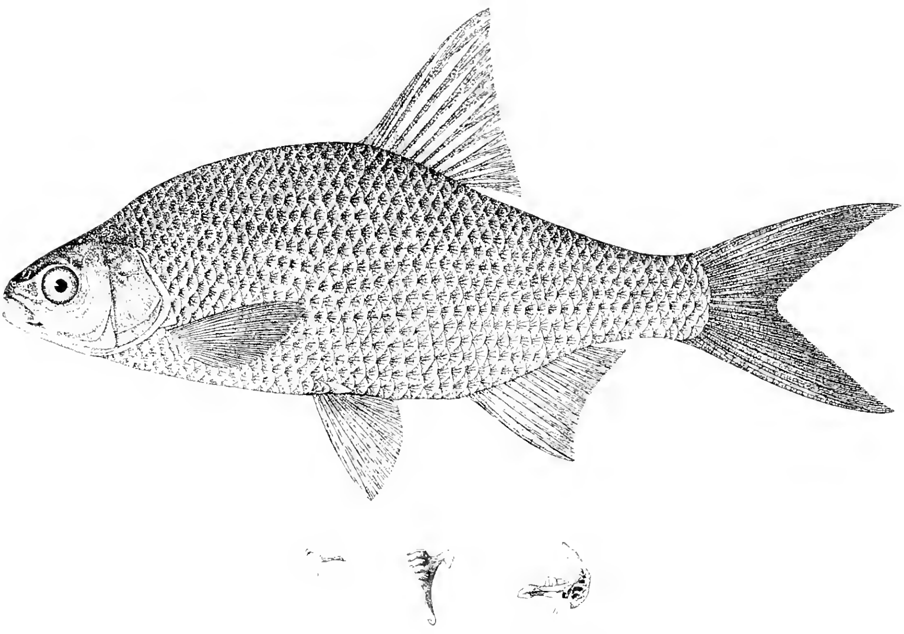

Fig. 205. *Abramidopsis Buggenhagii.* 2/3 of the natural size, from Dalecarlia, STEFFENBURG. The property of the Zoological Museum of Upsala University. *a*, the left lower pharyngeal, seen from above, natural size; *b*, the same, seen from without, natural size. *c*, the hindmost tooth, twice the natural size. *a*, *b*, and *c* from a somewhat smaller specimen in the Royal Museum.

R. br. 3; *D.* $\frac{3}{10}$; *A.* $\frac{3}{15-18}$; *P.* $\frac{1}{16-18}$; *V.* $\frac{2}{8}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 44—51[a]; *L. tr.* $\frac{10-11}{5-6}$ 1.

Syn. Cyprinus Buggenhagii, BL., *Fisch. Deutschl.*, part. III, p. 137, tab. XCV; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, vol. XVII, p. 53; — (?) THOMPS. (*Abramis*), *Nat. Hist. Irel.*, vol. IV, p. 137; YARR., *Hist. Brit. Fish.*, ed. 2, vol. I, p. 391; COUCH, *Fish. Brit. Isl.*, vol. IV, p. 42, tab. CLXXXIX. — MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 400.

Abramis Leuckartii, HECK., *Ann. Wien. Mus. Naturg.*, Bd. I, p. 229, tab. XX, fig. 5; NORDM., *Voy. Russ. Mér.* (DEMID.), tom. III, p. 508; CUV., VAL., l. c., p. 59; HECK., KN., *Süsswasserf. Östr. Mon.*, p. 117; SIEB., (*Abramidopsis*), *Süsswasserf. Mitteleur.*, p. 134.

[a] 45—54, according to SIEBOLD.

Abramis Heckelii, Sel. Longch., *Fne Belge*, p. 217.
Hybrid between Abramis brama and Leuciscus rutilus, Gthr., *Cat. Brit. Mus., Fish.*, vol. VII, p. 214; Lillj. (p. p.), *Sv., Norg. Fn., Fisk.*, vol. III, p. 287.

Of this form, which according to Siebold attains a length of about 31 cm. (to the extreme tips of the caudal lobes), we have been in a position to examine three specimens 17—22 cm. long (to the end of the middle caudal rays), all three taken in Dalecarlia by Dr. Steffenburg, and two others, resp. 20 and 32 cm. long, from the Helge River (Scania). Instead of a description at length we shall here give those average measurements of the first-mentioned three specimens which express the most important relations of form.

Length of the body expressed in millimetres		193
Length of the head	in % of the length of the body	21.9
Greatest depth of the body	" " " " " " " "	31.8
Greatest thickness of the body	" " " " " " " "	(9.3)
Least depth of the tail	" " " " " " " "	10.5
Distance between the dorsal fin and the tip of the snout	" " " " " " " "	49.7
Length of the base of the dorsal fin	" " " " " " " "	13.5
" " " longest ray of the dorsal fin	" " " " " " " "	(23.0)
Distance between the anal fin and the tip of the snout	" " " " " " " "	62.8
Length of the base of the anal fin	" " " " " " " "	17.2
" " " longest ray of the anal fin	" " " " " " " "	(15.5)
" " " middle rays of the caudal fin	" " " " " " " "	9.4
" " " longest ray " "	" " " " " " " "	(25.4)
" " " pectoral fins	" " " " " " " "	(18.1)
" " " ventral "	" " " " " " " "	(16.5)
Distance between the ventral fins and the tip of the snout	" " " " " " " "	42.8
Preabdominal length	" " " " " " " "	20.9
Postabdominal "	" " " " " " " "	(20.5)
Length of the peduncle of the tail behind the perpendicular from the termination of the base of the anal fin	" " " " " " " "	15.9
Diameter of the eyes	" " " " " " " head	23.9
Length of the snout	" " " " " " " "	(30.3)
Breadth of the interorbital space	" " " " " " " "	37.5
Length of the upper jaw from the tip of the snout	" " " " " " " "	29.5
" " " lower "	" " " " " " " "	35.2
" " " suboperculum at the upper margin	" " " " " " " "	35.6

The characters of the Roach here find expression in the comparatively short lower jaw and pectoral fins, in the forward position of the dorsal fin and its comparatively long base, and in the comparatively great postabdominal length. The influence of the Bream type may be traced, on the other hand, not only in the great depth of the body and, relatively, of the peduncle of the tail, but also in the height of the dorsal and anal fins and in the comparatively great preabdominal length.

Bloch described this form from Swedish Pomerania, Heckel and Siebold from Central Germany and Austria, Nordmann from the Lower Danube, Valenciennes from France, Selys-Longchamps from Belgium, Yarrell and Günther from England. According to Thompson it also occurs in Ireland; but this statement seems to require further corroboration, for, as Day[a] has remarked, the Roach does not belong to the Irish fauna. In Sweden this hybrid had as yet been found, to the best of our knowledge, only in Dalecarlia and, according to Lilljeborg, in the Klar Elf, until we received very recently (May, 1893), through Fisherman Billing of Kristianstad, two splendid specimens from the broad below that town on the lower course of the River Helge.

The German name of *Leiter* (Leader) has been conferred on this hybrid as well as on several other more or less singular fishes that occur in solitary specimens among a shoal of some common species, and are therefore supposed to pilot their comrades. A catch of this kind is enough to give the fisherman hope of a plentiful take of Bream.

Like the Cyprinoid hybrids in general this form too is prolific, the spawning-season occurring in Germany, according to Siebold, at the end of April.

[a] *Fish. Gt. Brit., Irel.*, vol. II, p. 195.

THE ZOPE (SW. FLIRAN OR FAREN).

ABRAMIS BALLERUS.

Plate XXXIV, fig. 1.

Scales in the lateral line about 70 (69[a]—73). Anal fin with 34—42 branched rays. Between the lateral line and the dorsal fin 14—16 rows of scales. Mouth ascending, with the tip of the lower jaw slightly projecting. Pharyngeal teeth set in a single row: 5—5.

Fig. 206. Left lower pharyngeal of *Abramis ballerus*, natural size.

R. br. 3; *D.* $\frac{3}{8^b}$; *A.* $\frac{3}{34-42}$; *P.* $\frac{1}{15-18}$; *V.* $\frac{2}{7-8}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 69[a]—73; *L. tr.* $\frac{14-16}{8-10(11)}$ 1; *Vert.* 47—48.

Syn. Cyprinus admodum latus et tenuis; pinna ani ossiculorum quadraginta, ART., *Ichthyol.*, *Gen. Pisc.*, p. 3; *Syn. Pisc.*, p. 12; *Descr. Spec. Pisc.*, p. 23 + *Cyprinus* iride flava: pinna ani ossiculorum triginta (viginti) septem, ibid., *Gen.*, p. 3; *Syn.*, p. 13; *Spec.*, p. 23; *Cyprinus* pinna ani ossiculorum quadraginta, LIN., *Fn. Suec.*, ed. I, p. 122 + *Cyprinus* pinnæ ani radiis triginta septem, ibid., p. 123 + *Cyprinus* pinnæ ani radiis viginti quinque (p.p.), ibid., p. 124, obs.

Cyprinus Farenus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 326; RETZ., *Fn. Suec. Lin.*, p. 361.

Cyprinus Ballerus, LIN., *Syst.*, l. c.; RETZ., l. c., p. 361; BL., *Fisch. Deutschl.*, part. I, p. 62, tab. IX; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 327; NILSS., *Prodr. Ichthyol. Scand.*, p. 30; EKSTR., V. WR., *Skand. Fisk.*, ed. I, p. 112, tab. 26; CUV., VAL. (*Leuciscus*), *Hist. Nat. Poiss.*, vol. XVII, p. 45; LILLJ. (*Cyprinus*), Vet. Akad. Handl. 1850, p. 305; KR. (*Abramis*), *Danm. Fisk.*, vol. III, p. 411; SUNDEV. (*Cyprinus*), Stockh. L. Hush. Sällsk. Handl. 1855, p. 81; NILSS. (*Abramis*), *Skand. Fn.*, *Fisk.*, p. 331; LLOYD (*Cyprinus*), *Scand. Adv.*, vol. I, p. 51; KESSL. (*Abramis*), *Bull. Soc. Natur. Mosc.*, tom. XXIX: 1 (1856), p. 377; HCKL, KN., *Susswasserf. Oestr. Mon.*, p. 113; DYB., *Cypr. Livl.*, p. 196; SIEB., *Susswasserf. Mitteleur.*, p. 130; WIDEGR. (*Cyprinus*), Landtbr. Akad. Tidskr. 1863, p. 203; GTHR (*Abramis*), *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 302; MALM, *Gbgs. Boh. Fn.*, p. 566; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 122; MOB., HCKE, *Fisch. Osts.*, p. 116; GRIMM, *Fish.*, *Hunt. Russ. Wat.*, pp. 15 et 22; LILLJ., *Sv.*, *Norg. Fn.*, *Fisk.*, vol. III, p. 294.

Cyprinus Biorkna (nec synon.), LIN., *Fn. Suec.*, ed. II, p. 130; RETZ., l. c., p. 360.

Obs. When EKSTRÖM wrote his *Morko Fiskar* and NILSSON his *Prodromus*, they had both received from Lake Mälar young Bream under the name of *farnar* (Zope); and the parenthetic remark in ARTEDI's diagnosis of the *Faren* (*Gen. Pisc.*) that in *Syn. Pisc.* (as well as in the diagnosis of *Faren* in *Descr. Spec. Pisc.*) a misprint had escaped observation (27 anal rays instead of 37), was supposed to be an insertion of no importance made by LINNÆUS. Up to the present day EKSTRÖM's followers have therefore regarded the *Cyprinus Farenus* of ARTEDI and LINNÆUS as a young Bream. But ARTEDI's minute description of this fish plainly shows that he really referred to the form still known by most of the Mälar fishermen as the *Faren*. Not only do we read in Clause 12 of this description "pinna ani . . . ossiculorum triginta septem"; the measurements given by ARTEDI (Longitudo tota ad initium caudae unc. 8, lin. 8; ad pinnam dorsi unc. 4, lin. 8; ad pinnam ani unc. 5, lin. 3[c]) demonstrate beyond doubt that his specimen was a *Faren*. The following table contains our measurements of Bream and Zope preserved in spirits — the dimensions given by ARTEDI were probably those of fresh specimens — ranged in parallel columns with ARTEDI's measurements of the Bream and Zope in *Descr. Spec. Pisc.*, pp. 22 and 25.

[a] Sometimes 65, according to VALENCIENNES.

[b] 7—9, according to KRØYER.

[c] Whether these measurements are duodecimal (12 lines to the inch) or decimal (10 lines to the inch), I am unable to determine: but the difference is of no importance to the solution of the question. For the sake of completeness I have included in the table (in parentheses) the percentages which the decimal system would involve.

	Royal Museum specimens of *[illegible] Farcn*							Artedi's			Royal Museum specimens of *Abramis ballerus*			
	Island belt of Stockholm, Sept., 1890	Island belt of Stockholm, Sept., 1891	Island belt of Stockholm, Sept., 1890	Island-belt of Stockholm, Sept., 1890	Lake Oppmanna, Sept., 1882	Lake Oppmanna (Scania), Sept., 1882	Average in the preceding six specimens	*Bream.*	*Farcn*	Average in the following four specimens	Sigtuna (Mälar), July 11, 1831	Lake Wener, 1861	Sigtuna (Mälar), July 11, 1831	Strengnäs (Mälar), April, 1861
Length of the body from the tip of the snout to the base of the caudal fin, expressed in millimetres	152	166	169	180	391	124	247	330	216	189	92	199	203	263
Distance between the dorsal fin and the tip of the snout in % of the above length of the body	63.4	59.4	60.0	59.1	63.0	63.4	61.4 [illegible] 59.[illegible]	60.0, 59.5	54.5, 54.0	52.9 [illegible] 55	53.2	52.8	52.2	53.2
" " " ventral fins "	46.7	48.2	47.9	51.7	46.5	47.0	48.0 [illegible] 46.[illegible]	48.7, 48.5	42.8, 42.3	40.9 [illegible] 43	42.9	40.4	39.9	40.3
" " " anal fin "	64.5	65.5	66.2	65.8	66.7	67.9	66.1 [illegible] 64.[illegible]	67.5, 67.2	60.0, 59.7	57.0 [illegible] 61	59.8	56.8	57.1	58.1

No further evidence seems necessary to show that ARTEDI's and LINNÆUS's *Farcn* and *Braxnaflicka* (*Blicka*, which they erroneously identified with RONDELET's *Ballerus*) and LINNÆUS's (not ARTEDI's) *Bjorkna*, all belong to the same species. The specific name of *farenus* has consequently as great claims to recognition as *ballerus*, and has the advantage, as compared with the latter, of not being based on a false explanation of names already in use.

The ordinary length of the 'Zope' is between 20 and 25 cm., but may rise, according to LILLJEBORG, to 45 cm., including the whole caudal fin.

The body is strongly compressed and deep, but more elongated than that of the Bream, the greatest depth, which occurs at the beginning of the dorsal fin, being about 29 % ($27^1/_2$—31 %) of the length of the body, measured to the end of the middle caudal rays. The greatest thickness, which lies as a rule across the opercula, is less than $^1/_3$ of the greatest depth, and at most half of the length of the head. The least depth of the tail is about $8^1/_2$—8 % of the length of the body. The back, which has only a faint break at the occiput, then forms a regular curve to the beginning of the dorsal fin, where it makes a very obtuse angle, and from this point slopes almost in a straight line to the base of the caudal fin. It is moderately compressed, with a faint, convex, longitudinal ridge, especially near the dorsal fin. The part between the dorsal and caudal fins is somewhat plumper. The belly is of a broad convex shape or flat from the isthmus to the ventral fins, from this point to the vent sharply carinated (with the very edge, as in the other true Abramidines, naked, i. e. not covered, although concealed, by the scales at its sides), and then very strongly compressed and thin throughout the length of the base of the anal fin. The ventral profile forms an unbroken curve from the chin to the anal aperture, then runs in a straight line to the end of the anal fin, and finally bends slightly inwards to the base of the caudal fin.

The head, the length of which is about 20—19 % of that of the body, is comparatively smaller than in the preceding Abramidines. It is pointed, but the snout is thick and blunt, and does not project beyond the tip of the lower jaw. The forehead is broad and convex, with straight frontal line and a slight slope from the nostrils to the tip of the snout. The breadth of the interorbital space measures about $^2/_5$ (39— a little more than 40 %) of the length of the head. The sides of the head are so compressed that its greatest thickness is equal to the perpendicular drawn through the anterior orbital margin. The mouth is not large, but turned sharply upwards and protruded, when the mouth is opened, in a tubular form. The anterior margin of the upper jaw is somewhat less prominent than that of the lower, and the length of the upper jaw from the tip of the snout to the hind extremity of the maxillaries is in young specimens somewhat greater than that of the snout to the anterior margin of the eyes, in old equal to, or somewhat less than, the latter, and measures about 28—29 % of the length of the head. The lower jaw is valvular in shape, contracted at the base, expanded in front; it points upwards, and is articulated in the perpendicular from the anterior margin of the eyes. Its length is as a rule equal to the breadth of the interorbital space. The eyes are rather large, their longitudinal diameter varying in specimens 10—29 cm. long between about 32 and $26^1/_2$ % of the length of the head. They are set fairly low, the upper margin of the pupil (sometimes of the iris) being touched by the line joining the margin of the upper jaw at the tip of the snout to the middle of the tail at the base of the caudal fin. The postorbital length of the head measures in young specimens somewhat less than half its entire length; in old specimens these two measurements are equal to each other, and the postorbital part is twice as long as the snout. The nostrils are similar to those of the preceding forms, but lie a little higher in relation to the eyes. The gill-openings are large, the branchiostegal membranes coalescing with the isthmus rather near each other, just behind the perpendicular from the hind margin of the eyes. The gill-rakers are long, thick-set, and pectinated, with more or less distinct serrations. The outer row on the first branchial arch contains about 30—37, that on the outer anterior margin of the pharyngeals 21—26. The pharyngeals, which are remarkably thin, are each furnished with a row of five teeth, these being compressed, obliquely cut, and hooked at the tip, with concave (one-grooved) masticatory surface.

The dorsal fin begins at a distance from the tip of the snout measuring 47—49 % of the length of the body. It is very obliquely truncate, with straight, or even slightly convex margin, and its height in front is more than twice its length, the longest ray measuring about 20—21 % of the length of the body, the base about 9 % of the same. The anal fin is very long, highest in front, then sinking in a small hollow, and afterwards proceeding with the margin almost straight. Its beginning lies at a distance from the tip of the snout measuring about 51—53 % of the length of the body; the length of its base is about $^1/_3$ ($32^1/_2$— nearly 35 %), and that of its longest ray about $13^1/_2$—15 %, of the same. The caudal fin is deeply forked, the lower lobe being the longer: its middle rays measure about $^1/_{10}$ of the length of the body and about $^2/_5$ of that of the longest caudal rays.

The pectoral fins are long and pointed, and their tips extend, when the fins are at rest, sometimes scarcely to the perpendicular from the insertion of the ventral fins, sometimes a little further back. The fins are longest as a rule in the males; but this rule is subject to exceptions which render it useless as a sexual character. Their length is about $^1/_6$ ($16^1/_2$— nearly 19 %) of that of the body. The tips of the ventral fins commonly extend, at least in the males, quite to the anal aperture. The length of these fins is generally greatest in the males, and measures about 13—15 % of of that of the body. The distance between the tip of the snout and their insertion is greatest as a rule in the females, and occupies about 36—37 % of the length of the body. Both the preabdominal length and the postabdominal measure 16 ($15^1/_2$)—18 % of the length of the body.

The body is covered with comparatively small and thin scales, set in very oblique rows and densely imbricated. They are in general more rounded than the scales of the Bream; but the true distinction lies in their still finer concentric striation and the smaller number of radiating grooves.

The coloration is indeed subject, as usual, to great variations dependent on the age of the fish and the season of the year; but it closely resembles that of young Bream. The sides of the head display many colours, shot with silver and brassy yellow. The silvery white iris is dashed with yellow above the pupil, where the fine, green dots with which it is strewn are collected in a dark spot. The forehead is olive gray, and a somewhat lighter shade of the same colour extends to the back and the upper part of the sides, gradually fading below and passing, somewhat above the lateral line, into silvery gray. This last colour grows lighter and lighter towards the belly, which is almost white. The dorsal, caudal, and anal fins are of a plain olive gray, though the outer margin, especially of the last-mentioned fin, is dark. The pectoral and ventral fins are light gray with a dash of brown, red, or yellow at the base.

In its habits the Zope seems nearly allied to the Bream. It occurs in our largest lakes, Mälar and Wener, but is common only in the former, which appears to be its true habitat in Sweden. Sometimes it descends the River Gotha from Lake Wener (MALM), and it, no doubt, wanders from Lake Mälar, as LILLJEBORG has remarked, out into the island-belt of Stockholm (SUNDEVALL). But in Sweden it does not seem to belong to the common fishes of the island-belt. The case is the same in Finland, though to the south of this country the Zope is common, according to MELA, in the interior. In the south of the Baltic, however, in the German Haffs and in the Gulf of Riga off the mouth of the Düna, it seems to be a stationary fish (MÖB., HEKE). According to LINNÆUS it occurs in Småland, being there known by the name of *Braxenflicka*; but no trustworthy information on this head has since been procured, and the name may easily be due to a confusion. In the River Helge at Kristianstad, on the other hand, two specimens about 3 dm. long were taken in 1869, the first in March, the second in May; and they are now preserved among the stuffed collections in the museum of the said town. LILLJEBORG assumes that these examples were stray visitors from the south or east of the Baltic; but their occurrence in the lower course of the Helge, which there widens into broads, finds a parallel in many places, the Zope often ascending rivers both from the Baltic and the Black Seas. The Zope is further known from the lower parts of the Rhine, Weser, and Elbe (SIEBOLD), from the above-mentioned German rivers and Haffs connected with the Baltic, from the Danube, up to Hungary and the Hungarian lakes (HCKL., KN.), from upper Austria (SIEB.), from the whole of Russia-in-Europe, with the exception of the river basins sloping to the Arctic Ocean, and from the Black and Caspian Seas (PALLAS, KESSLER, and GRIMM).

The temperament of the Zope seems in the main to resemble that of the Bream. Its diet, however, includes less vegetable substances, and consists more of insects and worms. The spawning-season occurs in April and May, much earlier than that of the Bream, and sometimes, according to Baron GYLLENSTJERNA as quoted by NILSSON, even before the ice has melted in the inlets of Lake Mälar. The spawning-place is chosen in shallow water with a weedy bottom. At this season the Zope often ventures even upon flooded meadow land. The operation of spawning is performed as we have described in the case of the Bream, but is said to last no more than 1—3 days, during which time the Zope is no less afraid of noise than the said species. The course of its development and its growth are little known; but of its fecundity BLOCH states that in a female weighing $468^1/_2$ grm., with ovaries 16·7 grm. in weight, the number of the ova, which were of the size of a poppy seed, was about 67,500.

When the spawning is over, the Zope retires to deeper water, and is seldom found near shore throughout the rest of the year, but only in the depths. In autumn and winter it assembles in large shoals, like the Bream, where it can find a deep pool.

The flesh of the Zope, is flabby, white, bony, and of sweetish, indifferent flavour, being poorer in summer than in winter, and fattest previous to the spawning in April. Still the fish is eaten fresh, in which case it is boiled, and is also salted and dried for future consumption.

During the spawning-season, at which time the Zope, as we have mentioned, approaches the shore and ascends into the shallows, it is taken in traps (*ryssjor*, see p. 33, fig. 7), nets, and seines hauled from the shore, where the bottom admits of this operation. It is occasionally speared by accident. Late in autumn it is sometimes caught in a kind of seine shot in deep water, the hauls being always large, if made at the right place, as the fish have now assembled in their winter-quarters. The Zope may also be taken with rod and line baited with a common earthworm.

On the south coast of Lake Mälar throughout its length the Zope is called *Farne* or *Fana*, in the central and western parts of the lake *Faren*, and in the neighbourhood of Upsala, according to LILLJEBORG, *Vimma*. In Lake Wener, according to LLOYD, it bears the name of *Langstjert* (Longtail) or, according to WIDEGREN, *Langhala* (Norw. *Hale* — *stjert*). But it is often confounded by the fishermen with White Bream and young Bream, being included with these under the names quoted by ARTEDI and LINNÆUS, *Blecka* (*Blicka*), *Braxenpanka*, *Braxenflia* (*Braxenflira*). In order to preclude the error into which he had himself been betrayed by the name of *Faren*, EKSTRÖM preferred to use *Flira*.

(EKSTRÖM, SMITT.)

GENUS PELECUS.

Beginning of the short dorsal fin situated vertically above that of the long anal fin, and the base of the former less than $^1/_4$ of that of the latter. Dorsal musculature extending forward across the interorbital space. Lateral line bent sharply downwards behind the pectoral fins, and in the posterior part of its course undulating, or even externally interrupted. Scales like those of the Bleak, but with the nucleus situated in the posterior half. Mouth sharply ascending, and the tip of the lower jaw projecting.

Among the Cyprinoids to which the Scandinavian fauna can lay claim, this genus is in several respects the most remarkable. With a form of body reminding us of the Herrings, it has several characters that range it beside the Bleaks, others again being Abramidine characters at their highest point of development. The characters of *Alburnus* may be seen in the form of the mouth, with the point of the lower jaw fitting into a sinus at the tip of the snout, the slender and prolongated pharyngeals, and the thin, comparatively deciduous scales. The Abramidine type, on the other hand, may be traced not only in the long anal fin and the nakedness of the median dorsal line throughout a considerable part of its length in front, but also in the similar appearance of the median ventral line, which is sharply carinated and naked all the way from the isthmus to the vent, the latter being situated, as usual, just in front of the anal fin. The most natural course is therefore to regard the genus as the type of an offshoot from the common stock of the Bleaks and Breams. But in the structure of the mouth, the pharyngeals, and the scales the Zope shows signs of transition from the true Breams to this genus. *Pelecus* is further distinguished by its long and pointed, almost scythe-shaped pectoral fins, which recur, however, in some other genera, notably *Chela*, a genus belonging to Indian and the East Indian Archipelago, fairly rich in forms, and very nearly approximated to *Pelecus*. This latter genus was established by AGASSIZ[a] in 1835, and contains only one species, essentially differing from *Chela* merely in the irregular, undulating lateral line.

FRIES and EKSTRÖM adopted the genus — though as a subgenus entitled *Chela* — in the previous edition of "*Scandinavian Fishes*" (1837), under the Swedish name of *Skär-Braxnar*; but for the species they retained the Linnaean name of *Skarknifven* (Carving-knife).

THE ZIEGE (SW. SKÄRKNIFVEN)

PELECUS CULTRATUS

Fig. 207.

Pharyngeal teeth slender, compressed, hooked at the tip, with pectinated masticatory surface, and set in two rows: 2, 5—5, 2.

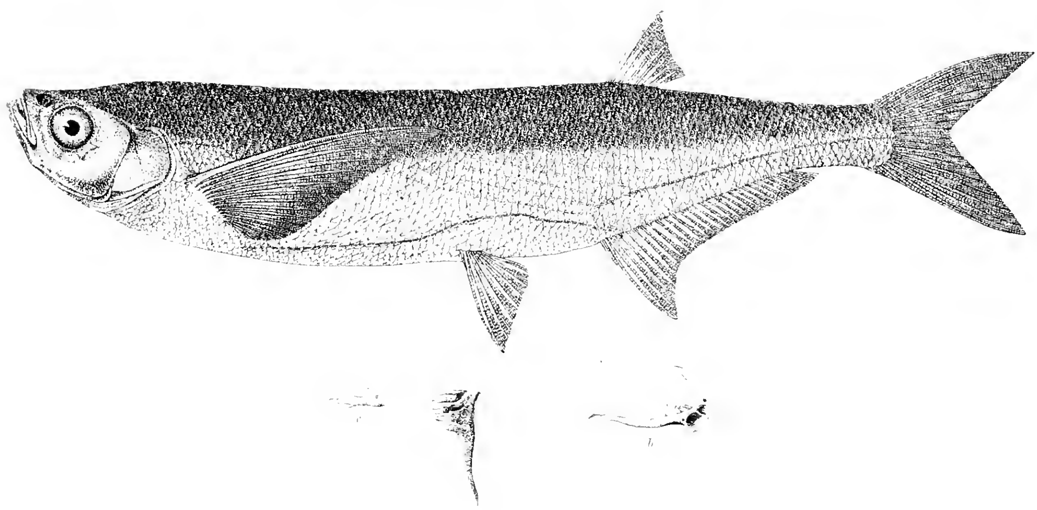

Fig. 207. *Pelecus cultratus*, from Finland. NYLANDER, 1850. $\frac{1}{2}$ of the natural size. *a*, the left lower pharyngeal, seen from above, natural size; *b*, the same seen from without, natural size; *c*, the hindmost tooth in the inner row, twice the natural size.

R. br. 3; *D.* $\frac{3}{7}$[b]; *A.* $\frac{3}{25-28}$; *P.* $\frac{1}{14-16}$; *V.* $\frac{2}{7}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* ca 100; *L. tr.* $\frac{14-15}{4-6}$ 1; *Vert.* 48[c]—51[d].

Syn. Sarachu congener, MARSIGL., *Danub. Pann. Mys.*, tom. IV, p. 21, tab. VIII. *Leucus*, sp. 2 et 3, KLEIN, *Hist. Pisc. Nat. Miss.*, V, p. 74, tab. XX, fig. 3. Cyprinus pinnae ani radiis XXX, linea laterali declinata, ventre acutissimo, LIN., *It. Scan.*, p. 82, tab. II, fig. 1.

[a] Mém. Soc. Sc. Nat. Neuch., tom. I, p. 39.
[b] 6—7, according to GÜNTHER.
[c] According to GÜNTHER.
[d] " " KRÖYER.

Cyprinus cultratus, Lin., *Syst. Nat.*, ed. X, tom. I, p. 326; Bl., *Fisch. Deutschl.*, pt I, p. 255, tab. XXXVII; Retz., *Fn. Suec.*, *Lin.*, p. 360; Pall., *Zoogr. Ross. Asiat.*, tom. III, p. 331; Nilss., *Prodr. Ichthyol. Scand.*, p. 32; Agass. (*Pelecus*), l. c.; Cuv., Val. (*Leuciscus*), *Hist. Nat. Poiss.*, vol. XVII, p. 330; Kr. (*Pelecus*), *Danm. Fisk.*, vol. III, p. 511; Nilss. (*Abramis*, subg. *Chela* ex. Buchan.), *Skand. Fn.*, *Fisk.*, p. 340; Kessl. (*Pelecus*), Bull. Soc. Natur. Mosc., vol. XXIX, 1 (1856), p. 376; Heck., Kn., *Susswasserf. Östr. Mon.*, p. 126; Dyb., *Cypr. Livl.*, p. 153; Sieb., *Susswasserf. Mitteleur.*, p. 152; Mgrn, *Finl.*, *Fiskfn.* (disp. Helsingf.), p. 43; Günth., *Cat. Brit. Mus.*, *Fish.*, vol. VII, p. 330; Bncke, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 125; Mela, *Vert. Fenn.*, p. 337, tab. X; Möb., Hcke, *Fisch. Osts.*, p. 121; Grimm, *Fish.*, *Hunt. Russ. Wat.*, pp. 16 et 22; Mela, Sundm., *Finl. Fisk.*, tab. XXVII; Lillj., *Sv.*, *Norg. Fn.*, *Fisk.*, vol. III, p. 324.

The 'Ziege' attains even in the North a length of 4 dm.; but in Southern Russia, where it apparently has its true home, it sometimes measures, according to Kessler, as much as 6 dm. The elongated and compressed form of the body is most suggestive of a lean Herring, but the most characteristic external features are the almost straight dorsal margin and regularly arcuate belly, without the more or less sharp angles which we have seen in the profiles of most of the preceding Cyprinoids. Furthermore the form differs from that of our other Cyprinoids in the strong elongation of the forepart of the trunk, for in no other Scandinavian member of the family is the preabdominal length more than $^3/_{10}$ of the length of the body. The greatest depth in adult specimens is somewhat less than $^1/_5$ of the length of the body (about 19 % in our specimens, which are 22—36 cm. long); the greatest thickness about $^1/_3$—$^4/_9$, and the least depth of the tail about $^1/_3$, of the greatest depth of the body.

The head also measures somewhat less than $^1/_5$ of the length of the body, and is characterized principally by the above-mentioned relation to the dorsal muscles, the origin of which extends forward over the forehead. The eyes are large and set rather low, almost as in the Zope. Their longitudinal diameter, which even in adult specimens is somewhat, though only slightly, greater than the length of the snout, measures a little more than $^1/_4$ (28—26 %) of the length of the head. The postorbital length of the head is about half its entire length. The position of the nostrils is normal. The sides of the snout (the preorbital bones) are remarkable for the distinct ducts belonging to the suborbital branch of the cephalic system of the lateral line. The shape and position of the mouth we have already described. The length of the upper jaw from the tip of the snout is somewhat less than the least depth of the tail, but the length of the lower jaw is perceptibly greater than the latter, measuring about 42 % of the length of the head. Both the operculum and the preoperculum are comparatively large, and the latter is distinguished by the rectangular form of its hind inferior corner. The gill-openings are large, the branchiostegal membranes coalescing with the isthmus rather near each other and in a line with the posterior orbital margin. The gill-rakers are strong and rather scattered. The outer row on the first branchial arch contains about 17 or 18, the inferior pointed, the superior flat and branched or lobulate at the tip.

The dorsal fin is remarkable both for its small size and its backward position. It begins almost vertically above the origin of the anal fin, at a distance from the tip of the snout measuring about 64 % of the length of the body. Its base is equal to the longitudinal diameter of the eye (in our specimens 5·3—5 % of the length of the body) and measures about half of its height in front, which is nearly 11—$9^1/_2$ % of the length of the body. It is sharply and obliquely truncate, with the upper posterior margin somewhat concave. The anal fin is more deeply concave, reminding us of the Garpike, with the anterior part prolongated to a lobe, but with the posterior part of almost uniform height. Its base measures about $21^1/_2$—22 %, and its height in front about 12—11 %, of the length of the body. The caudal fin is deeply forked, with pointed lobes, the lower somewhat longer than the upper. Its middle rays occupy about 7 % of the length of the body, and measure a little more than $^1/_3$ of that of the longest caudal rays.

The shape of the pectoral fins too — expanded at the base and incised at the lower margin — calls to mind the Garpike or, still more, the Horse Mackerel; and they are remarkable, as in the latter of these two species, for their great length, 29—28 % of that of the body and only slightly less than the preabdominal length. The ventral fins, which are inserted half-way along the body, are also more pointed than in the rest of the Scandinavian Cyprinoids. Their length, which measures about 12—$12^1/_2$ % of that of the body, is less than the postabdominal length, though the latter is remarkably small, being only about $16^1/_2$—15 % of the length of the body.

The scales are thin and deciduous; they vary greatly in size and shape on different parts of the body, being small on the back and belly, largest at the middle of the sides. The large scales are of a rounded quadrilateral shape or almost circular: the small elliptical, with the longitudinal axis set across the body. The concentric striæ are extremely fine and dense; the radiating grooves few and faint on the hind part of the scale, hardly visible on the inserted part, though the latter, at least in the large scales, is usually sinuate at the margin.

The coloration resembles that of *Alburnus* and *Clupea*. According to HECKEL and KNER "the occiput is steel-blue or bluish green, the back grayish brown, the cheeks of a nacreous lustre, the sides of a light silvery lustre; the dorsal and caudal fins grayish, the others with a dash of red; the iris silvery."

The Ziege, like the Zärthe and, in some localities, the Zope, is an anadromous fish, ascending rivers from the sea or the great lakes in order to spawn. Its best known haunts, where it is taken in millions, are the Black Sea, the Sea of Azov, the Caspian, and the Sea of Aral, with all the large rivers flowing into these waters. But the species also occurs in the Baltic, chiefly to the south and east, west to Greifswald, and in Lake Ladoga. From these localities it makes its way into the North German Haffs and estuaries and into most Russian and some Finnish rivers. Within the basin of the Danube it is common in Hungary, and in summer some Hungarian lakes yield large catches of Ziege; but in Bavarian waters it is rare. At the middle of the last century, according to LINNÆUS, it frequented the River Helge off Kristianstad, in spring, till the end of May. The specimen taken in this river and described by LINNÆUS (length 22 cm.) is still preserved in the Zoological Museum of Upsala University. The species has never since been caught in the Helge, but off the mouth of this river it is well known to some of the fishermen of Åhus, according to their own assertion, being frequently taken in the Herring-nets. In Denmark it has never been found.

The Ziege is an active and roving fish, not unlike the Herring. It lives on miscellaneous small animals, such as crustaceans, insects, the fry of other piscine species, and small fishes. It seeks its food, as indicated by the position of the mouth, in the same manner as the Bleak, mostly at the surface of the water. In spring and early summer, from May to July, it spawns in shallow water on a weedy bottom. In a female weighing 147 grm. and with ovaries weighing 77 grm., BLOCH estimated the number of the eggs at 105,740.

Bony, lean, and thin — hence, it is said, the German name of *Ziege* (goat) — the species is held in little esteem where other fish is to be had; but where this is not the case, or where the Ziege is taken in enormous quantities, as in Southern Russia, it is used as human food. Its scales are employed, like those of the Bleak, in the manufacture of the so-called *essence d'orient*, the colouring matter of imitation pearls. The nearest fishing-stations to Scandinavia where the Ziege is taken in any considerable quantity, lie on the Prussian coast and in the German Haffs, the tackle used consisting of gill-nets, which are set at the surface, or drift-nets. "It has numerous foes," says BLOCH, "in predatory fishes and waterfowl, to which it often falls a prey, its silvery colour rendering it easy of observation." Thus the Ziege shares the fate of the Herring, and where these two species live in company, the former has as good means of escape as the latter, if not better, its sharp fins being well adapted for rapid flight and speedy doubling.

THRISSOMORPHI.

Physostoms with the shoulder-girdle suspended from the head (as usual in the Teleosts). *Scapular disk internally strengthened by an arch formed by a special bone (os praecoracoideum) from the coracoid bone to the clavicle. The first four abdominal vertebræ of normal form and development. Hyomandibular and pterygopalatine arches complete, as well as (in most cases) the opercular apparatus. Maxillary bones fully developed.*

That the Salmons and Herrings have much in common, was declared by AGASSIZ in 1843[a], when he united them into one family, *Halecoides;* and COPE followed up this opinion in 1871[b] by the establishment of the order *Isospondyli*, answering to the series of the Thrissomorphs, and distinguished from the preceding series mainly by a negative character, the absence of the so-called acoustic bones. The connexion between the organs of hearing and the air-bladder, however, is not foreign to this series. In the Clupeoids WEBER[c] discovered that the air-bladder, which tapers forward for some length, is divided in front into two branches, one to the right and one to the left, which pass through the occipital bone into the cranium, and there, as HASSE[d] has shown, touch with their tips the outer wall of the lymphatic chamber surrounding the auditory apparatus. SAGEMEHL has given good reason[e] for his assumption that this mode of communication is the more primitive, from which the more complicated connexion of the preceding series has been evolved, and which has been persistent not only in the Clupeoids and some other Physostoms, but also in some Physoclysts of ancient type, as for instance the Berycoids (cf. above, p. 66), the Macruroids, some Gadoids and Balistoids. We have also seen a reminiscence of this connexion in the two tubular processes which ascend from the anterior extremity of the air-bladder of the Gadoids (cf. above, p. 176) in vermicular curves towards the head, one on each side of the anterior renal mass. The absence of the so-called acoustic bones is thus explained as an earlier stage of development; and a negative character of this signification can hardly be sufficient to define a natural evolutionary series. We also find that a great number of the Thrissomorphs are without the character adduced by AGASSIZ as one of the most important in his definition of *Halecoides*, namely the participation of the maxillary bones in the formation of the margin of the upper jaw. Thus we might reasonably treat these forms as a distinct series of families (*Scopelomorphi*); but the resemblances in other respects are sufficiently great to render the Thrissomorphs a natural whole, with the same limitations as COPE's *Isospondyli*, although the said resemblances do not constitute characters applicable to the whole series. Within this series too the variation of form and structure is great and affects most of the organs. Scales and a distinct lateral line may be present or wanting. The maxillaries may be simple, as in the rest of the Teleosts, or composite, furnished with so-called supplementary bones answering to the cheek-bones (*ossa jugalia*) of the higher vertebrates. The teeth may be numerous and well developed or wanting. A so-called adipose fin is present on the hind part of the back in many forms, but wanting in others. Luminous organs, so-called phosphorescent spots, may be present or absent. The ovaries may be furnished with an oviduct or without a complete tube of this description. The air-bladder may be present or wanting. Such great differences in forms which nevertheless show their natural affinity in some way or other[f], render the characterization of

[a] *Rech. Poiss. Foss.*, tom. V, pp. 3 and 96.

[b] *Ichthyol. Less. Ant.*, Trans. Amer. Philos. Soc., Philad. N. ser., vol. XIV, pp. 452 and 454.

[c] *De aure* cett., p. 73, cett.; figg. 63, cett.

[d] *Anat. Stud.*, Bd. I, p. 599, cett.

[e] Morphol. Jahrb., Bd. X, p. 51.

[f] Thus for example the *Haplochitonida* — a family of fresh-water fishes from South America and Australia — are almost typical Salmons, but have the margin of the upper jaw formed by the intermaxillaries alone; and similarly the *Sternoptychidæ* and *Scopelidæ* are families so like each other that they ought hardly to be kept apart, though in the former the osseous framework of the mouth follows the Halecoid type, while the latter preserve in this respect the ordinary Teleosteous character.

the series extremely difficult. Within the Scandinavian fauna the series contains the following families.

I: Hind part of the back furnished with an adipose fin.

A: Ovaries without special oviduct communicating directly with their cavity: the ripe eggs fall into the abdominal cavity and pass thence through a genital pore. No phosphorescent spots on the sides of the body . . . Fam. *Salmonidæ*.

B: Ovaries furnished with a complete oviduct. Sides of the body furnished in all Scandinavian forms with phosphorescent spots[a] . . . Fam. *Scopelidæ*.

II: No adipose fin ... .. Fam. *Clupeidæ*.

Fam. SALMONIDÆ.

Body of the typical Salmon form or more compressed, approximated to the Roach or the Herring form. Scales middle-sized or small, rather firmly attached[b]. *No phosphorescent spots on the sides of the body. Dorsal margin of the tail furnished with an adipose fin. Margin of the upper jaw formed in front by the intermaxillaries and behind by the maxillaries. No barbels. Air-bladder simple and not connected with the cranial cavity. Branchial cavity furnished with pseudobranchiæ. Ovaries open on the outside, without oviducts or with oviducts opening inwards (into the abdominal cavity).*

The family of the Salmons and Gwyniads is well known everywhere in the frigid and temperate regions of the northern hemisphere. In the southern hemisphere, on the other hand, only two genera occur, a Capelin form (*Retropinna Richardsonii*) belonging to the fresh water of New Zealand, and two (?) Argentine species, marine fishes of the same locality. The family possesses more than ordinary interest both from an economical and a scientific point of view, to the economist because the flesh of these fishes is one of the most highly esteemed and most remunerative foods, to the scientist because there is hardly any other part of the system where he is confronted with such difficulties in defining the limits of the species. This is due in most cases to a plasticity and inconstancy of form, caused beyond doubt by the periodic migrations of the Salmonoids from the sea or the great lakes to running fresh water. The economical value of these fishes has also contributed to the said difficulties. Where they appeared at certain seasons and certain places in enormous masses, with one or other of their various dresses predominant, the fishermen gave these dresses different names which the systematist had to explain, often merely after examining solitary specimens that were supposed to represent distinct species. "*Kärt barn har många namn*"[c], says the Swedish proverb; and this rule has repeatedly asserted itself in the nomenclature of the Salmonoids. The investigations of recent years, however, have elucidated the significance of the variation of form within this family and the relationship to each other of the more or less constant forms, and have thereby thrown light upon the comprehensive question of the origin of the species.

The geological researches of AGASSIZ[d] have traced the Salmonoid family back to the Cretaceous Period. At that time there lived, where the green sand now lies in modern Westphalia, and where the chalk subsided over Southern England, several forms, which AGASSIZ referred to the genera *Osmerus* and *Osmeroides*[e], the latter furnished with scales resembling those of the modern genus *Argentina*. The evolution of the Salmonoid family, we might hence conclude, began with marine fishes of the Smelt and Capelin type, with few pyloric appendages or none at all, and its development advanced in two directions, 1) towards the Salmon and Charr, furnished with teeth and with comparatively small scales, 2) towards the toothless and comparatively large-scaled genus *Coregonus*. In both these directions of evolution the pyloric appendages were more and more developed, to assist these fishes in storing up a reserve supply of

[a] An extremely rare form, *Sudis atlanticus*, is an exception.

[b] The genus *Salanx* (*Albula chinensis*, OSBECK, *Ostind. Resa*, p. 237), however, is scaleless or has small, extremely thin, and deciduous scales (GÜNTHER).

[c] "A dear child has many names."

[d] *Rech. Poiss. Foss.*, vol. V, p. 103.

[e] GÜNTHER, however, considers that this genus perhaps belonged to the Scopeloid family. *Introd. Study Fish.*, p. 582, *Hist. Ichthyol.*, p. 417.

fat for the time when they must resort to fresh water for the reproduction of their species.

The Scandinavian genera of this family are the following:

A: Dentition strong, even the tongue furnished with teeth. Length of the maxillaries more than 53 % [a] of that of the head reduced (from the hind extremity of the intermaxillary bone to the posterior margin of the preoperculum). Base of the dorsal fin proper shorter than the head reduced. (*Salmonina.*)
- 1: Branched rays in the anal fin less than 17.
  - *a:* Transverse rows of scales on the sides of the body more than 100 ..... Genus *Salmo.*
  - *b:* Transverse rows of scales on the sides of the body less than 80 .... Genus *Osmerus.*
- 2: Branched rays in the anal fin at least 17 ..... Genus *Mallotus.*

B: Dentition weak or teeth wanting, at least the tongue toothless [b]. Length of the maxillaries less than 53 % of that of the head reduced. (*Coregonina.*)
- 1: Base of the dorsal fin proper more than 15 % of the length of the body and longer than the head reduced ..... Genus *Thymallus.*
- 2: Base of the dorsal fin proper less than 15 % of the length of the body.
  - *a:* Base of the dorsal fin proper more than half the length of the head reduced .... Genus *Coregonus.*
  - *b:* Base of the dorsal fin less than half (<45 %) the length of the head reduced Genus *Argentina.*

In this manner we have endeavoured to find an expression for the said two directions of development. The development, however, has not been so regular that a sharp and fixed line can be drawn between two distinct subfamilies; and the intermediate position occupied by the Graylings (genus *Thymallus*) may perhaps justify the establishment of a third subfamily, characterized principally by the advanced development of the dorsal fin. The community of origin in the case of all these genera affords an explanation of the fact that the fry of the most differentiated forms in one group show points of resemblance to the other group.

In order rightly to comprehend the relations between the genera, it is indeed necessary to have a knowledge of the exotic forms as well. But two of the Scandinavian genera are so rich in forms, even within the limits of our fauna, that in them we may trace the development of form in its past course and, seemingly, in its present continuation.

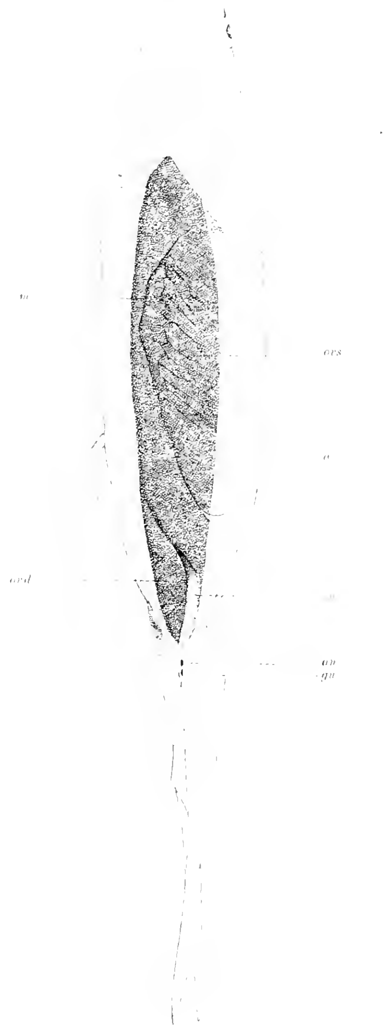

Fig. 208. A gravid female Smelt, taken at Stockholm on the 19th of April, 1892. Natural size. *ors*, left ovary, with eggs arranged in transverse rows; *ord*, lower (posterior) part of the right ovary; *m*, margin of the mesoarium, which envelops the ovary both above (in front) and below (behind) even on the left (outer) side, but below, owing to the coalescence of the margin with the wall of the abdominal cavity, forms a funnel-shaped duct, open above at *a*; *r*, rectum; *an*, vent; *gu*, situation of the genital and urethral apertures, the former in front of the latter, drawn as a common opening because the wall between them could not be distinguished externally.

[a] Exceptions occur among Salmon fry.
[b] ,, ,, ,, Grayling ,,

In the structure of the ovaries the Salmonoid family stands almost alone among the Teleosts. Only among the Eels, in a New Zealand family (*Galaxiidæ*) and an East Indian and West African family (*Notopteridæ*), are the eggs deposited in the same manner. Yet the Salmonoids cannot be said to be entirely destitute of oviducts. The true difference between the ovaries of this family and those of most other Teleosts is that, while in the latter the said organ is a closed sac, open only behind (through the oviduct), the outer wall of which is formed by a fold of the peritoneum (mesoarium), and round the inner surface of which the oviferous layer is set in transverse or longitudinal folds (lamellæ), in the Salmonoid family this layer extends only over the outer side (the side facing the lateral wall of the abdominal cavity) of the simple, pendent mesoarium (peritoneal fold). Or in other words, we may imagine the otherwise closed ovary (together with the oviduct) to be split throughout the length of the outer side (the side facing the lateral wall of the abdominal cavity). Both at the anterior extremity of the ovary and at the lower (ventral) margin, however, the mesoarium bends towards the outer side, and behind the ovary the mesoarium is continued in the form of a simple lamella, either hanging between the intestine and the wall of the abdominal cavity, with the lower (ventral) margin free, or with the said margin curved upwards and outwards and coalescent with the wall of the abdominal cavity, thus forming an oviduct (abdominal funnel) open even in front. These oviducts (fig. 208) — one on each side in front, but united at the extreme end into a common passage behind the intestine — which occur in the Smelts and Capelins, are indeed imperfect in comparison with those of the other Teleosts. But in their anterior opening they show a remarkable anatomical resemblance[a] to the corresponding structure both in the Ganoids (with the exception of *Lepidosteus*), Sturgeons, and Cartilaginous fishes and in the higher vertebrates, where the oviducts (Müllerian ducts) are separate from the ovaries and open into the abdominal cavity, receiving in this orifice the ripe eggs when detached from the ovaries.

GENUS SALMO.

Mouth armed with strong and pointed, rather scattered teeth, set in one row on the lower jaw, the intermaxillaries, the maxillaries, and the palatine bones, in one or two rows (but deciduous and sometimes wanting) on the shaft of the vomer, in an irregular group on the head of the vomer, in two rows on the tongue. Length of the maxillaries behind the intermaxillaries as a rule 53—63 %[b]*, and of the lower jaw as a rule 75—95 %*[c]*, of that of the head from the hind extremity of the intermaxillary bone to the posterior margin of the preoperculum. Number of rays in the anal fin as a rule less than in the dorsal*[d] *and at most 14, of which 7—10 are branched, and the base of the anal fin shorter than that of the dorsal. Pyloric appendages well-developed and numerous (about 25—90). Scales small, more than 100 in the lateral line, which is complete.*

In the Tertiary Period, when the Rocky Mountains rose and divided the arctic and temperate waters of North America into two regions, an eastern and a western, the genus *Salmo* was differentiated in two distinct directions of development, of which in the above diagnosis we have taken into account only one, the Salmons and Charr of the eastern region. The other course of development ran side by side with this — branched like it into Salmon and Charr — but acquired a character peculiar to itself in the long anal fin, with a greater number of rays, (15?) 17—19, of which 14—16 may be branched. This direction of development, whether we choose to regard its forms as a genus or subgenus, has received in recent times[e] the name of *Oncorhynchus*. To the European faunist it is not without interest, for its best representative, the Quinnat

[a] Cf. RATHKE, *Beitr. z. Gesch. d. Thierw., Abth. 2. Über den Darmkanal und die Zeugungsorgane der Fische*, pp. 123 and 159; HUXLEY, Proc. Zool. Soc. London 1883, p. 132. WEBER, Morphol. Jahrb., XII, p. 366. Oviducts of the same description occur in the Capelin; but there only one (the left) ovary is fully developed. In *Salmo* and *Coregonus* the mesoarium passes over the rectum, forming on each side thereof a short abdominal funnel (peritoneal duct).

[b] In Parr and individual exceptions 43—53 %, or, on the other hand, up to 78 %.

[c] " " " " " 65—75 " " " " " " " " 111 %.

[d] Sometimes the number is the same.

[e] SUCKLEY, Ann. Lyc. Nat. Hist., New York 1861, p. 312.

Salmon (*Oncorh. tschawytscha*), has been introduced with success by piscicultural methods not only into the Eastern States of North America, but also into Australia and Europe, though not yet, to the best of our knowledge, into Scandinavia. The Scandinavian fauna has, however, been enriched in very recent years, according to a newspaper paragraph at the beginning of 1892, by the introduction from Germany of a form planted in the latter country, the Californian Rainbow Salmon (*Salmo irideus*). The said form, together with a Charr form — or rather an intermediate form between the Salmon and Charr — has its original home west of the Rocky Mountains and in the Pacific Ocean, although they both belong to the course of development otherwise represented only to the east of this mountain range. A closer examination of these forms leads us, however, to the result[a] that in them we have a blending of characters most naturally to be explained, if not on the assumption of hybridism, as a reminiscence of the time when the Salmon and Charr, in their common development, were not fully differentiated from each other. Another American form, a Charr from the Eastern States (*Salmo fontinalis*), has been cultivated with success in England, Wales, and Scotland. *Salmo fontinalis* is also an intermediate form between the Salmon and the Charr, the only character — though not of great validity — in which it differs from the Greenland Charr, the absence of teeth on the basibranchial bones (hyoid teeth), being a character of the Salmon[b]. The Brook-Trout (*S. fontinalis*) has been crossed both here and in America with the Salmon as well as with European Charr; and these experiments have taught us, among other things, that the character which otherwise composes a constant distinction between Salmon and Charr, the feeble ossification and toothlessness of the vomer in the latter, loses its validity in these hybrids[c]. Consequently, in elucidating the relations of the forms to each other, here as in the preceding family, we have to reckon with hybridism as an important factor in the modifications of the types. To all appearances the genus has its original home in the American seas, where Salmon and Charr still occur in masses almost inconceivable to the European.

From the preceding family we have learnt that cross-breeding may take place not only between different species, but also between different genera. Hybridism alone cannot, therefore, prevent the distinguishing of the species. But the variability of form within the genus *Salmo* has hitherto rendered it impossible to define with certainty the numerous species that have been adopted; and we doubt whether the observer who consistently requires trustworthy and distinct characters can recognise more than three European species of the genus: the Salmon, the Huch, and the Charr. As yet, however, to the best of our knowledge, only NILSSON and SUNDEVALL — the latter in the titles of the figures in Pl. 58 and 59 in the former edition of "Scandinavian Fishes" — have ventured to advance this simple opinion. Still, both from a scientific and an economical point of view, it is of importance to know the conditions that involve the said inconstancy; and to this end it has been necessary to denote by special names the more or less constant forms that appear under different circumstances and in different localities. As regards the Salmon, general credence has been given in recent times to the opinion first advanced by LILLJEBORG and afterwards by WIDEGREN, namely that we can distinguish between two "species", the Trout[d] (*Salmo trutta*, Sw. *grålaxen*) and the Salmon[e] (*S. salar*, Sw. *blanklaxen*). The same applies in essential points to the Scandinavian Charr, among which we can generally distinguish with ease two forms, the Northern Charr (*Salmo alpinus*, Sw. *Lapplands-rödingen*) and the Saelbling (*S. salvelinus*, Sw. *Vetterns-rödingen*). Of the Huch, which, at least up to the present, cannot be claimed for the Scandinavian fauna, there are also two forms, the Siberian Huch (*Salmo fluviatilis*) and the Danube Huch (*S. hucho*).

The Scandinavian forms of the genus *Salmo* may in general be distinguished most readily in the following manner:

A: Number of scales in a longitudinal row above the anal fin, for an extent of $^1/_{10}$ of the length of the body, at least 23 (23—30). **Salmo umbla.**
- *a:* Distance between the ventral fins and the tip of the snout more than half the length of the body ... . *Salmo salvelinus.*

[a] SMITT, *Riksmuseets Salmonider*, Vet.-Akad. Handl., Bd. 21, No. 8, p. 143.
[b] Cf., however, SMITT, l. c., tab. metr. V and VI, Nos. 371, 386 and 458.
[c] Cf. DAY, *British and Irish Salmonidæ*, pp. 261 and 270, fig. 52, 2 and 2a.
[d] DAY, *British and Irish Salmonidæ*, p. 143.
[e] DAY, ibid., p. 51.

b: Distance between the ventral fins and the tip of the snout less than half the length of the body .... *Salmo alpinus.*

B: Number of scales in a longitudinal row above the anal fin, for an extent of $^{1}/_{10}$ of the length of the body, as a rule at most 19 (15—19, exceptionally 13 or 21) **Salmo salar.**

a: Least depth of the tail less than 27 % of the preabdominal length (the distance between the first rays of the pectoral and ventral fins) .. .. *Salmo salar.*

b: Least depth of the tail more than 27 % of the preabdominal length .. .. *Salmo trutta.*

The natural relation between these forms asserts itself both in their changes of growth and their external differences of sex. These differences are most distinctly reflected in the characters here given for the said forms.

ARTEDI, the father of modern ichthyology, on whose opinions and method LINNÆUS, his contemporary and friend, in great part based his system, was born in Angermanland. As a native of Northern Sweden, he was undoubtedly well acquainted with the opinions that prevailed at his time in this part of the country, where the Salmon forms are most abundant, as to the differences between them and as to their nomenclature. Where he applies to the Swedish Salmon forms their current Swedish names, we have in the latter, beyond doubt, the best possible clue to a correct understanding of his scientific views on this head.

In ARTEDI'S *Genera Piscium* we find the following Salmons enumerated.

1: *Salmo* rostro ultra inferiorem maxillam sæpe prominente, in Swedish, *Lax* and *Blanklax*.

2: *Salmo* maculis cinereis, caudæ extremo æquali, in Swedish, *Grålax*.

3: *Salmo* latus; maculis rubris nigrisque, cauda æquali, in Swedish, *Laxöring*, *Borting* etc.

4: *Salmo* cauda bifurca; maculis solum nigris, sulco longitudinali in ventre = *Salmo lacustris*, auctt., from the Lakes of Geneva and Garda.

5: *Salmo* maxilla inferiore paullo longiore, maculis rubris, in Swedish, *Forell*, *Stenbit*, *Rofisk*, *Backro* etc.

6: *Salmo* oblongus duabus dentium lineis in palato, maculis tantummodo nigris = the *Hach* of the Danube.

7: *Salmo* pede minor, quinque dentium ordinibus in palato = a confusion, originating with WILLUGHBY, of *Salmo carpio*, auctt., from Lake Garda, with the *Gilt Charr*, an English form.

8: *Salmo* vix pedalis: pinnis ventris rubris, maxilla inferiore paullo longiore = *Lapplands-Rodingen*.

9: *Salmo* lineis lateralibus sursum recurvis, cauda bifurca = *Salmo umbla*, auctt., from the Lake of Geneva.

10: *Salmo* pedalis; maxilla superiore longiore = *Salmo salvelinus*, auctt., from the Lake of Geneva.

In ARTEDI'S *Synonymia Nominum Piscium* the Salmons are given in the following order:

1 1 in *Genera Pi*...
2 2 „ „ „
3 5 „ „ „ , *Trutta*, auctt.
4 7 „ „ „
5 3 „ „ „
6: *Salmo* dorso fulvo; maculis luteis, cauda bifurcata *Salmo salmarinus*, auctt., from Trent (the Tyrol)
7 9 in *Genera Piscium*
8 6 „ „ „
9 4 „ „ „
10 8 „ „ „ , here with the Swedish names of *Rötel* and *Roding*.
11 10 „ „ „
12. *Salmo* minor, vulgari (1) similis.

In the *Descriptiones Specierum Piscium, quas vivos præsertim dissecuit et examinavit* etc., from which title, as well as from LINNÆUS'S preface, it appears that ARTEDI there included all the species which he had personally been able to examine, we find only five species of the genus:

1 = 1 in *Genera Piscium*.

2 = 12 in *Synonymia Nominum Piscium*, is here explained as a young Salmon, though often more than 12 inches (i. e. about 30 cm.) long, bearing the name of *Laxunge* at Elfkarleby, and differing from the *Blanklax* only in the comparatively larger and blunter head, the denser black spots, and the slight bifurcation of the caudal fin.

3 = 3 in *Genera Piscium*.
4 = 5 „ „ „
5 = 8 „ „ „

When LINNÆUS framed on this foundation his scheme of the Swedish Salmons, he adopted in his *Fauna Suecica* (1746) the following:

Sp. 306 = No. 1 in ART., *Gen. Piscium*.

„ 307 = „ 2 „ „ „ „ , with the remark: "It occurs in company with the preceding form, and I should scarcely consider it to be specifically distinct therefrom".

„ 308 = No. 3 in ART., *Gen. Pisc.* according to the synonymy, but with a new diagnosis: *Salmo* maculis nigris brunneo cinctis; pinna pectorali punctis sex, and with the Swedish name of *Laxöring* altered to *Örlax*.

„ 309 = No. 5 in ART., *Gen. Pisc.*, but with the word *paullo* omitted from the diagnosis, and with the addition of the Swedish name of *Laxöring*.

„ 310 = No. 8 in ART., *Gen. Pisc.*

Now GISLER tells us in a series of papers (in the Transactions of the Swedish Academy of Science for 1751 and 1752) which are well worth reading even at the present day, that the *Blanklax* was called *Grålax* in Norrland, "when it had spent itself in the rivers and had become quite lean and gray, with a long hook at the tip of the lower jaw, especially in the males, after the flesh had wasted away". GISLER, it is true, recognised only three Norrland species, namely

1 Spec. *Lax*,
2 „ *Laxöring*,
3 „ *Stenbit* etc.

But as varieties of *Laxöring* he adopted 1) from LINNÆUS's *Fauna* Spec. 307, which he calls *Laxöring, Laxockel, Fjerd-lax*, or *Eriksmäss-lax*, and Spec. 308, which he calls *Börling, Sikmatk, Tajmen*, or *Lödjor*, and 2) from ARTEDI the above-mentioned No. 3 in *Gen. Pisc.*, which he calls *Trarspol*, and No. 12 in *Syn. Nom. Pisc.* which he calls *Laxunge, Smalax*, or *Padrifrare*. GISLER's third species, *Stenbit* etc., is indeed equivalent, according to his synonymy, to No. 5 in ARTEDI, *Gen. Pisc.*; but all that he says of it is that it "has its constant haunts in small streams, tarns, and lakes, and is quite rare further down the country in the great cascades. Deposits the roe in small streams at the middle of September. In clear water with a stony or sandy bottom its colour is light, but on a bottom of ooze or mud quite blackish". It is not improbable that GISLER meant the Charr, which was of less interest to him and perhaps, in consequence, less known, for both the Swedish name of *Röding* and the Lapp *Raud* (according to LINNÆUS) might easily be confounded with *Röfisk*. If this be the case, we find in GISLER the opinion now held by most ichthyologists, that within the Scandinavian fauna there are only three species of the genus *Salmo*, namely the *Lax* (Salmon), *Öring* (Trout), and *Röding* (Charr).

This opinion was subsequently advanced first by LILLJEBORG in *Öfvers. Vet.-Akad. Förhandlingar* for the year 1849, where he points out that "the characters which divide *Salmo salmulus* and *Salmo fario* have much in common with those which distinguish *Salmo salar* and *Salmo eriox*. That *S. salmulus* is the young of the *Blanklax* (*S. salar*), and *S. fario* that of the *Okla* or *S. eriox*, is therefore almost unquestionable, especially as they occur in the same waters, and connecting links between them are known". A more explicit statement of this opinion was WIDEGREN's principal object in his "*Bidrag till kännedomen om Sveriges Salmonider*" (*Öfvers. Vet.-Akad. Förh.* 1863).

But another, still more radical reduction of the species had been proposed, conditionally so to speak, by NILSSON in *Öfvers. Vet.-Akad. Förh.* for 1848. "Under such circumstances, and seeing that *all* the characters prove variable in so high a degree, we are almost tempted to ask whether there are here more than two species of Salmons: *Trutta* and *Salvelinus*; or the very two which I have designated in my *Prodromus* as the representatives of distinct groups". Nevertheless he retains the *Blanklax, Gralax, Laxöring*, and two Charr forms as "the most differentiated" or "least intercommunicating" species. In his *Skandinavisk Fauna* he remarks, however (p. 395), that the *Gralax* "is most probably nothing more than an old outgrown form of *Salmo Trutta* or *Okla*"; and we may thus trace even in NILSSON's writings the opinion "that in the division of the true Salmons we have only two species certainly distinct from each other" (LILLJ.). While NILSSON, however, in his last-mentioned work, divided the Trouts (*Öringarne*), including the *Gralax*, into six (conditionally seven) species, SUNDEVALL adopted the above opinion, that the true Salmons of Scandinavia belong to one single species. This appears from the titles given by him to the figures in Pl. 58 and 59 in the first edition of "*Scandinavian Fishes*". The male Salmon represented in Pl. 58 is evidently a *Blanklax*, probably from Norrköping; fig. *a* in Pl. 59 is a *Laxöring* (*Börling*) from the Ljusne Elf, and fig. *b* in the same plate a *Gralax* from Lake Wetter; yet all three bear the specific name of *salar*.

All that different views as to specific determination has been able to accomplish, has thus been devoted to the elucidation of the Scandinavian Salmon forms. But here as elsewhere the point seems to be, not so much the establishment of a certain number of species, as the explanation of the natural relationship between the forms selected as distinct types. Before these forms can rank as distinct directions of development, it is of course necessary to show that the characters employed do not coincide with those which mark the common variations of the whole genus under the influence of different developmental, sexual, and other circumstances.

We begin with the investigation of these circumstances in the true Salmons, assuming at first the distinction between *Salmon* and *Trout*, as separate species, to be true.

In order to find an expression for those common variations of the Salmons which depend on their growth (their developmental circumstances), we have divided our Scandinavian material, 316 specimens, into five groups, arranged according to age (the length of the body). These five groups represent different stages of development which are in general well defined both by form and coloration, though the rule is often infringed owing to a cause long known, especially as a result of WIDEGREN's observations, namely the fact that the development is not uniform, one or other of the stages being often persistent in an individual specimen longer than in its fellows of the same age. In average calculations, however, such individual exceptions may be regarded as eliminated, and the said classification is observed, generally speaking, even in popular phraseology, the first group containing the *Laxyngel*, Salmon-fry (length under 70 mm.), the second group the *Stirrar*, Parr (length > 70 mm., < 130 „), the third group the *Foreller* or *Stenbit* (length > 130 mm., < 230 „), the fourth group the *Öringar* or *Börting* (length > 230 mm., < 450 „), the fifth group the full-grown *Laxar* or Salmon (length > 450 mm.). The average percentages calculated as expressions of the different relations of form in these groups, lead us to very singular results[a]. Out of 59 distinct relations of form 41 follow a fixed course in their changes of growth, i. e. they either decrease with increasing age (as for example the average length of the head in proportion to that of the body), or increase with age (as for example the average postabdominal length in proportion to the length of the body).

In order to obtain an expression for those common variations of the Salmons which are due to external sexual differences, we have compared 17 males of the different stages of growth with 17 females of about the same size as the males and with the sexual organs about equally ripe. The result is that 16 of the said 41 changes of growth run in the same direction as the sexual difference between male and female, i. e. a change of growth that shows decreasing percentages with increasing age answers to a sexual difference with greater percentages in the males than in the females, and *vice versa*. The two examples cited above appear in the following percentages:

Average	Fry	Parr	*Forell.*	*Öring*	*Lax*	♂	♀
Length of the body expressed in millimetres	48	108	179	318	595	218	218
„ „ „ head in % of the length of the body	25.0	23.6	22.7	21.9	20.9	23.4	21.8
Postabdominal length	16.9	19.7	19.7	20.4	21.2	19.6	20.9

The parallelism between the numerical alterations 1) in the first five columns and 2) in the last two columns, may evidently be expressed as follows: the younger Salmon are to the older as the males to the females.

If we now examine the difference of form between the two Scandinavian Salmon species that have received most general recognition, *Salmo trutta* and *S. salar* we arrive at exactly the same result: the difference between the averages for the said characters runs from the *Gralax* (*S. trutta*) to the *Blanklax* (*S. salar*) in the same direction as the averages for the changes of growth and also for the external sexual differences. Some of the most important of these characters may here be tabulated.

Average		Fry	Parr.	*Forell.*	*Öring*	*Lax*	♂	♀
Length of the body expressed in millimetres	*Salmo trutta*	17	108	182	313	587	218	218
	Salmo salar	50	109	161	403	609		
„ „ „ head in % of the length of the body	*Salmo trutta*	25.2	23.5	22.6	22.0	22.0	23.4	21.8
„ „ „ „	*Salmo salar*	21.6	23.5	22.2	20.1	20.2		
Postabdominal length	*Salmo trutta*	16.5	19.8	19.7	20.3	21.2	19.6	20.9
„	*Salmo salar*	17.7	19.5	19.5	21.3	21.1		
Length of the maxillaries	*Salmo trutta*	9.8	9.2	9.1	9.0	8.6	9.6	8.6
„ „ „ „	*Salmo salar*	8.1	8.0	7.6	7.0	7.0		
Least depth of the tail	*Salmo trutta*	9.5	9.1	9.4	8.7	8.7	8.7	8.4
„ „ „ „ „	*Salmo salar*	8.4	8.0	8.2	7.1	6.9		
Length of the middle caudal rays	*Salmo trutta*	11.1	9.0	8.0	7.7	7.7	8.1	7.1
„ „ „ „	*Salmo salar*	8.8	7.1	6.7	5.5	5.8		
Least depth of the tail in % of the preabdominal length	*Salmo trutta*	36.5	32.4	32.7	30.0	30.1	30.0	29.4
„ „ „ „ „	*Salmo salar*	30.4	27.8	28.1	23.6	25.2		

[a] As we cannot give here all the particulars of our investigations, we refer the reader to our *Kritisk Förteckning öfver de i Riksmuseum befintliga Salmonider*, Vet.-Akad. Handl., Bd. 21, No. 8.

Many other such relations might here be cited to prove the statement that *the relation between Salmo trutta and Salmo salar is the same as that between young Salmon and old and between the males and the females.* To judge by all analogous cases there must be some causal connexion between the difference of species, the difference of age, and the difference of sex.

We find, however, among the changes of age certain peculiarities which indicate that another factor has also asserted its influence in the differentiation of the species. We see something of the kind even among the above averages, for example in the average least depth of the tail: — a comparatively large gap appears in the numerical series, usually after the *Forell* stage, and this gap is greatest in *Salmo salar*. The most striking example, however, is perhaps the relation between the height of the anal fin (the length of its longest ray) and the length of the body:

Average		Fry.	Parr.	*Forell*	*Öring*	*Lax.*
Length of the body expressed in millimetres	*Salmo trutta*	47	108	182	313	587
„ „ „ „ „ „ „	*Salmo salar*	50	109	161	403	609
Height of the anal fin in % of the length of the body	*Salmo trutta*	13.6	13.2	13.1	12.1	11.5
„ „ „ „ „ „ „ „ „ „ „ „ „ „	*Salmo salar*	12.9	11.8	11.2	8.7	9.0

Now it is a well-known rule that after the *Forell* stage the Salmons change their habitual place of abode. The *Gralax* (*Salmo trutta*) leaves the brooks for meres and large lakes, sometimes directly for the sea; but the *Blanklax* (*S. salar*) must necessarily repair at this period to the sea, else its development is arrested, and it persistently retains a greater or less similarity to the *Gralax*. Thus the wide gap in the averages is probably connected in some way with an alteration in the abode and habits of the Salmons. Here we have assumably a third factor in the differentiation of the species.

A fourth cause of difference in form undoubtedly lies, here as among the preceding family, in hybridism, of which we have just given instances.

The relation of the Charrs to the Salmons leads us in most characters to the conclusion that the former should be regarded as more advanced stages of development of the Salmon type. To exemplify this, we shall only refer the reader to the above-mentioned characters, which afford the following averages:

Average		316 Salmon	108 Charr.
Length of the body expressed in millimetres		279	333
„ „ „ head	in % of the length of the body	22.5	21.5
Postabdominal length	„ „ „ „ „ „ „ „	19.9	20.9
Length of the maxillaries	„ „ „ „ „ „ „ „	8.8	8.5
Least depth of the tail	„ „ „ „ „ „ „ „	8.8	7.2
Length of the middle caudal rays	„ „ „ „ „ „ „ „	7.9	6.9
Height of the anal fin	„ „ „ „ „ „ „ „	12.3	10.5
Least depth of the tail	„ „ „ „ „ preabdominal length	30.7	24.9

In every case where the percentage decreases during growth in the Salmons, it is less in the Charrs, and *vice versa*. This applies also to an internal character which usually possesses great validity, the number of the gill-rakers. In the outer row on the front of the first branchial arch *Salmo trutta* has on an average 14—16, *Salmo salar* 17—20, *Salmo umbla* 23 or 24.

Hence it is clear that, in the great majority of cases, the *Blanklax* must come nearer the Charrs; but that the latter have not been developed directly from the former, appears from other relations, in which they stand nearer the *Gralax*. One of these relations is afforded by the character which, to the best of our knowledge, gives the only tenable distinction between the Salmons and the Charrs, namely the size of the scales, expressed in their number. The scales are generally larger in *Salmo salar* than in *S. trutta*, but larger even in the latter than in *S. umbla*. In a longitudinal row extending along $^1/_{10}$ of the length of the body, we find 1) on the anterior part of the belly above the lateral line in *S. salar* on an average 18 scales, in *S. trutta* 18—21, and in *S. umbla* 30, 2) on the tail in *S. salar* 15 or 16, in *S. trutta* 16 or 17, in *S. umbla* 26. Thus the Charrs have probably been developed from a race nearer to the *Gralax* than to the *Blanklax*; but the development has followed the same course and produced the same results in the differentiation of form.

The natural relation between the Charrs is indeed more complex, but all the more instructive. In Scandinavia we have two forms, the Northern Charr (*Salmo alpinus*) and the Sælbling (*S. salvelinus*), whose right to a specific rank is almost as certain as the difference between the *Gralax* and the *Blanklax*, and which occupy the same developmental relation to each other, *S. alpinus* representing the younger stages of growth, *S. salvelinus* the older ones. Besides these forms however — in order to gain a correct understanding of the relation between them — we must take into consideration a third form which strictly belongs to Greenland and the northern regions of North America, and for which we may employ the specific name given it by FABRICIUS[a], *Salmo stagnalis*[b].

On closer examination of these three Charr forms, we see that in many respects[c] the averages run in an uninterrupted series from *alpinus* through *stagnalis* to *salvelinus*, i. e. *alpinus* represents the youngest stages, *salvelinus* the oldest. Here, for the sake of brevity, we can only give one example.

The least depth of the tail in proportion to the length of the head diminishes as a rule in the Charrs with increasing age. In order more carefully to test the particulars of this relation and others, I have divided the material possessed by the Royal Museum into six groups according to age. As we have no corresponding terms in popular phraseology, I have denoted these groups by Roman numbers. The first group (I) contains the specimens under 228 mm. in length. Among all these specimens (of all forms and intermediate forms) the average length of the body is 188 mm. The second group (II) contains the Charr between 228 and about 355 mm. long. The average length of body in this group is 303 mm. In the third group (III) the maximum length of body is about 458 mm. and the average length 387 mm. In the fourth group (IV) these measurements are respectively about 538 mm. and 494 mm. The fifth group (V) contains only three specimens, all about 650 mm. long. The sixth group (VI) consists of only one specimen, a male from Spitzbergen, measuring 757 mm.

The alterations caused by growth in the relation between the least depth of the tail and the length of the head, are most regular in our specimens of *stagnalis*, being in this form:

Average in	II	III	IV	V
♂	34.0	32.9	30.4	
♀	35.9	33.6		32.6

The averages in the second group (II) are:

Average in	*alpinus*.	*stagnalis*	*salvelinus*
♂	36.5	34.0	29.4
♀	37.4	35.9	29.9

The form series, expressed in averages for all our specimens, is as follows:

Average	*alpinus*	*stagnalis*	*salvelinus*
Least depth of the tail in % of the length of the head	36.7	33.2	29.2

All these averages follow a regular course, constantly decreasing. Such is the case where the form series has retained its original type, and in the relations where the males evidently represent the highest stage of development. In several relations, however, the females have a special representative in *stagnalis*, and the original form series has thus been modified in a singular manner. We have an example of this in the proportion between the length of the maxillaries

[a] *Fauna Groenlandica*, p. 175.

[b] In order to simplify the question, we here omit some intermediate forms, the significance of which we may disregard for the time being.

[c] In the work quoted above (*Laksmus, Salmon.*) I have adduced 18 such points.

and that of the body. The general form series in this relation is the following:

Average	*alpinus*	*stagnalis*	*salvelinus*
Length of the maxillaries in % of that of the body	7.9	7.6	9.8

Here the series is irregular: *alpinus* occupies an intermediate place in the averages, *stagnalis* having a lower average, and *salvelinus* the highest of all. We arrive at the same result, if we examine the several stages of growth; e. g. the third (III):

Average		*stagnalis*	*alpinus.*	*salvelinus*
Length of the maxillaries in % of that of the body.	♂	7.8	9.9	9.9
	♀	7.3	8.1	9.6

Ranged in this manner the form series ascends with fair regularity, at least in the females, towards *salvelinus;* and the changes of growth are also in direct proportion to age. Thus, for example, we find

The average length of the maxillaries in % of that of the body in		I	II.	III	IV	V
stagnalis	♂		6.9	7.8	8.6	
	♀			7.3	7.8	8.5
alpinus	♂	7.9	8.8	9.9	—	—
	♀	7.3	7.5	8.1		—

In this relation, as in many others — we will not give more examples here — the influence of a marked sexual difference on the development of form has ranged *stagnalis*, with the female characters, on one side of *alpinus*, and *salvelinus*, with the male characters, on the other. If *alpinus* were omitted from the comparison, or if we were ignorant of its existence, the relation between *salvelinus* and *stagnalis* would seem almost exactly similar to that between *trutta* and *salar.*

The character, derived from the situation of the ventral fins, which as a rule — not entirely free from exceptions — separates *alpinus* from *salvelinus*, is merely an expression of the extremes in an evolution of form still proceeding. Its signification appears without difficulty from the following table of averages:

Average distance of the ventral fins from the tip of the snout in % of the length of the body		I	II	III	IV	V.
Salmo salvelinus	♂	51.7	51.4	52.6	54.3	—
	♀	51.4	51.5	51.9	52.2	
Salmo stagnalis	♂		48.7	49.1	50.3	-
	♀		46.4	47.9	49.4	47.0
Salmo alpinus	♂	47.5	48.2	48.4	—	—
	♀	46.4	47.2	47.7	—	—

The changes of growth here follow a regular course with increasing averages, at least in the females of *salvelinus* and *alpinus* and in the males of *stagnalis.* Nearly all the males have greater averages than females of the same form and age. The form series, expressed in averages for all our specimens, is as follows:

Average	*alpinus*	*stagnalis.*	*salvelinus.*
Distance of the ventral fins from the tip of the snout in % of the length of the body	47.4	48.5	52.0

Not only the form of the *Salmones*, but also their manner of life indicates their common descent. It seems most probable that the Salmons were originally marine fishes of an arctic or subarctic (boreal) region, that for procreative purposes they made their way into arms of the sea and the mouths of rivers, and that by a stronger and stronger development of this roving disposition they were transformed to fresh-water fishes for a great part of their life, or finally changed their abodes for all time. Among the Scandinavian Salmons the *Blanklax* (*Salmo salar*) represents the most migratory type, the Sælbling (*S. salvelinus*) is most completely a fresh-water fish. As there is nothing in the form characters to indicate an evolution of true Salmon from Charr, but everything seems to favour the converse opinion, it is most natural to assume that the primitive forms were marine fishes.

During their life in fresh water the Salmons acquire a coloration quite different from their sea dress: the epidermis becomes tumid, conceals the scales in a greater or less degree, and assumes a darker colour, gray, grayish or greenish brown, partly black and red or yellowish, developing at the same time spots of black and red. But this coloration appears, in general cases, only as the generative organs approach maturity; and at times the Salmons remain long enough in fresh water before these organs are fully ripe for spawning.

In great rivers, such as the Rhine[a] and Loire[b], at least some Salmon have been observed to pass a whole year in fresh water under these circumstances. Neither the spawning dress nor any of the other external characters of sex — the most remarkable of them being a cartilaginous projection, turned upwards and recurved, which appears at the point of the lower jaw in the males ready to spawn, and fits into a cavity in the upper jaw — is developed in such specimens. The Salmon which observers have traced in this condition for two spawning-seasons are consequently incapable of spawning until two, or perhaps three years have intervened. In Sweden, to the best of our knowledge, no direct observations on this head have been recorded; but in the Dal Elf, especially at Elfkarleby, specimens called *Oklor*, with bright (*blank*) dress and undeveloped generative organs, have long been known. These specimens are bright *Gralax*, resembling in coloration the *Blanklax*, and in other parts of Norrland, where they are also found in the Gulf of Bothnia, they bear the names of *Börting* and *Tajmen*. In Lake Wetter they are represented by the so-called *Silfverlax*. From Lake Wener WIDEGREN[c] records the occurrence of "adult individuals of *Salmo salar* which in autumn had neither matured roe nor ripe milt". Thus we possess trustworthy evidence from several parts of Sweden as well, to the effect that the Salmons do not invariably spawn every year, even if they remain in fresh water the whole time. WIDEGREN remarks the same circumstance[d] in the reproductive operations of the Charrs.

Quite natural is the consequence that the Salmons require a long time to recover the losses which their frame has suffered in propagating their kind. These losses are so great that many, perhaps most, of the older specimens, especially the males, die of exhaustion. All their fat and the greater portion of their flesh have been consumed, partly as a source of nourishment during the period when the fish entirely abstains from food, partly in the ripening of the sexual organs. In England these fish are known as *Kelts*, on the River Nissa in Halland they are called *pejsor*. MIESCHER-RUESCH[e] has shown how the great lateral muscles of the body and the dermal muscles undergo a fatty degeneration and yield the greater part of their volume to develop the ovaries; and a comparison (fig. 209) between the conditions of the intestinal canal of a male salmon before and after the spawning, is a striking illustration of the great changes which take place in the body, while the spawning-dress is in course of development.

a *b*

Fig. 209. Intestinal canal and testes of a *Salmo salar* before (*a*) and after (*b*) the latter have swollen to maturity. After BUCKLAND. Both figures reduced. *a* from a clean run fish weighing 35 lbs. and taken in the Avon on the 14th of March, 1871; *b* from an unclean (breeding) Salmon weighing 13 lbs. and taken on the 19th of January, 1871. *a*, oesophagus; *i*, intestine; *p*, pyloric appendages; *m*, testes. In *a* both the pyloric appendages and the intestine are embedded in fat, and the testes thin; in *b* the testes are distended, and both the pyloric appendages and the intestine are without adipose layers.

Statements have been made, it is true, which apparently show that in the sea, at least under favourable circumstances, Salmon may gain in strength and fatness with astonishing rapidity. From experiments made in 1855 at Stormontfield (a Salmon-breeding establishment on the Tay in Scotland) — as well as from still earlier experiments (1795[f]) in the River Berridale (Caithness) — it was concluded that Salmon-fry which left the Tay at the end of May, weighing at most 57 grammes,

[a] See MIESCHER-RUESCH, *Statistische und biologische Beiträge zur Kenntniss vom Leben des Rheinlachses im Süsswasser*, Intern. Fischerei-Ausstellung in Berlin 1880; Catal. Schweiz, p. 170.

[b] See KÜNSTLER, *Rech. s. la reproduction du Saumon de la Dordogne*, Congr. Intern. de Zoologie, Paris 1889, Compte-Rendu des Séances, p. 83.

[c] Öfvers. Vet.-Akad. Förh. 1864, p. 294.

[d] ibid., p. 295.

[e] l. c., pp. 186 etc.

[f] DAY, *British and Irish Salmonidæ*, p. 93.

returned in the beginning of July, about six weeks after their departure, having attained in the sea a weight of $1\frac{1}{3}$ kilo; and at the end of July others came back which had grown to a weight of nearly $1\frac{1}{4}$ kilo[a]. These experiments, however, were not carried out with sufficient precautions to render the results convincing[b]. The growth of older Salmon is better known, and, though not so rapid, is still considerable. In 1859 the Duke of ATHOL marked three Salmon, weighing respectively 10, $11\frac{1}{2}$, and $12\frac{1}{2}$ lbs. ($4\frac{1}{2}$—$5\frac{2}{3}$ kilo), then on their way to the sea, and took them again six months afterwards, as they were returning to fresh water, when their weights were respectively 17, 18, and 19 lbs. ($7\frac{3}{4}$—$8\frac{2}{3}$ kilo.)[c]. Even if these Salmon could have attained a breeding condition the same year, we have other observations and circumstances which indicate that, as a rule, their stay in the sea is longer. In February and March SCROPE marked several Kelts, weighing 4 lbs., from the River Shin in Sutherland, and on taking them again in June and July of the following year, found them to weigh 9—11 lbs.[c] The Salmon which descend into the Gulf of Bothnia from the rivers of Norrland and Finland, rove from the said gulf down to the south of the Baltic. As GISLER observed in 1752[d], as STECKSÉN remarked a century later[e], and as MALMGREN quite recently ascertained[f], in the rivers of Norrland and Finland Salmon are often caught which have hooks in the jaws or stomach that they have torn loose from long-lines in the south of the Baltic, even on the Pomeranian coast. Journeys of such length presumably demand too long a time for a Salmon to descend early in spring into the Baltic, exhausted by the exertions of the spawning, and to return the same year, even at so late a season as June—August, and ascend one of the rivers in breeding condition. To this we should add that in the south of the Baltic line-fishing for Salmon is practised chiefly, if not exclusively, in autumn and winter, so that we have all reason to believe that these Salmon must have wintered in the south. It is also quite possible that a sojourn in the brackish water of the Gulf of Bothnia — as in the fresh water of Lake Wener — can replace the year's stay in fresh water previous to the spawning, required by the so-called Winter Salmon of the Rhine. This is all the more probable now that Mr. ANDERSSON'S experiments have shown (see LÖNNBERG, Bih. Vet.-Akad. Handl., Bd. 18 (1892), Afd. IV, No. 2, p. 10) that the generative organs can ripen, even if the fish be detained in the Gulf of Bothnia while its fellows are preparing to spawn in the rivers.

The *Blanklaxar* thus pass the greater part of their marine life and, at least in certain cases, a considerable portion of their life in fresh water, without the development necessary for breeding and without the characters that mark their spawning-dress. This is also true of the *Gralaxar*, with the single exception that, for the most part, they live between the spawning periods in lakes. Yet it is no very simple task to explain all the names which these fishes have received in different dresses and at different stages of sexual maturity.

SIEBOLD advanced the opinion[g] that the "Silver Salmon" (*Schwebforelle, Maiforelle*) which are found in the alpine regions of Central Europe, are persistently sterile *Gralaxar* (*Grundforelle, Lachsforelle*); and that such individuals do occur, is also maintained by FATIO in Switzerland. But WIDEGREN showed that the characters of the former are inconstant, being more and more approximated to the *Grålax* type as their sexual organs are developed, and that they probably do attain maturity, "though[h] several years may possibly elapse before a sterile individual becomes fertile and acquires the characters typical of the generative power." On closer examination of this so-called sterility, however, we find[i] that it is attended with characters which are a combination of *Blanklax* and *Gralax* characters — the alleged difference between "fertile" and "sterile" *Gralaxar* is really the same as that between *Gralaxar* and *Blanklaxar* — and the same combination of characters occurs, as is natural, in hybrids between *Salmo salar*

[a] BROWN, *The Natural History of the Salmon* etc., pp. 49 and 52.

[b] RUSSEL, *The Salmon*, p. 54.

[c] DAY, l. c., p. 95.

[d] Vet.-Akad. Handl. 1752, p. 100.

[e] In NILSSON, *Skand. Fn., Fisk.*, p. 381.

[f] Bohuslänsk Fiskeritidskrift, II. 1—3, p. 50. In the Great Belt FIEDLER (Nordisk Aarsskrift for Fiskeri, 1884, p. 24) found a similar brass hook in the mouth of a Salmon caught in April south of Corsoer.

[g] *Susswasserfische Mitteleuropas*, p. 301.

[h] Öfvers. Vet.-Akad. Förh. 1861, p. 292.

[i] SMITT, *Riksm. Salmon*, l. c., pp. 83 etc.

and *S. trutta*. Now hybridism does not necessarily involve sterility; and with regard to the Silver Salmon and similar forms, it may well be difficult to determine in each case whether it is an altered manner of life — a longer stay in the sea or large lakes — or hybridism that has brought about the said changes of form. But it appears to be demonstrated that these changes attend either or both of the above conditions.

In Sweden and, generally speaking, in all temperate countries, the Charrs are true fresh-water fishes; but such is not the case in the arctic parts of their geographical range. There they live like the Salmon; Esmark[a] and Hetting[b] found them in the Arctic Ocean off Norwegian Finnmark, and off Spitzbergen they are the favourite food of the Beluga (*Delphinapterus leucas*), which follows them to the head of the gulfs and bays. In the sea they wear the colours of Silver Salmon, and do not acquire their proper Charr dress before entering the rivers.

Characters both of form and colour indicate in their variations a close relationship between the Salmons. Their differentiation seems to be of late origin, and they should perhaps be regarded as species which are still developing constancy of characters[c].

The skeleton of the Salmons is feebly ossified in sharp contrast to that of the preceding family. The cranium is for the most part persistently cartilaginous, and most of its bones lie as separate covering-bones on the almost continuous capsule of cartilage. The occipital ridge is merely a short terete process, extending about as far back as the ordinary processes from the mastoid (epiotic) and squamose (pterotic) bones. The posterior oculo-muscular canal is large, and penetrates the occipital region behind, being covered below by the parasphenoid bone, which is strongly bent in the sphenoidal region, and centrally divided in front by the Y-shaped basisphenoid bone, which is wanting in the preceding family. Here, on the other hand, as in the following genera, there is no pharyngeal process. The orbits are separated internally by a thick wall, composed of cartilage and the orbito-sphenoid bones. The osseous framework of the upper jaw, as we have mentioned above, is quite different from the corresponding structure in the Cyprinoids. The maxillaries articulate in front, like the intermaxillaries and the palatine bones, and close between these two pairs, with the cartilaginous rostral part of the cranium (the rostro-ethmoidal cartilage). But they have undergone considerable elongation — the intermaxillaries, on the other hand, are comparatively short — and are furnished with teeth, as well as the intermaxillaries and the palatine bones. Their anterior part is, however, covered below by the intermaxillaries, so that their externally visible length — as it is given in the above definition of the genus — is measured from the hind extremity of the latter bones. Above their posterior part lies the covering-bone (*os supplementare*) which answers to the cheek-bone (*os jugale*) of the higher vertebrates. The vomer is set as a covering-bone on the middle of the under surface of the rostro-ethmoidal cartilage and on the anterior extremity of the parasphenoid bone. In the Salmons its shaft (body) is fairly long and broad, carinated on the under (outer) surface, but thin; in the Scandinavian Charrs, on the other hand, ossified hardly at all or only on the sides. The dentition of the vomer is also confined, as a rule, in the latter to the anterior part, the so-called head; while in the Salmons it extends, at least during youth, to the shaft as well, but is generally more and more reduced with age. The other bones of the palate, except the palatine bones proper, are toothless in this genus. The pterygoid bones are slender and curved in the ordinary manner to unite the palatine and quadrate bones. Within them lie the mesopterygoid bones, which are thin, but broad behind, and form the greater part of the roof of the mouth. According to Lilljeborg these two bones afford a constant distinction between Trout and Salmon. In the former, he says, their breadth decreases from their middle point even in a backward direction, whereas in the latter they grow broader all the way from the anterior to the posterior extremity. A great difference from the preceding family appears in the branchiostegal membranes, which are furnished with a far greater number of rays (9—12, in exceptional cases 8 or as many as 14, in *Oncorhynchus* sometimes 16). These rays are, however, of the same broad, blunt, sabre-like form as in the Cyprinoids.

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[a] Skand. Naturf. Möde, Chria 1868, Förh., p. 527.

[b] Smitt, l. c., tab. metr. VI, No. 399.

[c] "In numerous cases one is much tempted to ask whether we have not to deal with a family which, being one of the most recent creation, is composed of forms not yet specifically differentiated": Günther, *Cat. Brit. Mus., Fish.*, vol. VI, p. V (preface).

The spinal column is also marked by its weak ossification. The neural arches proper (OWEN's *neurapophyses*) are persistently cartilaginous in most of the abdominal vertebræ, and the bases of their neural spines are united to the bodies of the vertebræ only by a suture or, in young specimens and in the anterior part of the column, by a mobile articulation. In the forepart of the skeleton these spines are also but loosely united to each other, the right to the left in each vertebra, and with the hind surface of each base articulates a rib-like muscular bone, directed outwards, backwards, and upwards (OWEN's *diapophysis*). In the posterior part of the abdominal region the cartilaginous neural arches disappear, the bases of the neural spines take their place and develop a firmer osseous connexion with the bodies of the vertebræ, the neural arches thus formed being strengthened at the same time by the coalescence of the spines on each vertebra. The diapophyses decrease in length, and disappear near the caudal region; but simultaneously there appear, though with only slight development, the knob-shaped articular processes (*zygapophyses*) that in the Cyprinoids are generally so prominent on the anterior abdominal vertebræ, one pair in front of and one pair behind the neural arches, which are here most constant in the caudal region, though even there they may be wanting. The development of the hæmal arches proper (OWEN's *hæmapophyses*) takes the reverse direction. It advances from the front of the body to the posterior part thereof: on the first vertebra they are scarcely distinguishable externally from the body of the vertebra; on the second vertebra they are distinct protuberances, one on each side of the lower part; on the third each of them is furnished with a rib; and they thus continue to increase until, near the caudal region, a succession of hæmal spines appears, each bearing a pair of ribs on the hind surface of its top, while the hæmal spines of each vertebra approach each other at the top, forming (usually on the last six abdominal, as well as on the caudal vertebræ) a closed hæmal arch. On the same vertebræ as the hæmal spines, there also appear lower articular processes similar to the upper. The ribs are slender, in sharp contrast to those of the Cyprinoids.

In the shoulder-girdle, the structure of which is else the same as in the preceding family, the clavicle is thin and broad, with the upper arm comparatively short, and the postclavicle consists of three, sometimes four parts, namely two (sometimes three) upper, thin and flat, and one lower, pointed and rib-like. This division of the postclavicle recurs in the Herrings.

The pelvic bones are simple and triangular, without the indentation in front, and with only a rudiment of the process behind, which we have seen in the Cyprinoids. But remnants of the older piscine types' radialia (mobile basal bones of the ventral rays) and also of the true pelvis of the said types, have been detected in the *Forell* stage by DAVIDOFF[a].

The intestinal canal is rather simple and short, as in most predatory fishes, its entire length, when extended, being about equal to the length of the body or somewhat less than the latter. The stomach is only faintly marked off from the rest of the canal; but a remarkable point is the thickening of its walls which attends a diet of mollusks or other testaceans[b]. This thickening has been most frequently observed in the so-called Gillaroo Trout of Ireland, a form which has hence been named by GÜNTHER *Salmo stomachicus*; but it may also be observed in common Lake Trout[c]. The pyloric part is directed forwards, as well as the beginning of the true intestine (duodenum), which is exceedingly well furnished with cæcal diverticula. These appendages, however, vary considerably both in size and number, from about 30 to nearly 100. They are generally most numerous in the Salmon proper, where KRØYER[d] has counted 96, though the usual number in this form is between 50 and 70. In the Trout that migrate to salt water, the usual number is about the same; but in those that live exclusively in fresh water, it is generally less, about 30—50. Thus in different specimens of Trout 29—69 pyloric appendages have been counted[e]. After the duodenum has advanced almost to the diaphragm, the intestine abruptly bends

[a] Morph. Jahrb., XVI (1880), p. 464, taf. XXI, fig. 5.

[b] According to DAY a seagull at Hunter's Museum was fed for some time on corn, and the muscular layers of its stomach were thereby thickened as in a crop; and from HOLMGREN's experiments on pigeons at Upsala it appeared that the muscular layers in their crop were reduced by a flesh diet.

[c] It is further known that a molluscous diet gives the body of the Salmons a singular, orange ground-colour.

[d] *Danm. Fiske*, Bd. 2, p. 558.

[e] DAY, *British Salmonidæ*, p. 188.

straight back to the vent; and in the posterior part of the intestine or the rectum, which is usually somewhat wider than the anterior part thereof, the mucous membrane is raised on the inner surface, at least in old specimens, in the shape of transverse rings, here and there united like the thread of a screw, instead of the longitudinal folds which it forms in the anterior part of the intestinal canal from the œsophagus. The liver is almost one-lobed, the right lobe being extremely little developed. The place of the latter is occupied by a rather large gall-bladder, the discharging duct of which opens into the duodenum at the beginning of the pyloric appendages. Before the spawning the spleen is rather large and sometimes extends from the bottom of the stomach beyond the insertions of the ventral fins; but after the maturation of the generative organs it shrinks considerably, and does not begin again to increase, until its functions are laid under contribution at the commencement of the above-mentioned transformation of fat and flesh into material for the development of the sexual organs (cf. MIESCHER-RUESCH, l. c.). The ovaries, as mentioned above, show the peculiarity that they are without special oviducts, the ripe eggs falling into the abdominal cavity, whence they are expressed through the genital aperture behind the vent. The testes, on the contrary, are furnished as usual with vasa deferentia. The air-bladder, which is simple and long, extends throughout the length of the abdominal cavity, and the pneumatic duct opens on the dorsal side of the œsophagus. Still more elongated are the kidneys, which penetrate behind into the hæmal canal of the tail.

The ancient Greeks have not bequeathed to us any name for the Salmon, which does not occur as a marine form in Mediterranean regions; but according to APOSTOLIDES[a] the Trout inhabits most of the rivers in Greece, and bears among the modern Greeks the name of *πέστροφα*[b]. *Salmo*[c] is of classical Latin origin and occurs in PLINY[d]. Among the fishes of the Moselle AUSONIUS enumerates *Salar* (the Parr), *Salmo*, and "the form that ranks between them", *Fario*[e] (the Trout). Such is the explanation given by FIGULUS (1540) of these names. *Trutta* belongs to mediaeval Latin[f]. *Umbla* is a Latinized form of the French *Ombre* or *Umble*. *Salvelinus* has arisen in the same manner from the German *Salmling* or *Sälbling*.

THE CHARR (SW. RÖDINGEN).

SALMO UMBLA.

Plate XXXVII, fig. 1 (♂) and 2 (♀).

Scales exceedingly small, their number in a longitudinal row above the lateral line just in front of the perpendicular from the beginning of the dorsal fin and extending along $^1/_{10}$ of the length of the body at least 25 (as a rule 27—34[g]), and in a row of similar length above the lateral line behind the perpendicular from the beginning of the anal fin at least 21 (as a rule 23—30, sometimes 33). Sides of the body marked with more or less distinct and light, red spots on the darker ground-colour, but no black spots behind the head.

R. br. (9)10—12(13—14); *D.* $\frac{3—4}{8—10(11—12)}$; *A.* $\frac{3—4}{7—9(10)}$; *P.* $\frac{1}{11—14}$; *V.* $\frac{1(2)}{7—8(9)}$; *C.* $x + 1 + 17 + 1 + x$; *Ser. squ. lat.*[h] ca 190—240; *Vert.* 62—63[i].

Syn. *Umbre* et *Umble*, BELON, *Nat. Div. Poiss.*, pp. 280 et 281; *Salmo Lemani lacus sive Umbla*, RONDEL., *Pisc. Lacustr.*, p. 160. *Salmo* lineis lateralibus sursum recurvis, cauda bifurca, ART., *Ichthyol.*, *Gen.*, p. 18; *Syn.*, p. 25; *Salmo* vix pedalis, pinnis ventris rubris, maxilla inferiore paullo

[a] *La Pêche en Grèce*, p. 33.

[b] *πέτροφα*(?) — phps. answering to the Scand. *stenbit* and *rör*, which denote the preference of the Trout and Charr for stony bottoms.

[c] From *salire*, to leap.

[d] *Hist. Nat.*, lib. IX, cap. 18.

[e] Another, perhaps better reading is *Sario*, a derivative from the same root as *salar* and *salmo*.

[f] Derived from the Latin *trudere*, to thrust, force; a fish which forces its way against the stream.

[g] 18—20 scales on an extent answering to $^1/_4$ of the length of the head, as NILSSON expresses this character; 16—20, according to LILLJEBORG.

[h] Counted above the lateral line; in the lateral line itself about 125—145 (DAY).

[i] Sometimes 65, according to FATIO, sometimes 59 (in the Windermere Charr), according to DAY, or 58 (in var. *fluviatilis*), according to FATIO.

longiore, ID., ibid., et *Spec.*, p. 52. *Salmo* dorso nigro, lateribus cærnleis, ventre fulvo, LIN., *Fn. Suec.*, ed. 1, p. 117. *Roding*, LIN., *It. Wgoth.*, p. 257.

Salmo umbla, LIN., *Syst. Nat.*, ed. X, tom. 1, p. 310: PENN., *Brit. Zool.* (1776), vol. III, p. 267; AGASS., Rep. Brit. Assoc. Edinb. 1834, p. 617; YARR., *Brit. Fish.*, ed. 2, vol. II, p. 121; AGASS., *Poiss. d'eau douce*, tab. IX—XI: THOMPS., *Nat. Hist. Irel.*, vol. IV, p. 160: WHITE, *Cat. Brit. Fish.*, p. 78: SMITT, *Riksm. Salmon.*, Vet.-Akad. Handl., Bd. 21 (1885), No. 8, p. 163; FATIO (*Salvelinus*), *Fn. Vert. Suisse*, vol. V, p. 395.

Salmo erythræus, PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 349.

Salmones salvelini, (*Salmo ventricosus* + *S. carbonarius* (ex STRÖM) + *S. alpinus* (ex LIN.) + *S. pallidus* + *S. salvelinus* (ex LIN.) + *S. rutilus*), NILSS., *Prodr. Ichthyol. Scand.*, p. 7; — unam speciem omnes has varietates censuit in *Skand. Fn.*, *Fisk.*, p. 422.

Salmo alpinus, MGRN, *Finl. Fiskfn.*, (disp. Helsingf. 1863), p. 56; WIDEGR., Landbr. Akad. Tidskr. 1863, pp. 201 et 209; MGRN, Öfvers. Vet.-Akad. Förh. 1864, p. 534; COLL., Forh. Vid. Selsk., Chrnia 1874, Tillægsh., p. 160; ibid. 1879, No. 1, p. 86; MALM, *Gbgs, Boh. Fn.*, p. 540; SMITT, Öfvers. Vet.-Akad. Förh. 1882, No. 8, p. 33; MELA, *Vert. Fenn.*, p. 343; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 112; *Brit. Salm.*, p. 237; TRYBOM, *Iaktt. Fisk. Ume-Lappm.*, Nord. Aarsskr. Fisk. 1883, p. 300; REUTER, SUNDM., *Finl. Fisk.*, tab. V; LILLJ., *Sv.*, *Norg. Fn.*, *Fisk.*, vol. II, p. 598.

a: Var. *Salmo salvelinus* (*Vetterns Roding*, NILSS. — *Storrodingen*, LILLJ.), cujus pinnæ ventrales pone mediam longitudinem corporis sitæ sunt.

Syn. Salvelin Germanis, RAY, *Syn. Meth. Pisc.*, p. 64; *Salmo* pedalis maxilla superiore longiore, ART., *Ichthyol.*, *Gen.*, p. 13; *Syn.*, p. 26.

Salmo Salvelinus, LIN., *Syst. Nat.*, ed. X, tom. 1, p. 309; (+ *S. Salmarinus*, p. 310); BL., *Fisch. Deutschl.*, pt. III, p. 149, tab. XCIX (+ *S. umbla*, p. 154, tab. CI); CUV., VAL., *Hist. Nat. Poiss.* tom. XXI, p. 246 (+ *S. umbla*, p. 233); NILSS., *Skand. Fn.*, *Fisk.*, p. 422; HCKL, KR, *Susswasserf. Östr. Mon.*, p. 280 (+ *S. umbla*, p. 285); SIEB., *Susswasserf. Mitteleur.*, p. 280; CANESTR., *Fna D'Ital.*, pt. III, Pesci, p. 23; LILLJ., l. c., p. 599.

Salmo umbla, JUR., *Hist. Poiss. L. Lem.*, Mém. Soc. Phys., D'Hist. Nat. Genève, tom. III, pt. 1, p. 179, tab. V; RAPP, *Fisch. Bodens.*, p. 32, tab. V; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 530.

b: Var. *Salmo alpinus* (*Vermlands och Lapplands Roding*, NILSS. — *Smårodingen*, LILLJ.), cujus pinnæ ventrales ante mediam longitudinem corporis sitæ sunt.

Syn. Salmo alpinus, LIN., *Syst.*, l. c.; ASCAN., *Icon. Rer. Nat.*, cah. 2, p. 7, tab. XVIII; LÆSTADIUS, *Journ. Lappm.*, Forts., p. 75; CUV., VAL., l. c., p. 249; NILSS., *Skand. Fn.*, *Fisk.*, p. 426 (+ *S. carbonarius*, p. 429 + *S. rutilus*, p. 430); NYSTRÖM, *Iaktt. Fn. Jemtl. Vattendr.* (disp. Upsala 1863), p. 11; OLSSON, Öfvers. Vet.-Akad. Förh. 1876, No. 3, p. 14; ibid. 1882, No. 10, p. 50; LILLJ., l. c., p. 609.

The Charr, which is, generally speaking, the smallest Scandinavian *Salmo*, still attains a fair size even in our fauna. It sometimes reaches, at least in Lake Wetter, a length of nearly $7\frac{1}{2}$ dm. and a weight of about $8\frac{1}{3}$ kilo[a]. TRYBOM was told at Lake Stor-Uman in Ume Lappmark that in 1878 a Charr had been taken there which weighed $7\frac{1}{2}$ kilo., and that it often runs to 4 kilo. in the same lake, though its usual weight is $1\frac{1}{3}$—2 kilo. In many parts of Sweden a Charr 1 foot long (3 dm.) or $1\frac{1}{2}$ lbs. in weight (0·7 kilo.) is considered quite an average-sized fish, and in many lakes it does not attain even these dimensions.

The body shows in young and middle-sized Charr the most handsome and best proportioned piscine type, a terete and regular fusiform shape, so little compressed that the greatest thickness is about half the greatest height, which lies a little in front of the dorsal fin proper, and is contained about 5 times, or in young specimens even more than 6 times, in the length of the body. With age, however, both the relative depth and the lateral compression as a rule increase — the former most, as usual, in gravid females, the latter in spent fish — and in our largest Charr the depth sometimes rises to 29 % of the entire length or 31 % of the length to the base of the caudal fin[b], while the greatest thickness of such specimens is only $\frac{2}{5}$ of the said depth[c]. During these modifications the sides of the body become almost flat and parallel, converging gradually and in a very elongated curve towards the base of the caudal fin. The differences, however, seem sometimes to depend on local circumstances: "We find the species," says THOMPSON (YARRELL, l. c., p. 123), "to be in one lake herring-like, and in another approximating the roundness of an eel". But both forms sometimes occur in the same lake (see NYSTRÖM, l. c.). The least depth measures about 7 or 8 % — in the Sælbling sometimes nearly 6 %, in the Northern Charr sometimes nearly 9 % — of the length of the body, or in the former about 28—30 %, in the latter about 34—39 %, of the length of the head.

The head shares in the above alteration of the body, growing more compressed in old specimens, and acquiring a longer, more pointed snout; but above it

[a] In the East States of North America there lives a Charr, *Salmo Namaycush*, which according to BROWN-GOODE (*Fisheries and Fishery-Industries of the Un. States*, sect. 1, p. 486) attains a weight of 120 lbs. (54·43 kilo.).

[b] According to FATIO the greatest depth may rise to $46\frac{1}{2}$ % of the length to the base of the caudal fin.

[c] According to FATIO the greatest thickness may sink in very old specimens to $\frac{1}{4}$ of the greatest depth.

is always convex, never flat as in the Huch. Its length, which is generally greater in the males than in the females, varies in the Northern Charr between about 20 and 22 % of that of the body, in the Sælbling between about 23 and 24 % of the same. The eyes are middle-sized or rather, in old specimens, small; they are always set in the anterior half of the head and fairly low, near the maxillary bones. They are nearly round, the longitudinal diameter being only slightly greater than the vertical, and varying between about 21 and 12 % (exceptionally $8^3/_4$ %) of the length of the head; but the outer orbital margin is prolongated in front to a point, and the anterior canthus formed in this manner is filled by an adipose membrane. The breadth of the convex forehead above the centre of the eyes is about $^1/_3$ (30—35 %[a]) of the length of the head. The nostrils of each side are set close to each other, on about a level with the upper orbital margin and half as far from the eyes as from the tip of the snout. The anterior nostril on each side is round, with the margin raised in a funnel; the posterior is obliquely placed and oblong. The length of the snout, which in young specimens is shorter and blunter than in old, and in adult males longer and more pointed than in females of the same size, varies between 26 and 36 % of that of the head. The mouth is large, owing to the elongation of the snout even relatively larger in old specimens than in young. The cleft of the mouth ascends somewhat, though only a little. The teeth, the extent of which we have above considered, are rather small, but strong and pointed, with the tip recurved. The small teeth on the copular parts of the hyoid bone are indeed irregular in occurrence, but rarely wanting. The maxillaries, which are generally straight, but in old males curved downwards behind, extend in the young hardly behind the perpendicular from the posterior orbital margin, but in old specimens some way beyond it. Their length is greatest in the males, and varies in Scandinavian Charr from about 35 to 46 % of that of the head; and their greatest breadth, which thus becomes comparatively less as a rule in the males than in the females and in old specimens than in young, varies between about 25 and 18 % (exceptionally 15 %) of their length. The lower jaw, which in most old specimens projects a little beyond the tip of the upper jaw, and has a small protuberance at the end that fits into an indentation in the latter, measures in the males about 60—75 %, in the females about 57—65 %, of the length of the head. The preoperculum is crescent-shaped. The operculum and suboperculum together form a parallelogram, usually somewhat wider below, and with the lower posterior angle rounded. The suture between them, the length of which may serve as an expression for the breadth of the opercular apparatus, is comparatively shorter in old Charr than in young and also as a rule, in the males than in the females, its length varying between about 26 and 20 or even 17 % of that of the head. The branchiostegal membranes coalesce with the isthmus in a line with the anterior part of the eyes, or even in front of the perpendicular therefrom. The gill-rakers are fairly numerous in comparison with those of the Huch and Salmon, numbering 23 (exceptionally 20)—27 in the outer row on the front of the first branchial arch, about 15 (13—16) of these being situated on the lower, projecting part of the arch. The inner row of spines on this arch, of which spines at least rudiments are present in the Salmons, is entirely wanting in the Scandinavian Charrs. The pseudobranchiæ are distinct in young specimens, concealed in old.

The true dorsal fin is obliquely quadrilateral (trapezoidal), the length of the last ray being as a rule less than half, but sometimes (in a form which has been named *alipes*[b]) as much as $^2/_3$, of that of the first branched ray. The latter is as a rule the longest ray in the fin, but in young Charr is sometimes a little shorter than the second branched ray. The distance between the fin and the tip of the snout increases even relatively with age, this depending principally on the prolongation of the snout, and is as a rule greater in the males than in the females, varying between about 42 and 46 % of the length of the body. Its base measures about 10—11 %, and its height about 11 (exceptionally 10)—15 (exceptionally 17) %, of the length of the body. The adipose (second dorsal) fin, which lies above the posterior part of the anal, is rather small

[a] In the Charr reared at the hatchery of Östanbäck this percentage was lower, sinking even to 27. In Arctic Charr (var. *stagnalis*) it may rise even to 39.

[b] *Salmo alipes*, RICHARDSON, *Fn. Bor. Amer.*, pt. III, p. 169, tab. 81 et 86 fig. 1. Cf. SMITT, *Riksm. Salmonid.*, tab. III, fig. 50, a similar form, a male with strongly developed fins, taken in Torneå Træsk.

in comparison with that of the Huch — though not so small as in the Arctic *stagnalis* — being usually of the same curved form and about the same size as in the Scandinavian Salmons. The anal fin is similar in form to the true dorsal, but always shorter and lower. The distance between it and the tip of the snout is about 67 (exceptionally 65)—71 % of the length of the body, and as a rule this percentage is less than 70 in the Northern Charr, more than 70 in the Sælbling. The caudal fin consists, here as in the preceding family, of 17 branched rays and an inconstant number of supporting rays, of which the hindmost at each margin extends quite or nearly to the end of the fin-lobe. This fin is as a rule more or less deeply forked in the young; but in old specimens, especially when in breeding condition, the hind margin is truncate or slightly concave when the fin is expanded. The middle caudal rays, which occupy about 9—6 % of the length of the body, generally measure less than half the length of the outermost rays, except in old Charr, especially males, where their length may rise to at least 56 % of that of the latter.

The pectoral fins are pointed in old specimens, even approaching to the scythe-shape of the Mackerel type; but in the young they are blunter at the tip. Their length varies considerably, from about 14—19 % (in *alipes*, ♂, up to $21^{1}/_{2}$ %) of that of the body, and is greater in the males than in the females. The preabdominal length (the distance between the foremost points in the insertions of the pectoral and ventral fins), on the contrary, is as a rule less in the males than in the females, varying between about 27 (exceptionally 25) and 32 %[a] of the length of the body. The ventral fins are obliquely triangular, with the truncate top as base. They are also longer as a rule in the males than in the females, their length varying between about 14 and 11 % (exceptionally 10 or, in *alipes*, ♂, as much as 16 %) of that of the body. The postabdominal length (the distance between the beginning of the anal fin and the foremost (outermost) point in the insertions of the ventral fins), which is less as a rule in the males than in the females, varies between about 18 (exceptionally 17) and 22 (exceptionally 26) % of the length of the body.

The scales are both small and thin, without radiating grooves, but with dense concentric striæ. The dorsal scales are oblong, elliptical or oval; those of the lateral line of a more quadrangular shape but with rounded corners; the ventral scales broader (deeper). From the beginning of the dorsal fin obliquely backwards and downwards to the lateral line 34 scales, if not more, may be counted in a transverse row, and from the beginning of the adipose fin a similar row contains about 21—24 scales. The lateral line runs straight, or with a faint downward curve in front, from the upper angle of the gill-opening to the middle of the base of the caudal fin.

In its festal dress, just before the spawning, the Charr is one of our most beautiful fishes. The back is bluish or greenish black — the former predominant in the Northern Charr, the latter in the Sælbling —, the belly flame red or paler — the latter in the females —, and the sides of the body bluish gray or green, with scattered, red or paler spots, varying in dimensions but of about the same size as the pupils. The dorsal and caudal fins are of the same colour as the back, but distally they grow paler. In male Northern Charr wearing this dress, the caudal fin is commonly edged with red, and the lower margin (sometimes the upper as well, at least in part) generally has the same white or yellowish white hue as the anterior margin of all the inferior fins. The rest of these fins generally partake, in the spawning-dress, of the same red tint as the belly, but sometimes the posterior (the anal and ventral) have a more or less predominant, grayish blue colour, which occurs on the pectoral fins only in a fainter tone, but has there a still more handsome, ash-gray shade. The forepart of the belly and the throat, as well as the branchiostegal membranes and the lower jaw, are generally of a light, yellow or whitish yellow ground-colour, more or less spotted with bluish black. The head is commonly coloured above like the back, below like the belly, with cheeks and opercula of the same ground-colour as the sides of the body; but it is often more or less spotted with bluish or sooty black, and sometimes entirely, though faintly, coated with one of these tints, which in the Northern Charr generally extend to the mouth and pharynx as well. The iris is brassy yellow, with an irregular, ring-shaped shading of black.

These sharply defined hues of the spawning-dress are exchanged during the intervening periods for a

[a] When the belly is abnormally distended, this percentage may rise to 35

lighter coloration, pale gray on the sides, light orange on the belly; and when the Charr go out to sea, as mentioned above, their sides adopt the silvery lustre of the Salmon, on which ground the red spots are hardly discernible, and sometimes, at least in the great lakes, the ventral side is almost white.

These forms, as well as the Salmons, wear a Parr dress during youth, most nearly resembling the pale coloration just mentioned, but distinguished on the sides of the body by about 13—15 transverse bands of the darker dorsal colour, rounded below.

In coloration European Charr generally differ from American, which are most often, but by no means constantly, marked on the back and the dorsal and caudal fins with vermiculate transverse spots and stripes.

In Scandinavia and the rest of Europe to the south, the Charr strictly belong to the mountain lakes, and hardly ever take up their abode in running water[a]. In the Arctic regions — south to Northern Helgeland in Norway[b] — they are marine fishes which, like the Salmons, ascend the rivers to spawn. In Lapland they rank among the most common and most important fishes, and the form which occurs there goes south in the interior to Dalsland, Bohuslän, and Wester Gothland[c]. But their range does not extend so high in the mountain tracts as that of the Trout[d], with which they are often confounded, and they are probably not found above the birch-region[e]. Whether the above-mentioned large Charr that are met with in the greatest lakes of Lapland, preserve the form-characters of the Northern Charr, is unknown to us. The other large Scandinavian form has its true and best known haunts in Lake Wetter, but is also met with to the north at least in Lakes Storsjö and Hemsjö (Jemtland). East of Lake Wetter Boheman found the Charr in 1836 in Lake Ören. According to Nilsson and Widegren the Charr inhabits Lake Sommen in Öster Gothland, but further south in Sweden it is unknown. Strange to say, it is wanting in Lake Wener, as well as in Lakes Mälar and Hjelmar. It evidently prefers clear lakes with water of a low temperature — though as yet we have not sufficient observations on this head to state a fixed number of degrees —, and the singular features in its geographical range — for instance, its occurrence in certain lakes, and absence in others situated near them and apparently of the same nature — cannot be explained until we have trustworthy information as to the temperature of our lakes and the food which they offer the Charr. That its aversion to turbid water is not unconquerable, we see on the coast of Spitzbergen, where Charr are most plentiful off the mouths of clayey glacial rivers. But it is undeniable that water of a high temperature, whether it be in the sea into which the river inhabited by the Charr flows, or in lakes on the lower course of the stream, stops the progress of the Charr like a dam[f].

According to the reports sent in to the Swedish Fisheries Commission of 1881—83 the Charr is wanting in the Governments of Stockholm, Upsala, Södermanland, Kronoberg, Kalmar, Gothland, Blekinge, Kristianstad, Malmöhus, and Halland. In addition to Lake Wener, the lower and southern districts of Sweden, generally speaking, are thus without its geographical range. It does not enter the Baltic, and is at least rare in the lowlands on the Gulf of Bothnia. In the valley of the Torneå Elf, for example, it does not descend below Juckasjärvi.

In Norway the Charr is common, according to Collett, in the lakes within the Government of Bergen, less common in the Government of Trondhjem, and occurs only in a few lakes within the Government of Christiania. Lilljeborg found it often[g] in the mountain lakes of Central Norway, where it is commonly called *Röe*. The pale-bellied individuals are known as *Blekröe*. Its manner of life in the north of Norway and off the coast has already been noticed. Its habits are similar on the Murman Coast and in Finnish Lappmark; but its strict range in Finland is confined, ac-

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[a] In this respect the European Charr is somewhat different from the true Salmons; but in North America a distinction is drawn between two varieties of Charr, the *Lake Trout* (*Salmo namaycush*), which attains a greater size than our Charr, but has the same habits, and the *Brook* or *Speckled Trout* (*S. fontinalis*), which does indeed occur in lakes, but commonly spawns in streams.

[b] Collett, 1879, l. c.

[c] Lake Nedsjö in Bollebygd Hundred, see Malm, l. c.

[d] Olsson, l. c.

[e] Nilsson, *Skand. Fn.*, l. c.

[f] "South of New York they are effectually land-locked by the prevailing high temperature of the lowland streams, and are never able to gain access to salt or brackish water". Brown-Goode, *The Fisheries and Fishery Industries of the United States*, Sect. I, p. 502.

[g] Öfvers. Vet.-Akad. Förh. 1844, p. 213.

cording to Mela, to the inland (eastern) tracts and Lake Ladoga, while it is also found in the basin of Lake Onega.

In Denmark the Charr is wanting; but in the alpine regions of Southern Europe and in Great Britain and Ireland it leads the same lacustrine life as in Sweden. In Switzerland it has been found, according to Tschudi, at a height of 1,900 m.[a], in Bavaria, according to Siebold, about 600—800 m., and in Austria about 400—700 m.[b], above the level of the sea. It has there maintained its existence since the period when a great part of Europe was covered with ice, and when it could make its way in the cold seas to its present abodes. In the lowlands between the Alpine Regions and the North it is now wanting.

The Charr is a powerful and voracious fish-of-prey, in proportion to its size not inferior to the true Salmons. Its favourite hunting-grounds lie in deep water, where it leads a sociable life; but it also ascends to the surface to secure the flies and gnats that come within its reach. Its food consists mainly, however, of crustaceans, mollusks, and fishes, both large and small; and it sometimes gorges itself on fish-roe, even that of its own species. In the mountain lakes it has generally to content itself with *Entomostraca*, which are, however, plentiful enough, as a rule, to yield it an abundant supply of food. *Lynceus* (*Eurycercus*) *lamellatus*, a small crustacean of the group *Cladocera*, is of particular importance in this respect, according to Nyström. In the lowland lakes and those of greater dimensions the Charr finds more ample store of Gammaroids, mollusks, and fish, chiefly Gwyniads and Cyprinoids. But not even fishes armed with spines escape its maw: in the stomach of a female Charr from Lake Wetter no less than five Bullheads (*Cottus quadricornis*) were found. In Lake Wetter, according to Widegren, the Charr passes the greater part of the year in the depths, and during spring and early summer is seldom met with in less than 30 fathoms of water, but after midsummer ascends towards evening into shallower places, where its lustrous body strikes the eye as it swims at the surface. During this season it also makes its way into various inlets with a sandy bottom. Towards autumn it retires to the shallows in the middle of the lake, or visits some of the reefs and rocky pools near shore.

The Charr spawns late in autumn and in winter[c], in Sweden most commonly in October, the month during which almost all the breeding Charr received by the Royal Museum have been taken. In the fish-ponds at Östanbäck, however, Mr. Lundberg caught a male with running milt on the 10th of September; and in the Jemtland lakes, according to Nyström, the general spawning begins during that month. At Stor-Uman in Lycksele Lappmark Trybom was told that there the *Light Charr* (the Greater Charr) commences to spawn at the beginning of October, the breeding-season lasting 1—1 1/2 weeks; but that the *Black Charr* (the Lesser Charr) does not commence before the end of November, and takes three weeks to spawn.

The Scandinavian Charr always select their spawning-places in a lake — according to all authenticated observations[d] — by preference on a gravelly or stony bottom in 2—4 m. of water, or sometimes, according to Norback, in water so shallow that the dorsal fin of the breeding fish projects above the surface. But they frequently resort for this purpose to places near the mouth of a stream. Nor do the Swiss Charr ascend the rivers to spawn, according to Fatio; but they choose water 20—60 m. (sometimes 80 m.) deep in the great lakes[e]. In England, however, according to Yarrell[f], the Charr of Lake Winandermere generally make their way up one of its affluents to breed, only a few of them spawning in the lake itself.

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[a] Fatio believes, however, that in Switzerland the Charr never ascends voluntarily to lakes more than 800 m. above the level of the sea; but that it has, no doubt, been introduced by pisciculturists into lakes of greater elevation.

[b] According to Heckel and Kner up to 1,900 m.

[c] In Bavaria breeding Charr are said to have been found at the end of June, and in Scotland the spawning-season is said to extend from November to February or March (Day, *Brit. Salmon.*, p. 244). Fatio gives instances from Switzerland (l. c., p. 409) of the Charr's spawning in the Lakes of Geneva and Neuchâtel both as early as June and as late as April, the usual months being November and December.

[d] According to Nyström "it seemed in some places (for example Lake Holder) as if the *rör* (Charr) also resorted to running water for the purpose of spawning".

[e] The *Deepwater Charr* which the Royal Museum received from Lake Wetter though Sergeant-major Hall (1830, without specified date) were in breeding condition, a circumstance which perhaps indicates that in Lake Wetter too the Charr may spawn at a considerable depth. Nilsson also states that the so-called *blankroding* (Bright Charr) spawns in 30—40 fathoms of water on a clayey or muddy bottom.

[f] L. c., p. 125.

From Sweden we have no observations of the manner in which the spawning is performed; but in *Land and Water* for the 11th of August, 1884, JACKSON described the actions of a female specimen in Southport Aquarium when constructing a nest for her eggs. "We obtained a fine shoal of char from Windermere at the opening of the season this year. Soon after they came, I saw one of them had not spawned, and was busy making its nest. Its *modus operandi* was exactly as described by Mr. BUCKLAND. It swam slowly down towards the selected place as though concentrating its energies; when it arrived over the spot, it threw itself partially on its side, and dropping the hind part of the body, it gave several violent blows (three or four) with its tail, scattering the gravel right and left. The impetus of the blows not only scattered the gravel, but drove the fish upwards in a slanting direction. Quietly allowing the force to expend itself, it then turned round, swam slowly, and repeated the process time after time, until it had made quite a large hole." This observation inclines us to the opinion that in essential respects the spawning of the Charr resembles that of the Salmon.

The ova are comparatively large — from 4 to $5\frac{1}{2}$ mm. in diameter when ripe. DAVY counted 1,230 eggs in a female weighing $\frac{1}{4}$ kilo.[a], and LUNEL 4,108 in a female weighing 4 kilo[b]. Their hatching requires a longer or shorter time according to the temperature of the water. In a temperature of $4\frac{1}{2}°$ C. (40° Fahr.) REYNOLDS found the period of incubation to vary between 60 and 70 days for most of his Charr ova, 75 days for some, and 90 days in a few instances; and in a temperature of $12\frac{3}{4}°$ C. (55° Fahr.) most of the eggs were hatched in 41 days. From the eggs which MALM impregnated by artificial means at Baldersnäs in Dalsland at the end of October, the fry commenced to appear in the beginning of the following March, being then about 17 mm. long. After living 19 days in an aquarium in his room, they were 27 mm. long, and had begun to develop the characteristic *Parr* markings. At Östanbäck, according to BYSTRÖM[c], the eggs taken in September from the neighbouring spawning-places were hatched in January, but the fry at first grew slowly in the cold spring-water of the fish-ponds, and were only a little over an inch long in August. The broods of Charr fry sent from Östanbäck to the Royal Museum show that at the end of the first year the length is 97 mm., at the end of the second year 123 mm., at the end of the third year 137—216 mm., and in Charr five years old 250 mm. The growth is dependent, however, in the highest degree on the more or less plentiful supply of food.

The Charr is not only one of the most beautiful fresh-water fishes in Scandinavia, but also one of the best — for good digestions the best of all. In summer, however, it keeps out of the fisherman's way, living, as we have mentioned, in the depths of the lakes, and being taken almost exclusively by angling, as a rule the least destructive fishery. The Charr is in good condition at this time of year, best towards the end of summer, if cooked and eaten at once; but its flavour rapidly deteriorates, especially in summer. The fisherman changes his tactics when the Charr begin to approach their spawning-places. Where the bottom is not too rough, the seine is used; else the place is surrounded with nets. In either case an abundant take may reward the fisherman; but the spawning-season is never the best time of year, either in the condition of the fish or with a view to the maintenance of the fishery.

In Lake Wetter Charr are taken during summer on long-lines baited with Smelt or bits of Gwyniad or Vendace, and where the shores are steep, the line may be set close to land in a semicircle, so that both ends touch the shore. In other places the line must be taken farther out into the lake, and set in at least 20—30 fathoms of water. The spawning fishery for Charr in the shallows of Lake Wetter begins, according to WIDEGREN, about the 10th of October and does not close in some parts until the 20th of November. The annual take, according to his computation, is about 3,000 kilo. In the south of Lake Wetter distinctions were drawn about 1830, according to Sergeant-major HALL, between three kinds of Charr: the Shore Charr (*Landroding*), which attained a length of 9 dm. and a weight of $5\frac{1}{4}$ kilo., back green, belly flame-red, fins of the latter colour with white margin: the Deepwater Charr (*Djuproding*), which attained a length of only 6 dm. and a

[a] See DAY, *Fish. Gt. Brit. and Irel.*, vol. II, p. 117.
[b] See FATIO, l. c., p. 410.
[c] See NYSTRÖM, l. c., p. 15

weight of at most $3^2/_3$ kilo., body shorter, head smaller, coloration lighter, than in the former variety; and the Salmon Charr (*Laxröding*), of the same size as the Deep-water Charr and also similar in other respects to the latter, but with white belly. At the same time, according to Dr. MARIN, in the north part of Lake Wetter the following kinds of Charr were named: the *Red*, with red back, belly and sides of lighter red, yellow fins, and red flesh; the *Spotted*, sides and back spotted with white on a gray ground, belly whitish, flesh white, whitish yellow, or gray; and the *Gray*, with grayish green back and sides, belly and flesh as in the Spotted Charr. All these names simply indicate the great variableness of the Charr in different haunts, even within the limits of a single lake. Especially worthy of remark from a culinary point of view is the great difference in the colour of the flesh, which varies from bright red to whitish. The pronounced red tint is due to a diet consisting chiefly of crustaceans.

In Lakes Stor-Uman and Malgomaj (Lycksele Lappmark) a distinction is drawn between *Light* and *Black Charr*. There the Charr fishery is best, according to TRYBOM, during the spawning-season and immediately afterwards. Stationary nets are used, and they must be set, at least towards the close of the fishing, under the ice. After the breaking up of the ice, and until the Charr retires to deep water, a productive fishery is carried on with long-lines. In a few Lapland lakes the bottom is smooth enough for the employment of seines, but this is seldom the case at the spawning-places. In the Lajsan lakes, towards the end of summer and in autumn, the take includes not only breeding Charr, but also numerous fish that are *"gall"* (barren, i. e. not ready to spawn the same year) and very fat.

In many places the Charr is caught with hand-lines, and voracious feeder as it is, it takes any kind of bright bait, if only this be kept moving. DAY[a] describes a sort of *whiffing* for Charr practised on Lake Winandermere: "By far the most important and interesting means of taking char there is by means of the *plumb-line*. This line is made of strong cord, and varies in length according to the number of baits which are to be put on it; but it is usually between forty and fifty yards long, and this is sufficient to carry five baits. The baits usually used are artificial, pieces of metal silvered on one side, copper, red, green, or brown on the other, spinning from either the head or tail. Minnows can be used in the same way, spoon baits too, and both the blue Phantom and Garnet-quill minnows have been tried successfully. Still the natives prefer the metal baits, and the sizes used for ordinary trout are of course the correct ones. Usually two such lines as the above are worked by each boat, and the fisherman shows considerable skill in his manipulation of them and rowing his craft along at a proper speed at the same time — the latter is just sufficient to keep the baits spinning and the tackle taut. The boatman knows the ground char frequent, and the nature of the bottom too, for should he come upon rocks and weeds his tackle gets entangled, and a big smash must almost inevitably result. This fishing usually commences about the beginning of March, and at that time the fish are got about thirty yards from the surface and in the deepest parts of the lake. As the weather gets warmer they gradually approach the top." The Charr is also taken at the surface of the water during summer with the *otter-line*[b] and the *casting-rod*.

"The Charr is very easy to breed", says MAX VON DEM BORNE[c], "and best adapted of all the Salmon-fishes for fattening. But it must without fail be supplied with pure spring-water of a fairly uniform temperature, which should never exceed + 15 to $17^1/_2$° C. (59 to $63^1/_2$° Fahr.). It is especially to be recommended to the pisciculturists who have a plentiful diet of insects to offer it, as well as to those who desire to keep their fish in small ponds, and to fatten them for market from their earliest youth on a diet consisting mainly of meat and fish. It is very sociable and tame, being perfectly at its ease among fishes of different genera and sizes, while the Trout, on the contrary, is always shy and especially intolerant of smaller companions."

[a] L. c., p. 111; *Brit., Ir. Salmonidæ*, pp. 235 and 243.

[b] A line with flies or spinning baits, natural or artificial, and constructed, for surface-fishing, partly on the same principle as the *otter-trawl* for ground-fishing. An *otter-board* at the end of the line is arranged vertically floating at the surface, but obliquely to the direction of the rowboat, thus leaping out from this and stretching the line, trolling the baits on the water.

[c] *Handbuch der Fischzucht und Fischerei*, p. 284.

THE SALMON (SW. LAXEN)

SALMO SALAR.

Plate XXXVII, figs. 3 and 4, plates XXXVIII—XL

Scales small, but their number in a longitudinal row above the lateral line just in front of the perpendicular from the beginning of the dorsal fin and extending along $^1/_{10}$ of the length of the body at most 24[a] (as a rule 16—20[b]), and in a similar row above the lateral line behind the perpendicular from the beginning of the anal fin at most 19[c] (as a rule 14—18). Sides of the body more or less distinctly spotted with black.

R. br. (9)10—12(13)[d]; *D.* $\frac{(2)3-4}{(7-8)9-12}$; *A.* $\frac{2-4}{7-9(10)}$; *P.* $\frac{1}{(10-11)12-14}$; *V.* $\frac{1}{(6)7-8(9)}$; *C.* $x+1+17+1+x$; *Squ. lat.*[e] ca 120—140; *Vert.* 57—60[f].

Syn. *Trutta* 1. *Salmo* proprie, NILSS., *Skand. Fn., Fisk.*, p. 368. *Salmo salar*, SUNDEV., v. WR., *Skand. Fisk.*, ed. 1, tab. 58 et 59, SMITT, Vet.-Akad. Handl., Bd. 21 (1885), No. 8, p. 162.

Var. *Salmo salar* sens. str. 1. *nobilis*: Spinæ branchiales lateri anteriori arcus primi paris affixæ numeri sunt minimi 18—vulgo 19—21(22). Longitudo ossis maxillaris maximam partem $\frac{81}{1000}$ longitudinis corporis vel $\frac{36}{100}$ longitudinis capitis æquat. Distantia inter pinnam adiposam et pinnam caudalem longitudine superat altitudinem pinnæ analis. Altitudo minima caudæ maximam partem $\frac{27}{1000}$ longitudinis prædabdominis haud æquat. Maculæ nigræ sub linea laterali nullæ vel paucæ solum adsunt.

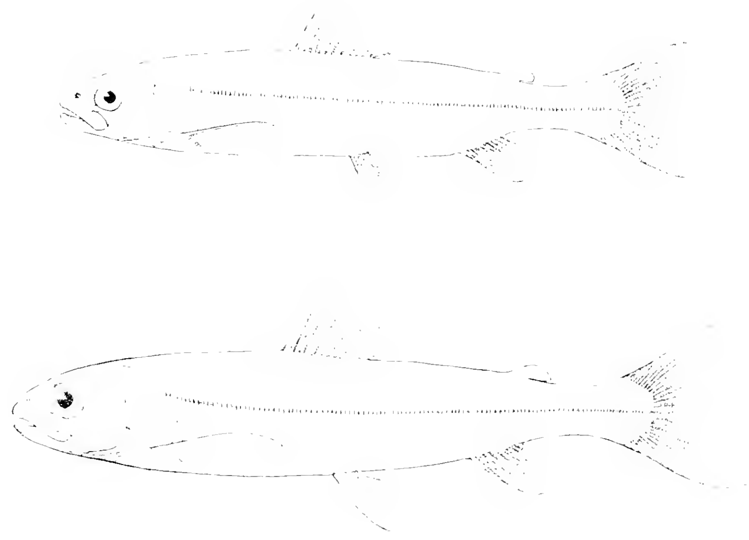

Fig. 210. Two young Salmon, the upper figure a female 2 years old from the Hatchery of Hofsmölla on the R. Laga in Halland, the lower a mature male, hooked in the R. Nissa off Halmstad in April, 1863. Natural size.

[a] Extremely seldom 25, in which case the number of scales on the tail may be employed as a character.
[b] 10—12 scales on an extent = $^1/_4$ of the length of the head, as NILSSON expressed this character; 9—13, according to LILLJEBORG.
[c] Extremely seldom 21, in which case the number of scales on the forepart of the body may be employed as a character.
[d] Extremely seldom 8 or 14.
[e] Counted above the lateral line; in the lateral line itself 115—130, according to DAY.
[f] Sometimes 61, according to NILSSON.

Syn. [illegible] SCHONEV., *Ichthyol. Slesv. Holst.*, p. 64 (nomen prælinnæanum nec modo systematico propositum); OLAFSEN, *Reise gm Island*, vol. I, p. 65; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 342.

Salmulus, WILLUGHBY, *Hist. Pisc.*, p. 192, tab. N. 2, fig. 2; RAY, *Syn. Meth. Pisc.*, p. 63; *Salmo salmulus*, TURT., *Brit. Fau.* p. 104; JEN., *Man. Brit. Vert.*, p. 426; FR., Vet.-Akad. Handl. 1837, p. 3, tab. I.

Salmo rostro ultra inferiorem maxillam sæpe prominente, ART., *Ichthyol.*, *Gen. Pisc.*, p. 11; *Syn.*, p. 22 (ubi *Erroe* ex ALBERTO MAGNO et e CUBA citatur); *Descr. Spec.*, p. 48; LIN., *Fn. Suec.*, ed. I, p. 115.

Salmo Salar, LIN., *Syst. Nat.*, ed. X, tom. I, p. 308 (+ *S. Eriox*, p.p.); NILSS., *Prodr. Ichthyol. Scand.*, p. 2; YARR., *Brit. Fish.*, ed. 1, vol. 2, p. 1; Suppl. vol. 2, p. 1; AGASS., *Hist. Nat. Poiss. d'eau douce*, tab. 1 et 2; JARD., *Brit. Salmon.*, tab. 1, 2, 7, 8; KR., *Danm. Fisk.*, vol. 2, p. 540; NILSS., Öfvers. Vet.-Akad. Förh. 1848, p. 62; LILLJ., ibid. 1849, p. 36; NILSS., *Skand. Fn.*, *Fisk.*, p. 370; HECKL, KN., *Susswasserf. Oestr. Mon.*, p. 273; STORER, Mem. Amer. Acad. Arts., Sc., vol. VI, pt. II, p. 320, tab. XXV, fig. 2; WGRN, Öfvers. Vet.-Akad. Förh. 1862, p. 541, tab. IV, figg. 3 et 4, tab. XXII; SIEB., (*Trutta*), *Susswasserf. Mitteleur.*, p. 292; MGRN, *Finl. Fiskfn.*, (disp. Helsingf.), p. 58; GTHR (*Salmo*), *Cat. Brit. Mus.*, *Fish.*, vol. VI, p. 11; STEIND. (*Trutta*), Stzber. Akad. Wiss. Wien., LIV, 1 (1866), p. 23; COLL. (*Salmo*), Forh. Vid. Selsk. Chrnia 1874, Tillægsh. p. 155; ibid. 1879, No. 1, p. 85; N. Mag. Naturvid. Chrnia, Bd. 29, p. 106; MALM, *Gbgs. Boh. Fn.*, p. 534; FEDDERSEN, Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 76; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 525; SMITT, Öfvers. Vet.-Akad. Förh. 1882, No 8, p. 32; MÖB., HCKE, *Fisch. Osts.*, p. 124; REUT., SUNDM., *Finl. Fiskfn.*, tab. XVIII; DAY, *Brit. Salmon.*, p. 51, tab. III et IV; LILLJ., *Sv.*, *Norg. Fisk.*, vol. II, p. 511; FATIO, *Fn. Vert. Suisse*, vol. V, p. 298.

Salmo hamatus, CUV., *Règne Anim.*, ed. II, tom. II, p. 303; CUV., VAL., *Hist. Nat. Poiss.*, tom. XXI, p. 212, tab. 615.

Salmo Salmo, CUV., VAL., l. c. p. 169, tab. 614.

Formæ intermediæ:

Salmo cauda bifurca; maculis solum nigris, sulco longitudinali in ventre. ART., *Gen. Pisc.*, p. 12; *Syn. Pisc.*, p. 25.

Salmo lacustris, LIN., *Syst. Nat.*, ed. X, tom. I, p. 309; AGASS., l. c., tab. XIV et XV; SIEB. (*Trutta*), l. c., p. 301; NILSS., *Skand. Fn.*, *Fisk.*, p. 404.

Salmo Schiefermulleri, BL., *Fisch. Deutschl.*, pt. III, p. 157, tab. CIII; RETZ., *Fn. Suec.*, *Lin.*, p. 348.

Salmo salopo, GIR., Proc. Acad. Nat. Sc. Philad. 1853, p. 380 + *S. gloveri*, ibid. 1854, p. 85.

Salmo ocla, NILSS., *Skand. Fn.*, *Fisk.*, p. 397.

Salmo salar, var. *lacustris*, HARDIN, Öfvers. Vet.-Akad. Förh. 1861, p. 382 = *Salmo Hardinii*, GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VI, p. 107.

Var. *Salmo trutta* 1. *fario*: Spinæ branchiales lateri anteriori arcus primi paris affixæ numeri sunt maximi 17 (vulgo 14—16, rarius usque ad 18 unius lateris). Longitudo ossis maxillaris minimam partem $\frac{86}{1000}$ longitudinis corporis l. $\frac{37}{100}$ longitudinis capitis superat. Altitudo pinnæ analis distantiam inter pinnam adiposam et pinnam caudalem mensura superat. Altitudo minima caudæ minimam partem $\frac{27}{100}$ longitudinis præabdominis superat. Color corporis maculas nigras etiam sub linea laterali crebras præbet.

Syn. *Trutta salmonata*, BELON, *Nat.*, *Divers. Poiss.*, p. 274; *Trutta fluviatilis*, RONDEL., *De pisc. fluviat.*, p. 169. *Salmo* nis. 2 (p.p.), 3, 5, ART., *Gen. Pisc.*, p. 12.

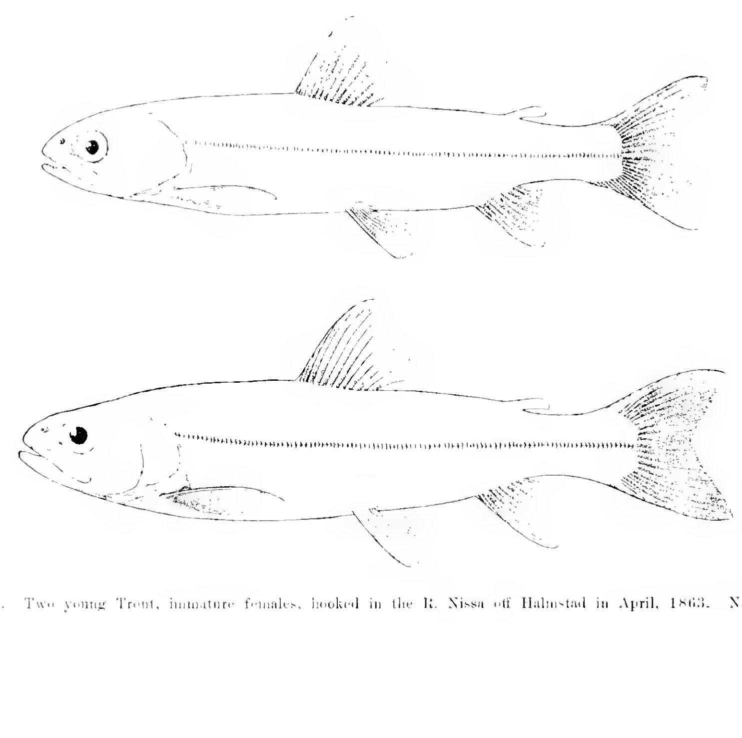

Fig. 211. Two young Trout, immature females, hooked in the R. Nissa off Halmstad in April, 1863. Natural size.

Salmo Eriox (p.p.), LIN., *Syst. Nat.*, ed. X, tom. I, p. 308; TURT., *Brit. Fau.*, p. 103; JEN., *Man. Brit. Vert. Anim.*, p. 422; KR., *Danm. Fisk.*, vol. II, p. 602; NILSS., Öfvers. Vet.-Akad. Förh. 1848, p. 63; LILLJ., ibid., 1849, pp. 36—37; NILSS., *Skand. Fn., Fisk.*, p. 395; COLL., Forh. Vid. Selsk. Chania 1874, Tillægsh., p. 157; ibid. 1879, No. 1, p. 85; OLSS., Öfvers. Vet.-Akad. Förh. 1876, No. 3, p. 132; ibid. 1882, No. 10, p. 48; FEDDERS., l. c., p. 77; REUT., SUNDM., *Finl. Fisk.*, tab. XVI et XVII.

Salmo Trutta, LIN., l. c.; BL., *Fisch. Deutschl.*, pt. I, p. 143, tab. XXI (+ *S. Goedenii*, pt. III, p. 155, tab. CII); NILSS., *Prodr. Ichthyol. Scand.*, p. 5 (+ *S. Truttula*, ibid.); AGASS., l. c., tab. VI—VIII; KR., l. c., p. 582; NILSS., Öfvers., l. c.; *Skand. Fn., Fisk.*, p. 406; WIDGR., Öfvers. Vet.-Akad. Förh. 1862, p. 560, tab. IV, figg. 1 et 2; tab. V; tab. VI, fig. 1; tab. VII; tab. VIII; ibid. 1864, p. 279, tab. VIII—XIV; NYSTRÖM, *Iaktt. Jemtl.*, (disp. Ups. 1863), p. 7; SIEB. (*Trutta*), l. c., p. 314; MOBN, l. c., p. 61; SIEIND., l. c., p. 22; GTHR (*Salmo*), l. c., p. 22 (+ *S. brachypoma*, p. 87 + *S. gallivensis*, p. 88 + *S. mistops*, p. 105 + *S. cenerensis*, p. 110 + *S. polyosteus*, p. 111 + . . .); MALM, l. c., p. 538; SMITT, Öfvers., l. c., p. 31; MOB., HCKE, *Fisch. Osts.*, p. 126; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 565.

Salmo Fario, LIN., l. c., p. 309 (+ *S. carpio*, ibid.); BL., l. c., pt. I, p. 148, tab. XXII et XXIII; NILSS., *Prodr.*, p. 6; AGASS., l. c., tab. III—V; KR., l. c., p. 625; NILSS., *Skand. Fn., Fisk.*, p. 415; SIEB. (*Trutta*), l. c., p. 319; SIEIND., l. c., p. 24; GTHR (*Salmo*), l. c., p. 59 (+ *S. orcadensis*, p. 91 + *S. ferox*, p. 92 (ex JARD.) + *S. stomachicus*, p. 95 + *S. nigripinnis*, p. 96 + *S. levenensis*, p. 101 (ex WALKER) + . . .); CANESTRINI (*Trutta*), *Fau. d'Ital.*, pt. III (*Pesci*), p. 24; APOSTOL., *Pêche en Grèce*, p. 33; MÖB., HCKE, l. c., p. 127.

Salmo Illanca, WARTMANN, Schr. Berl. Ges. Naturf. Fr. 1783, p. 55.

Salmo alpinus, BL., l. c., pt. III, p. 158 (nec synon.), tab. CIV.

Salmo cambricus, DONOV., *Brit. Fish.*, tab. XCI; GTHR, l. c., p. 34.

Salmo spurius, PALL., *Zoogr.*, l. c., p. 343 (= *S. Eriox* LINNÆI) + *S. hucho*, p. 344 (nec. LIN.).

Salmo lemanus, CUV., *R. Anim.*, ed. 2, tom. II, p. 303 (+ *S. trutta* + *S. fario* + *S. punctatus* + *S. marmoratus*, p. 304 + *Saimlet*, p. 305).

Salmo ferox, JARD., N. Phil. Journ. Edinb., vol. XVIII, p. 55; *Brit. Salmon.*, tab. IV; NILSS., *Skand. Fn., Fisk.*, p. 412.

Fario argenteus, CUV., VAL., *Hist. Nat. Poiss.*, tom. XXI, p. 300, tab. 616 (+ *F. lemanus*, p. 300, tab. 617 + *Salar Ausonii*, p. 319, tab. 618 + *S. Bailloni*, p. 342, tab. 619).

Genera *Salar* et *Fario* apud HCKL., KN., *Süsswasserf. Oestr. Mon.*, p. 247 et cett.

Salmo microps, HARDIN, l. c., p. 383.

Trutta variabilis, LUNEL, *Hist. Nat. Poiss. du bassin du Léman*, p. 116, tab. XVI—XVIII.

Salmo lacustris, FATIO, *Fne Vert. Suisse*, vol. V, p. 323.

The Salmon, with its multitude of names, occurs within the Scandinavian fauna in numerous varieties, both of form and colour, the extremes being very easy to distinguish by well-marked characters, but connected by intermediate forms in a manner that compels us, after a comparative study, to comprehend them under one specific designation. The most clearly distinct varieties have long been known by different names in popular parlance, and are now recognised even in scientific nomenclature, the first as the Trout (Sw. *Grälax*, *Salmo trutta*), the second as the Salmon (Sw. *Blanklax*, *Salmo salar*). The Salmon is generally the larger; it attains, according to BUCKLAND[a], a length of 14 dm. and a weight of $31^{3}/_{4}$ kilo.[b], and FATIO[c] mentions specimens as much as 16 dm. long; but even the Trout (if the determination be correct) sometimes measures nearly 14 dm.[d]

The chief external distinction between these two varieties consists in the more elongated form, the shorter maxillaries, and the more scattered spots of the Salmon. In 1848 a fisherman from Elfkarleby showed LILLJEBORG a practical method of telling a Trout from a Salmon merely by taking it in the hand. If you grasp a Salmon round the tail, you have no difficulty in holding it fast; but a Trout held in this manner easily slips out of the hand. This is due to the greater contraction of the peduncle of the tail in the Salmon, a character which also affords the safest expression of the greater elongation of the body in this form. The least depth of the tail in the Salmon is less than 28 % (as a rule less than 25 %), in the Trout about 30 %, of the preabdominal length (the distance between the foremost points in the insertions of the pectoral and ventral fins). But this character holds good only in adult and typical specimens. The case is the same with another character expressing the same difference in the form of the body: the length of the dorsal margin of the peduncle of the tail (behind the adipose fin) is greater in the Salmon, less in the Trout, than

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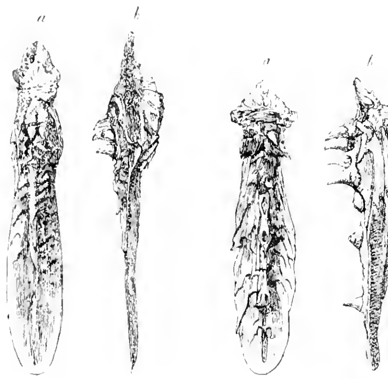
[a] *Nat. Hist. Brit. Fish.*, p. 292.

[b] According to information received by the Swedish Fisheries Commission of 1881—83, the Salmon in Sweden attains a length of at least $1^{1}/_{3}$ m. and a weight of at least $25^{1}/_{2}$ kilo.

[c] *Fne Vert. Suisse*, vol. V, p. 305.

[d] DAY, *Brit., Ir. Salm.*, p. 181. The above-mentioned Commission was informed that in Sweden the Trout attains a length of 9 dm. and a weight of $7^{3}/_{4}$ kilo.

the height of the anal fin. But in the young this character loses its validity, as well as in very old male Salmon during the spawning-season. The length of the maxillaries is, as a rule, less in the Salmon, greater in the Trout, than 8 % of that of the body or 36 % of that of the head; but the character, which was originally sexual, applies only to typical specimens. Salmon, as mentioned above, in general have comparatively larger scales than Trout. GÜNTHER and DAY have expressed this by the statement that, in an oblique transverse row forward from the posterior extremity of the



A B

Fig. 212. Vomer of a Salmon (*A*) and a Trout (*B*), seen from below (*a*) and from the left (*b*). Natural size. After V. SIEBOLD.

adipose fin to the lateral line, the Salmon has 11 or 12 scales, the Trout 13—15. But even this character holds good only in typical specimens[a], and sometimes the two sides of the body differ in this respect[b].

Among the internal characters that may be used to distinguish Trout from Salmon, we have above mentioned the number of the gill-rakers, which in the outer row on the front of the first branchial arch is, as a rule, under 17 in the Trout, over 17 in the Salmon, or, if it be greater in the former, made up in front and at the anterior upper corner of verrucose, spiniferous protuberances. Another character, derived from the shape and dentition of the vomer, has received special attention of V. SIEBOLD. In typical Salmon the head of the vomer has a more or less distinct pentagonal or hexagonal shape, in Trout it is triangular. In the former the vomerine teeth disappear earlier, and in old Salmon are sometimes almost entirely wanting; whereas even the oldest Trout commonly have several teeth not only in a transverse row on the base of the head of the vomer, but also in a double or single row along the carina on its shaft.

But these internal characters are no more trustworthy than the external: the naturalist who examines hundreds of specimens will find them too often merged in each other.

Note. One of the best examples to show the relation of the two varieties to each other, as regards the last-mentioned characters, seems to be afforded by the attempts to introduce the typical Salmon into the Lake of Geneva[c]. These experiments were commenced by the hatching of Salmon eggs from the Rhine and from the hatchery of Hüningen; but the fry excluded from these ova escaped into the Rhone, and none of them was ever regained and identified with certainty. From 1857 to 1860, according to CHAVANNES, about 7,000 fry were placed in the feeders of the lake, and during 1863 about 4,600; and in 1882 a pisciculturist, LUGRIN by name, is said to have deposited nearly 100,000 Salmon fry in the Rhone near Geneva. Hardly any results, according to both LUNEL and FATIO, are known to have been attained by these experiments; the 'Salmon' which have been caught from time to time in the Lake of Geneva, have proved on closer examination to be Trout. The latter author, however, is still dubious with regard to at least three finds. In these specimens Trout and Salmon characters were blended, and especially in two of them the vomer was most nearly approximated to its Salmon type. Though it is indeed possible that all the Salmon fry have been destroyed, it seems more probable that during growth the fry have passed to the Trout form, as this appears in its normal development where the water offers to the fish no practicable means of communication with the sea.

The Salmon is so well known that a minute description would be here superfluous, especially as it differs but slightly from the Charr, which we have just described. We may instead refer the reader to our figures and to the following comparative table of the most important external characters, expressed in averages which have been computed 1) in the first two columns, from our measurements of Trout in the *Forell*, *Öring*, and Salmon stages and of typical Salmon at the same periods of growth, 2) in the third column from all these measurements combined for each character, and 3) in the fourth column from the corresponding measurements of Scandinavian Charr.

[a] To *Salmo trutta fluviatilis* (the Freshwater Trout) DAY assigns in his last work (*Brit., Ir. Salmonidæ*, p. 199) 12—15 scales in the said row.

[b] See, for example, specimens Nos. 284, 285 and 306 in Tabula metrica IV in SMITT's *Riksmuseets Salmonider*.

[c] See LUNEL, l. c., pp. 128—130, and FATIO, l. c., pp. 308—313.

Average percentage		Trout	True Salmon	Salmons	Charr
Length of the body expressed in millimetres		561	391	364	563
Length of the head	in % of the length of the body	22.2	20.8	21.1	21
" " " " reduced (from the hind extremity of the intermaxillaries to the hind margin of the preoperculum)	" " " "	11.6	13.5	11.6	11.1
Breadth of the interorbital space	" " " "	7.2	6.1	7.2	6.6
Length of the snout	" " " "	6.1	6.7	6.6	6.1
" " " maxillaries	" " " "	8.4	7.2	8.6	8.5
" " " lower jaw	" " " "	13.6	11.7	13.3	13.4
Longitudinal diameter of the eyes	" " " "	3.4	3.2	3.4	3.3
Vertical " " " "	" " " "	3.4	2.9	3.1	3.0
Length of the suboperculum	" " " "	5.1	5.2	5.4	4.9
Distance between the dorsal fin and the tip of the snout	" " " "	42.3	41.3	42.1	43.7
Base of the dorsal fin	" " " "	11.8	11.5	11.8	10.3
Height " " "	" " " "	12.5	11.0	12.3	11.9
Length of the pectoral fins	" " " "	15.1	14.6	15.0	14.3
Preabdominal length	" " " "	29.6	29.7	29.1	28.4
Distance between the ventral fins and the tip of the snout	" " " "	49.2	49.1	49.1	49.2
Length of the ventral fins	" " " "	11.8	10.8	11.7	11.1
Postabdominal length	" " " "	20.4	20.6	20.4	20.9
Base of the anal fin	" " " "	8.5	7.9	8.1	8.1
Height " " "	" " " "	12.2	9.6	11.8	10.3
Dorsal margin of the peduncle of the tail	" " " "	11.3	12.1	11.1	12.0
Ventral " " " " "	" " " "	12.4	13.3	12.1	13.0
Least depth of the tail	" " " "	8.1	7.4	8.0	7.2
Length of the middle caudal rays	" " " "	7.8	6.0	7.5	6.9
" " " longest " "	" " " "	14.4	14.5	14.4	15.1
Breadth of the maxillaries in % of the length of the head reduced		14.8	13.4	14.5	12.1
" " " " " " " " " maxillaries		24.7	25.1	24.7	21.6
Number of gill-rakers in the outer row on the first branchial arch of the right side		15	18	—	23
" " " " " " " " " " " " left "		15	18		21
Number of scales in a longitudinal row = 1/10 of the length of the body just above the lateral line and in front of the dorsal fin		20	18	—	30
" " " " " " " " " " " " above the anal fin		17	15	—	26

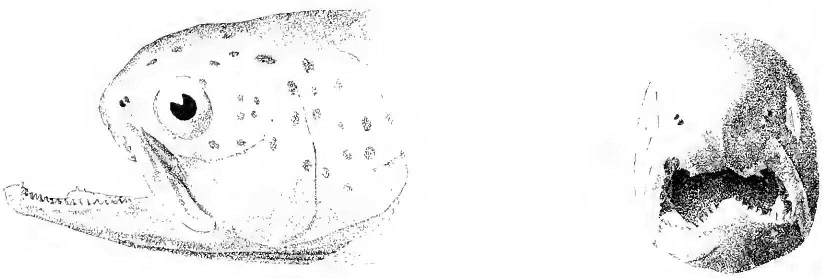
The first two columns of this table show 1) the differences between typical Trout and Salmon, 2) the developmental alterations of Salmons during the more advanced stages of growth, the latter partly because the Trout, as we have proved above, in most of their characters represent the earlier stages of growth, partly because the specimens measured were on an average shorter than the typical Salmon included in the table. The last two columns, on the other hand, show the relation of the Salmons to the Charr; and although the Charr measured were on an average shorter than the Salmons, still we see that in the great majority of cases the percentages of the former betoken a more advanced development, in the direction indicated by the changes of growth in the first columns of the table. Where the relation is the contrary, and cannot be explained by the difference of age, as in the case of the distance between the dorsal fin and the tip of the snout in proportion to the length of the body, or the breadth of the maxillaries in proportion to their length, another factor, the difference of sex, has asserted itself. In the males the dorsal fin is, as a rule, situated further back, and the maxillaries are longer, than in the females; and here the Charr represents the male characters.

The Salmon, like other fishes, is subject to various malformations. These are especially prevalent and have received most attention at hatcheries[1], where the fry live under more or less unnatural conditions, and where there is better opportunity for observation than in nature. One of these deformities, that may often be seen, is the so-called *pug-nose* (reduction of

[1] See, for example, DAY, *British and Irish Salmonidæ*, pl. XII.

the rostral region), which may be persistent in Salmon normal in all other respects, and admits of quite a considerable development (fig. 213).

The Salmon leads a life full of changes, and it adapts itself to them both in form and colouring. The form undergoes the same variations as in the Charr, but is never so terete as it may sometimes be in the latter. Most terete, most nearly fusiform, though always laterally compressed, is the true Salmon in its sea-dress, with broad, convex back and sometimes with the greatest thickness of the body equal to two-thirds of its greatest depth, which is then about one-fifth of the length to the middle of the base of the caudal fin. The difference from the Trout in the same dress is, however, inconstant and sometimes absent; and in the spawning-dress they both assume a deeper and thinner form of body. This is especially prominent in old males; which during the spawning-season develop, besides the singular jaw-hook, to which we shall return below, a high and more or less sharp dorsal projection in front, supported internally by an indurated connective tissue. This hump, however, in no instance attains the same development in the Salmons as in Charr of the *Onchorhynchus* group[a]. Where the true Salmon lives confined in fresh water, as in Lake Wener, it also acquires as a general rule a deeper, more compressed form; and that the Kelts (spent Salmon) have a thinner body, we have already remarked. During the earlier stages the distinction between Salmon and Trout is, as a rule, more evident in the above respect: it is generally easy to distinguish by the form young Salmon (*blanklax-foreller*) from young Trout (*foreller*), the body of the former being shallower, with the greatest depth less than one-fifth of the length. At this stage, however, the difference is most marked in the more or less forked shape of the caudal fin: in young Salmon the length of the middle caudal rays is less, in young Trout more, than half that of the longest rays in the fin. As appears from the table of averages on the preceding page, this character is indeed persistent, in typical specimens of the two varieties, even in later life; but it disappears in old Salmon wearing the spawning-dress, and sterile Trout have a caudal fin most like that of typical Salmon.



a *b*

Fig. 213. Monstrous head (simous malformation) of a *Salmo salar venernensis*, taken by Mr. DAHLGREN in 1880. $^1/_2$ of the natural size; *a*, from the left; *b*, from in front. The specimen probably measured 7—8 dm.

Among the changes of growth that most contribute to modify the appearance of the Salmons, the most striking are those which affect the form of the snout. In young Salmon the snout is comparatively short and blunt; but its length sometimes increases with age from about 5 %[b] to about 13 %[c] of that of the body, or from about 21 %[b] to 47 %[c] of that of the head reduced. This prolongation mainly affects the anterior, praenasal part, the nostrils remaining at a distance from the anterior orbital margin which in young specimens is less, in old only slightly greater, than the diameter of the eyes. The elongation proceeds uniformly in the females and the middle-sized males, where the snout acquires a more or less point-

[a] See SMITT, *Riksmusei Salmonider*, tall. III. fig. 28.

In Parr.

[c] In the largest breeding males of the typical Salmon which we have been enabled to examine

ed, conical shape; but in old males this process is accompanied by a depression in front, the intermaxillary bones being parted from each other, and the median region of the praenasal part being hollowed underneath or even perforated, to receive the tip of the hook simultaneously formed by an upward growth of indurated connective tissue from the point of the lower jaw. These old males are known in popular language by the name of *kroklaxar* (Hook Salmon, the French *bécard*, *Salmo hamatus*, see above).

Not only have these males with their singular snout — the function of which is not yet known[a] — been regarded as a distinct species, but the same rank has also been conferred, for their short snout and peculiar coloration, on the two stages of growth following next after the fry, the Parrs (*Salmo salmulus*) and the *Foreller* or so-called Common Trout (*Salmo fario*).

Even in early youth the ground-colour of the Salmons varies according to the colour and light of their environments. v. WRIGHT's figure (Plate XL, fig. 1) represents a young specimen some months old as it appears during the assumption of the dress which is more fully developed in the Parr stage.

The dress of the Parrs is described at length by FRIES (l. c.), from the coloration of the Salmon fry in Norrköping River: "The top of the head and the back are olive-green, with dark, round, stellate spots and patches along the back. These small, dark spots extend in front down to the lateral line; but from the neighbourhood of the dorsal fin to the caudal they terminate half-way between the dorsal edge and the lateral line. The belly is white with a dash of yellow. The sides are of a handsome light yellow shading into red. Along the lateral line lie 8 or 9 small, round orange spots and the same number[b] of large and oval, bluish patches, set transversely and crossed half-way up by the lateral line. These patches (the so-called Parr markings) alternate with the orange spots[c]. Above each eye is an arch of 4 round, dark spots, and further back, between these arches, are 3 similar spots, set in a triangle; but all these markings may be more or less distinct, and they show some variation. Very constant, on the other hand, are the two round, black spots that adorn the gill-covers, though their size and position vary. In most cases one of them is situated at the centre of the operculum, the other in front of the preoperculum, just behind the eye. Sometimes traces of a third spot may be detected at the very margin of the operculum. The dorsal fin is of a light olive green, with one distinct and one less prominent and irregular row of dark spots, the former at the bottom, quite near the base and parallel to the back, the latter along the middle of the fin. The anterior corner shades into flame-yellow, marked off by a dark gray band, which starts from the tip of the second simple ray and runs in a straight line to that of the fourth branched ray[d]. The adipose fin wears the olive-green colour of the back, with yellowish tip. The caudal fin is olive-green, tinged with yellow, edged with flame-yellow above, below, and, less distinctly, behind. The anal fin is of a dirty yellow, with the outer part of the anterior margin lighter, and with an indistinct gray band obliquely across the anterior corner. The pectoral fins are olive-green with a darker band across the middle. The ventrals are similar in colour and markings to the anal fin. The pupil is rounded and very large in the living fish, but after some exposure to the atmosphere it assumes a triangular shape. The flesh is white, without red tinge."

During the Forell stage the two varieties differ more widely from each other, for the young Salmon make their way to the sea as early as possible, and when this instinct begins to awaken, they gradually

[a] Many conjectures have been made on this head. Some have supposed that the hook is a kind of spade or thrusting apparatus to be used in working holes to receive the eggs. But, so far as is known, the female is at least more active than the male in this operation. Others have thought it to be a hook with which the male holds the female fast while spawning. But the most trustworthy observers have seen the spawning performed without its assistance. Others, again, have suggested that it is a protective organ, to prevent the males from inflicting too severe injuries on their rivals in the breeding-season. But such means of protection seem far from natural. The least violent explanation appears to be that the hook is an essentially pathological appearance, characteristic of age, but produced by the irritation caused by blows on the snout, both during combats and in leaping over obstacles.

[b] Sometimes, however, as many as 15.

[c] The ground-colour of the sides generally grows lighter round the Parr markings, at least along their lower margin, thus rendering them still more prominent.

[d] Cf. the analogous marking (the corner pure white and the stripe black) on the dorsal fin of Trout Parrs, according to JARDINE, *British Salmonidæ*, pl. XI.

adopt their bright dress. The Parr markings and the red spots slowly disappear, and the sides of the body at the same time exchange their orange ground-colour for a brighter and brighter silvery lustre, caused by the depositing of a silvery pigment on the inner surface of the scales and opercula. Now, and not until now, do the scales begin to be quite distinct. Young Salmon of this age are known in England as *Smolts*. Great irregularity, however, may be observed in the growth of these Parrs and the consequent alteration of colour. At Stormontfield, among a brood excluded from eggs impregnated at the end of December, 1861, and hatched in April, 1862, were found on the 1st of April, 1863[a], some specimens 54 mm. long and $1^1/_2$ grammes in weight, others 92 mm. long and $3^3/_4$ grm. in weight, and others 165 mm. long and $37^1/_4$ grm. in weight. Only the last were Smolts, and these would probably have migrated to the sea the same season, the others not until the following year or even the year after that.

The alteration in the colouring of young Trout after the Parr stage is generally not great, provided that they belong to a race which is either unable or has no inclination to enter salt water. They assume a dress in which they are known as *Foreller* (Eng. River Trout, Common Trout), and which they may retain in small, land-locked waters almost unchanged throughout their life. Under these conditions their growth too is inconsiderable. v. WRIGHT's figure (Plate XL, fig. 2) represents a common Scandinavian Forell. The orange ground-colour of the sides and the red spots on the lateral line — each surrounded here by a more distinct, light ring — are persistent; and both above and below the lateral line there appear similar spots, scattered over the sides of the body[b]. At the same time the number and extent of the dark (black) spots on the back and head are generally increased, these spots now occurring even down the sides, while the Parr markings disappear. The dorsal fin also shows an increased number of black spots, and in this fin — but more commonly in the ventral and anal fins alone — the anterior margin sometimes becomes red or white, which colour is usually marked off sharply behind, as in the Charrs, by a black streak. The young Trout which are to repair to the sea or the great lakes assume, like the Salmon Parrs, a lighter, more and more silvery dress.

In salt water, as well as in the great lakes, the main alteration in the colouring of the Salmons after the Forell (Smolt) stage affects the black spots, which pass from a round or irregularly angular shape to a stellate form (X-spots). As a rule, however, though by no means always, the two varieties may be distinguished even in the sea by their coloration, the Sea Trout being usually more thickly spotted than the true Salmon, and bearing numerous black spots even below the lateral line and on the greater part of the body, even behind. Such is the case with the *Taimen* from Torneå figured by v. WRIGHT (Plate XXXVIII, fig. 3). Under certain conditions, however, especially in the sterile individuals mentioned above and in the specimens which should probably be explained as hybrids (mongrels), this difference vanishes. Nor is there any constant distinction in colouring between the marine form known in England as the Sewin (*Salmo cambricus*) and a true Salmon. How this distinction asserts itself in Scandinavian waters, may be gathered from a comparison between v. WRIGHT's figures of a Salmon (Plate XXXVIII, fig. 1) and a Silver Salmon (Plate XXXVIII, fig. 2).

The Salmon which have no access to the sea or to any large, deep, and clear lake — whose *Öring* and *Lax* stages are thus more immediate progressions from the *Forell* stage — are remarkable for the exceeding inconstancy of their colours, whence LUNEL proposed to unite them under a distinct specific name, *Trutta variabilis*. In Scandinavia, as elsewhere, they occur in brooks, rivers, and lakes. They are usually small, $^1/_2$ —1 lb. in weight, but frequently weigh 10 lbs., sometimes up to 18 lbs. Their coloration — lighter (redder) or darker (sometimes nearly black), with denser or more scattered red and black spots — is determined, as in most fishes, primarily by the colour and light of their surroundings, but also, in a high degree, by their food. Of this as clear evidence as one could desire was afforded by a visit in 1883 to Sir JAMES MAITLAND's hatcheries at Howietown (near Stirling). Two of the ponds contained, among other fishes, a variety of Trout from Loch Leven (*Salmo levenensis*). In one pond, where they were fed on horseflesh, the

[a] See *The Field* for the 25th of April, 1863.

[b] Red spots above the lateral line are not uncommon in young Salmon.

silvery colour prevailed on the sides of the body, while in the other, where their diet consisted of crushed scallops (*Pecten*), the ground-colour was orange, not unlike that of an *Öring* from Bohuslän figured by v. WRIGHT (Plate XL, fig. 3). One of these Trout varieties, the darkest and most thickly covered with black spots, sometimes spotted with black even on the pale ventral side, but often — where it has attained a sufficient size — without red spots, has been named by JARDINE *Salmo ferox*. The same variety is commonly the largest fresh-water Trout in Scandinavia, and the males are furnished during the spawning-season with a hook almost as large as in old males of the true Salmon.

The Salmon in all its stages of growth is a predatory fish of great voracity. Where it roves in the sea — as along the greater part of the west coast of Europe, in the White Sea, and in the Baltic — it lives on all kinds of animals, principally crustaceans (shrimps), Herrings (Baltic Herring) and Sand-Eels. To the last it seems to be especially partial, and in quest of them it resorts in large shoals to the sandy shallows off the coasts of Scania and Pomerania. In these waters a seine-fishery has been instituted, the seine being shot in the sea, we may almost say, at hazard, and drawn ashore frequently with a good haul of Salmon. This fishery is carried on during spring, in March, April, and May. Another fishery, based on the well-known voracity of the Salmon, is pursued, as mentioned above, with long-lines (Salmon-lines) in the south of the Baltic by Swedish, German, and Danish fishermen[a]. During the roving excursions of the Salmon in the south of the Baltic at the season specified above, drift-nets are also used. As the spring advances, however, and the North Baltic with the Gulf of Bothnia becomes open, the marine Salmon begin their journey thither. They are taken here and there on the way with gill-nets and long-lines, at least up to the island-belt of Stockholm. Farther north they come to the shore-traps (so-called stake-nets and *mockor*), to which have been added in recent times the so-called Finnish *stor-ryssjor*, where many of the Salmon making for the rivers meet their fate. In the rivers the marine Salmon eats hardly any food, at all events after it has been there some time, though the eagerness with which it takes the fly-fisher's bait in the lower courses of the Scandinavian rivers, shows that it has not yet laid aside its voracity. Different are the habits of the River Trout and the large Salmon of the lakes. Hardly any other fish can be said to be more voracious or a more greedy eater in proportion to its size. BREHM has described the life of the River Trout[b]. "In quickness and dexterity of movement," he says, "hardly any river fish surpasses the Trout. It is probably to be included among the fishes that are nocturnal in their habits; all observations indicate, at least, that the Trout does not display its full activity until evening, and prefers to perform its principal task, the procuring of food, by night. In the daytime they mostly take shelter under projecting stones in the bank or in any hollow or cranny of the rocks to be found in the water which they inhabit. But when everything around them is perfectly still, they move about in the open even by day, always with the head pointing up the stream. Here they either remain apparently motionless at the same spot for a quarter of an hour or more, though their fins really move with sufficient rapidity to counteract the current, or dart like arrows through the water, following the main channel with surprising adroitness, and in this manner finding their way along shallow brooks, where you would think it impossible for them to advance. When disturbed, they retreat, if possible, to some hiding-place, for they are among the most timid and cautious of all fishes. Streams with a swift current they descend by two different devices, either by turning their heads up the river and letting themselves slowly drift with the stream, or by summoning up all their powers and shooting so rapidly through the water as far to exceed the rate of the current. While the Trout is at rest, it carefully surveys its preserves, the water beside and before it and the surface or the air over its head. If an insect, whether great or small, approaches the post occupied by the Trout, it keeps anxious watch until the insect has come within reach, and then, with a powerful blow or two of the caudal fin, rushes upon its victim, or leaps out of the water to secure its prey. While the Trout is young, it feeds mostly on insects, worms,

[a] See BENECKE, *Fische, Fischerei und Fischzucht in Ost- und Westpreussen*, p. 401, and LUNDBERG, *Meddelanden rörande Sveriges Fiskerier*, 1:sta häftet, p. 78, tab., fig. 18.

[b] *Thierleben*, Grosse Ausg., Abth. III, Bd. II, p. 227; *De kallblodiga ryggradsdjurens lif* (Sw. transl. 2nd ed.), p. 358.

leeches, mollusks, small fishes, and frogs. But as soon as it has attained a weight of 1—1½ kilo., it rivals in voracity all other predatory fishes of the same size, being hardly surpassed by the Pike, and boldly attacks any living thing which it believes it can overcome, not excepting its own progeny, though the peaceful Bleaks and Gwyniads are perhaps its most frequent victims. Even in later life, however, its diet is composed mainly of all insects that live in the water in a larval or a perfect state, and small crustaceans. Its partiality to the former is so great that it seems to suffer from want of food, if other insectivorous fishes — even those which it readily preys upon itself — multiply too extensively in the same waters." When the lemmings migrate from the mountain tracts of Lappmark, and endeavour, as they often do, to swim the rivers in their path, they are devoured in numbers by the large Trout (*Grolaxar*).

Such is the life led by the true fresh-water Salmons from the extreme north of Europe to the southernmost parts of Spain, in Algiers, Asia Minor, and probably, to the north of the Hindu Kush. In those southern regions they are reminiscences of the time when their present abodes were connected with seas cold enough for the Salmon to thrive and rove about in their waters. Their occurrence in Africa is no solitary phenomenon; the range of the Sticklebacks shows the same memories of primeval times. Since the Mediterranean has become too warm and perhaps too salt for the Salmons, they have succeeded in adapting themselves to their environments in some scattered rivers and lakes, and in there maintaining their existence at the Forell stage. In Scandinavia these are the fishes that ascend to the greatest heights among the mountains, as high as a fish can well advance in the mountain lakes and brooks. Clear and oxygenated waters, freshened by rushing falls, are the favourite haunts of the River Trout. On the plains and to sluggish, clayey rivers it is a stranger. In Switzerland, according to FATIO[a], it ascends to a height of 2,630 m. above the sea-level. In salt water, on the other hand, the range of the Salmon is terminated to the south by Cape Finisterre, in about 43° N. lat., and it thus does not enter the Mediterranean. On the west side of the Atlantic its southward range extends to about 41° N. lat., but there its northward extension is not so great. It occurs, it is true, up to the middle of Labrador, but is probably wanting in Greenland and on the west coast of North America. It has, however, been introduced, after several unsuccessful attempts, both about 1860 and in more recent years, into Australia[b] and New Zealand, where Trout, originally hatched from ova of the English River Trout, are said to have adopted the habits and dress of the migratory Salmons[c]. From these regions DAY[d] received, among other specimens, a male and a female, the former measuring 825 mm., the latter 800 mm., whose characters he found most closely to resemble those of the English *Salmo ferox*.

The Salmon spawns, like the Charr, in autumn and winter. As a general rule it is, no doubt, true that the Salmon is bound by its love of home to return from the sea to spawn in the watercourse and the place where it was itself born and bred. Herein it is guided by instinct so unerring that in many localities the fishermen declare they can distinguish without fail between Salmon belonging to different rivers, even if the mouths of two or more of these rivers lie close besides each other. Marked fish have often been retaken in the river where they had been marked and set at liberty. But exceptions also occur; according to DAY[e], for example, Salmon have been seen making their way up the Thames, a river which had long been deserted by the true Salmon. From the results of the fishery in the rivers which fall into the Gulf of Bothnia, it is also known that the run of the Salmon in these rivers — more plentiful one year in one stream, less plentiful in another — is greatly affected by different states of wind and weather, which would probably exert a less appreciable influence if the same Salmon always repaired to the same river.

Early in spring, soon after the breaking up of the ice, the Salmon begin to appear at the mouths of the rivers which they are to ascend. The Salmon is

[a] *Faune Suisse*, vol. V, p. 373.
[b] See NICOLS, *The Acclimatisation of the Salmonidæ at the Antipodes*, London 1882.
[c] DAY, *British Salmonidæ*, p. 145.
[d] L. c., p. 198.
[e] L. c., p. 66.

then in its best condition, though infested with a number of parasites, which it gets rid of in fresh water, where they die. For a time it roves to and fro in the brackish water; but when the spring floods come, it commences the ascent in earnest. But not all the Salmon arrive at the same time; the companies seem generally to contain some 30—100 fish, and the ascent may last the whole summer. Throughout the season for the upward journey, the Salmon may be seen thronging at the surface and leaping into the air both in the sea off the mouths of the rivers and in the lower part of their course; but higher up the stream they muster in an angular formation, like that observed by birds of passage, with one of the strongest fish at their head, and the others tailing off gradually on each wing. In this array they sometimes advance "with such vigour," says GISLER, "that the din thereof has been heard on shore like a storm or subdued thunder, the fish now and then swimming with the back half above water or appearing like waves on the surface." In stormy weather or oppressive heat, however, they keep nearer to the bottom. The females usually lead the way, the smallest males bringing up the rear; and when the fisherman takes one of the latter, he may conclude that the main body of the shoal has passed by. When obstacles bar their progress, they disperse; but the ranks are again closed when by strength or cunning the impediment has been surmounted. If they come to a fall, they pass it by leaping, perhaps after many unsuccessful attempts and only by springing from one resting-place to another, found behind some stone or jutting rock with slack water under its lee. In this manner the Salmon leap to a height of 1—$1^1/_2$ m. and a distance of 2—3 m., if necessary; and from the brink of the fall they advance seemingly none the worse for their exertions. But many of them fail in the endeavour, and pay the penalty with their lives. Natural obstacles are, however, less destructive to the Salmon than the contrivances of man. In the sea it is intercepted, as we have mentioned above, by apparatus of ordinary design, nets hung on stakes driven into the bottom, *strandsätt* in Halland, *stakanät* (*mockor*) in Norrland (fig. 214), and *kilnotar* (mostly in Norway), with a long arm straight out from the shore and a bend (*kil*) at the outer end, or Finnish *storryssjor*, in which the bend is replaced by a huge *ryssja* (p. 33, fig. 7) and its short arm. In the lower parts of the rivers too similar nets are used, *ior* in

Fig. 214. Plan of a stake-net with the so-called *mocka* or *pata* (the angle at the outer end). After LUNDBERG.

the R. Laga. Salmon-pens (*laxgardar*) are also constructed, these consisting, according to law, of upright stakes at a fixed distance from each other; within these the larger Salmon are detained for a time also appointed by law and taken in seines, into which they are driven with 'beaters', or enticed into so-called *kar*, constructed in the same manner, where they may be caught with greater ease. Baskets are also hung in the falls, for the Salmon to drop into if they miss the leap. The rivers are lined too with more expensive engines, *pator*, *minor*, *tinbyggnader*, and *vrakhus*. The first are built on the same principle as the Salmon-pens, of upright stakes, but the shore arm and the interior of the court itself are covered with nets, and

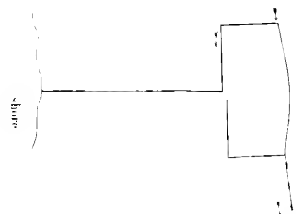


Fig. 215. Plan of a *pata* in the Ume Elf, built out from the right bank. The arrows indicate the direction of the current. After LUNDBERG.

within the court, the entrance of which is first closed with a net, seines are hauled. The *minor* (fig. 216)

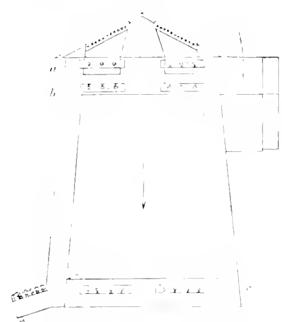


Fig. 216. Plan of a Salmon *mina* at Baggböle (Ume Elf). The arrows indicate the direction of the current. After LUNDBERG.

are regular lock-weirs, with sluices above and below, the former in two rows. The uppermost row (*a*) is merely a grating, which continually lets the water through, as well as the gates (*c*) at the lower end. The latter are let down only when the watertight gates in the second row at the upper end (*b*) are shut, the water now running out, but the fish being left behind. In the *tinbyggnader* large Salmon-traps (*tinor*) are set, which are lifted with a hoist when they are to be examined[a]. The *vrakhus* are, strictly speaking, large *kar* (see above, Salmon-pens), constructed beside a race. So manifold are these

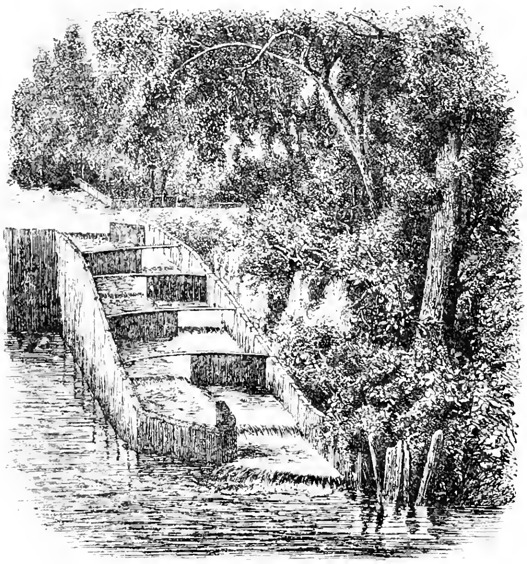


Fig. 217. A Salmon stair. After Day.

contrivances that Sweden, to her cost, can boast of her wealth of devices for the taking of Salmon.

In order to counterbalance the destruction wrought by these engines, and to extend the run of the Salmon by enabling them to surmount falls otherwise impassable, *Salmon stairs* are built. In these the force of the water is diminished by transverse walls projecting alternately from the sides, and extending across more than half the width of the staircase but not reaching to the opposite side. The stairs may be erected beside a fall in many different modes, according to the nature of the locality; but care should be taken to avoid placing the lower opening of the stair in the same direction as the fall, and to turn it obliquely across the stream or, still better, straight against the current.

The River Trout too — even those which pass their whole life in brooks and small streams — rove to the spawning-place. "In a valley not far from my native place," says Brehm[b], "there rise copious springs, which together form a brook that has power enough to drive a mill-wheel. This brook falls into the Roda and clears the water of the latter, which is sometimes rather thick. As long as can be remembered, Trout have lived here, but only for an extent of at most eight kilometres. Above and below this part of the brook they do not occur, as a general rule; and only during the spawning-season does it happen that they abandon their true home and rove to rocky parts of the Roda in quest of breeding-places, though they have equally good spots in their usual haunts." The spawning-dress of the River Trout sometimes includes a black coating on the forepart of the body, such as that we have above remarked in the Charrs.

The longer marine Salmon remain in the rivers, the more tumid are their generative organs, and the darker their dress. Our figures show the appearance both of the true Salmon (Plate XXXVII, figs. 3 and 4) and the Sea Trout (Plate XXXIX, figs. 1 and 2) at the beginning of these alterations; but at the end of their wanderings, when the spawning-season commences, they have assumed quite a different colour, of much darker tone, as depicted by v. Wright in his figure (Plate XXXIX, fig. 3) of a female Sea Trout (*Öring*) in fresh-water dress. The belly of the males becomes entirely red. In old males of the true Salmon the margin of the caudal fin is also straightened, without a trace of indentation, or even, like the margin of the anal fin, convex. By a retrogression to the characters of youth, they are besides approximated to the Sea Trout in the characters relating to the least depth of the tail and the height of the anal fin, otherwise the most constant distinctions between the two varieties.

In September the spawning-season begins. The old fish commence first. The young sometimes wait even till the following March. And among the latter

[a] See Gisler, Vet.-Akad. Handl. 1752, tab. I.

[b] *Thierleben*, l. c., p. 227.

the males sometimes attain a breeding state in the Parr stage, but this is probably never the case with the females. The accounts of the spawning differ somewhat in certain particulars; but in general terms we may say that the eggs are deposited in a hole on a sandy or gravelly, loose bottom and covered, after impregnation, with sand or gravel. Each female is attended by one or more large males and usually by several smaller ones. When she has found a suitable spot in shallow water — often so shallow that she can only just keep her body submerged — she turns to right and left and lashes with her tail — according to others she also roots with the snout — until a hole one or more decimetres deep is formed. She then sheds a portion of her roe and quits the place, the male at once coming up to impregnate the eggs, unless he be engaged for the moment in combat with some rival. These conflicts are sanguinary enough, often one of the antagonists leaves the other to die on the field, or at least tears away great pieces of his flesh. But the female continues to deposit her roe, portion after portion, returning from her excursions to the spawning-bed, and lashes up showers of sand, gravel or pebbles, so long as she has a male to hasten to her side when the eggs are laid. YOUNG observed how a single female Salmon conducted nine males, which were all taken, one after the other to her spawning-bed; and when even the last male was caught, she returned with a large Trout in her train. Among the smaller Trout, several of which usually keep at a respectful distance below the spawning-place, the greater number are most probably on the look-out for the eggs that are carried away by the current; but now and then a male seizes his opportunity of joining in the spawning, when the female Salmon's partner is battling with a rival. In this manner the spawning proceeds, with incessant pauses, a fullgrown female taking 3 or 4 days, according to some observers up to 8 or 10 days, to empty her ovaries. We have mentioned above the condition of the Salmon after the spawning: some die of exhaustion, the greater number repair to some calm haven for rest, afterwards prepared to rove or drift with the current down the path along which they have ascended. When they let themselves drift, the descent is made backwards, tail first; and they may then be speared with a leister, as they stand in a race before a stone, resting the caudal fin against the latter.

The eggs are of an orange colour and vary in size according to the dimensions of the mother fish; when ripe, their diameter is about 5—7 1/2 mm. in the Salmon and Sea Trout, 4 1/2—6 mm. in mature River Trout. Their number varies in the same manner. In England it is customary to reckon 800—900 ova to each pound in the living fish; but DAY[a] computed the number of eggs in a female Salmon weighing 20 lbs. at 27,850. According to NORBACK[b] a Brook Trout 1 lb. in weight contains only about 150—200 eggs. The period of incubation varies greatly, but as a rule depends on the temperature of the water. According to DAY[c] it proved in a constant temperature of 45° Fahr. (+ 7·2° C.) to last 90 days, in 43° Fahr. (+ 6·1° C.) 101 days, in 41° Fahr. (+ 5° C.) 97 days, and in 36° Fahr. (+ 2·2° C.) 114 days. By keeping them all the time in a low temperature, their hatching has been delayed until the 148th day after impregnation; but if frozen hard, they generally die.

The new-hatched fry are about 15—18 mm. in length, with a vitelline sac about half as long hanging from the forepart of the body, and lie still at the bottom, keeping the pectoral fins, however, in continual motion to renew the water in the gills, or flounder to and fro in the water, soon to sink again to their shelter behind a stone or in some other hiding-place. In about 4—6 weeks, at a length of 25 or 26 mm., the yolk is absorbed, and the fry grow more lively. They now begin to eat, seeking their food chiefly in small crustaceans (*Entomostraca*), but not disdaining other small portions of animal food that come in their way. At the age of 2 months Salmon-fry are about 32 mm. long, at the age of 4 months on an average 63 mm., and when 6 months old, on an average 95 mm. But the growth is extremely variable, of which we have above adduced evidence.

The Salmon has always been one of the most highly esteemed fishes for table; and to the sportsman the River Trout has given most amusement of all fishes, even if his passion — the enjoyment of overcoming a powerful resistance, of mastering a strong,

[a] *British Salmonidæ*, p. 78.
[b] *Handbok i Fiskevård och Fiskafvel*, p. 284.
[c] l. c., p. 82.

a stubborn, and a cunning lord of the waters — be more tickled when a huge Salmon has gorged the fly on his line, and been brought ashore after desperate struggles to escape. In delicacy of flavour too, the River Trout is preferred to the Salmon; but its smaller size renders it of less economical importance.

The annual value of the Swedish Salmon fisheries may be estimated at a minimum of between 600,000 and 700,000 crowns (£66,000—77,000)[a]. In Norway the corresponding figures are half as great, or even more[b]. YOUNG[c] estimated the value of the Salmon fisheries for 1877 in England at £100,000, in Ireland at £400,000, and in Scotland at £250,000. On the Lower Rhine, including the whole of its course in Holland, the average annual take for 1878—79 was 44,302 fish[d] of an average weight of 8·28 kilo.; and the average weight per annum of the whole catch was thus 364,320 kilo., each kilogramme of Salmon fetching in the Rhine countries, according to BREHM[e], between 3 and 9 reichsmarks. The value of the Salmon is influenced, however, in an essential degree by the depth of red colour shown by the flesh, a tint which seems most, though not entirely, to depend on the proportion in the Salmon's diet of crustaceans. The flesh is also paler as a rule in the Sea Trout than in the true Salmon. The spent fish (Kelts) are of but very little alimentary value, and should never appear in the market, from which Salmon in the spawning-dress should also be excluded. By the legislation of most countries all Salmon fishing during the Spawning-season is, as a rule, forbidden. The fry and the Parrs too must be protected by law if the fisheries are to retain their value.

The great importance everywhere possessed by the Salmon fishery has induced efforts not only to preserve, but also to extend its bounds, and a special means to this end has been discovered in Salmon culture. Hardly any other European fish — the Carp perhaps excepted — has lent itself more readily to cultivation; and the Salmon was also the first European fish to attract the attention of pisciculturists. In the fifteenth century a monk, DOM PINCHON by name, is said to have successfully hatched ova in a trough filled with running water; but not until long afterwards were more elaborate experiments instituted. In 1763[f] S. L. JACOBI, a Westphalian farmer from Hohenhausen, published in a letter to the editor of the *Hannover. Magaz.* (No. 23) his observations on the artificial breeding of Salmon. The English Government found the question so important that they rewarded JACOBI with a pension. About 1850 the French Government established at Hüningen in Alsace, not far from Basel and near the Rhine and Rhone Canal, an extensive hatchery, which in 1871 passed into the hands of the Germans. During the present century many persons have gained a reputation by efforts in this direction. First we may mention the Englishmen SHAW, BUCKLAND, and Sir JAMES MAITLAND, and the German MAX VON DEM BORNE; but all Europeans were eclipsed by the American SPENCER BAIRD (*d.* 1887), who prevailed upon the Government and Congress of the United States to make grants at that time unprecedented, for the advancement of pisciculture. Doubts have indeed been raised, whether the results, especially as regards Salmon breeding, have really repaid this lavishing of money and exertion. But America, with practical discernment, has not been disheartened by these more or less well-meant warnings from foreign quarters[g]. Salmon culture has also gained an undeniable victory in the above-mentioned introduction of the genus *Salmo* into Australia and New Zealand.

The cause of the success won by Salmon culture and of its importance, is to be found simply in two circumstances. First the mass of ova can be more completely impregnated than in nature, the discovery having been made that the fecundation can be accomplished by the so-called *dry method*, by pouring the undiluted milt on the eggs in a dry vessel, in which manner its fertilising properties are not dispersed or weakened by water previous to the impregnation. Second it is

[a] *Underdånigt Betankande med Forslag till Ny Fiskeristadga*, Stockholm 1883, p. 148.

[b] Average annual value 1877—81 386,000 kr. (£42,460), according to Norges officiella statistik, Ny Række, Udgiv. 1884, C. No. 9.

[c] See D. MILNE HOME, *Salmon and Salmon-Fisheries*, Gt. Intern. Fish. Exhib. London 1883, p. 55.

[d] According to MIESCHER-RUESCH, *Statistische und biologische Beitrage zur Kentniss vom Leben des Rheinlaches im Susswasser*, Intern. Fischer. Ausst. Berlin 1880, Cat. Schweiz, p. 157.

[e] *Thierleben*, l. c., p. 200.

[f] Four years before the publication of Alderman LUND's method of cultivating fishes that spawn in spring (Vet.-Akad. Handl. 1767).

[g] See *Nordisk Aarskrift for Fiskeri* 1883, p. 324, and BROWN-GOODE and WILMOT in D. MILNE HOME, l. c., p. 27.

easier in the receptacles of a hatchery and in well-constructed ponds than in nature to protect the eggs and the defenceless fry from their numerous enemies. As soon as the voracity characteristic of the genus begins to awaken in the young brood, it is not difficult to supply them with suitable food, either *Entomostraca*, where these can be procured in sufficient quantity — no doubt a rare occurrence — or lean beef or horseflesh, mixed with hard-boiled eggs and chopped fine. But important conditions of success are to have a constant supply of pure running water at a proper temperature, and to remove every diseased egg. The latter end is most conveniently attained by admitting the current of water at the bottom of the hatching-vessel and allowing it to run over at the top, the diseased eggs, which become white and rise to the surface, being thus carried away with the overflow.

Here we have no space, however, for a full description of Salmon culture in its details. The reader who desires more information on this head may consult either the *Handbuch der Fischzucht und Fischerei* by MAX VON DEM BORNE, a work which we have often quoted, or Sir JAMES MAITLAND'S *History of Howietoun*. In Swedish these questions are handled with ability by O. G. NORBACK in his *Handledning i Fiskevård och Fiskafvel*.

GENUS OSMERUS[a].

Canine teeth on the vomer and tongue; two rows of small teeth in the anterior part of the lower jaw, one row of larger teeth in its posterior part, and on the palatine bones; small teeth of uniform size, set in one row, on the intermaxillaries, the maxillaries, and the mesopterygoid bones. Length of the maxillaries as a rule 60—66 %[b], of the lower jaw as a rule 85—100 %[c], of that of the head reduced. Number of rays in the anal fin greater than in the dorsal, but at most 17, 12—14 of which are branched; and the base of the anal fin longer than that of the dorsal. Pyloric appendages few (at most about 7) and short. Scales middle-sized, about 60—70 in a row along the sides of the body, only the anterior (10—22) being pierced by the lateral line.

According to the above limitation of the genus, based on the most generally adopted opinions, it contains only three species, very nearly related to each other, one from the basin of the Atlantic, the second from the Arctic Ocean, and the third from the basin of the Pacific. Its most prominent character consists in the dentition of the mouth and palate. The vomer is especially remarkable, its development having been arrested so that it is made up of the anterior part (the head) alone, and officiates merely as a point of attachment for two[d] large and widely separated, canine teeth. Another dental character, shared, however, by the following genus, is the presence of inner palatine teeth. On opening the mouth of a Smelt, we see a deep and narrow, longitudinal groove at the middle of the palate, furnished at the sharp edges with a row of small but keen teeth, which are set on the inner margin of the broad mesopterygoid bone, the largest bone on each side of the palatine arch. The pterygoid bone proper is toothless, consisting simply of a narrow osseous disk, which lies close to the outer margin of the mesopterygoid bone and unites the palatine and quadrate bones. All the palatine teeth are canines, but their development as such differs considerably, being most advanced in the foremost and hindmost teeth. The largest teeth in the whole mouth, however, are as a rule the outermost in the transverse row belonging to the head of the vomer. The teeth in the lower jaw are also canines, the posterior larger and set in one row, the anterior set in two rows, with the smallest teeth in the outer row. The intermaxillary teeth are about equal in size to the last, and show at

[a] From the Greek ὀσμήρης or ὀσμηρός, *odorous*.

[b] 59·4—66·7 %, according to our measurements of specimens in the possession of the Royal Museum.

[c] 85—102·4 %.

[d] Or three, or two pairs — one in front of and within the other — or five, in which case the inner teeth are smaller than the outer.

least a trace of canine formation; but the maxillary teeth are still smaller, set closer together, at least in places, and rather blunt. The tongue is boat-shaped, with fleshy lateral margins and bears at the tip one or two large canines and on each side of the true hyoid bone (os linguale), within the said margins, a row of somewhat smaller, similar teeth or only one or two, in the latter case large canines. The copular part of the hyoid bone is armed with smaller teeth, of about the same size as the intermaxillary teeth, the largest in a row along each of the edges, the others (the inner ones) irregularly distributed in two rows. The pharyngeal teeth are about equal in size to those on the copular part. Among the upper pharyngeals of the Scandinavian Smelt only the two hind pairs are furnished with teeth, the hindmost with several (3—4) rows, the penultimate with one row. On the elongated lower pharyngeals the teeth are set in two rows. These numerous teeth of different form show that the Smelt, in proportion to its size, is a voracious fish-of-prey.

The intestinal canal is short. The œsophagus with its longitudinal inner folds passes uniformly into the thick-walled stomach, which resembles a caecum, and the bottom of which sometimes does not even extend to a line with the tips of the pectoral fins, but sometimes reaches to the anterior extremity of the pelvic bones. On its under surface and in about a line with the middle of the pectoral fins, the pyloric part originates, running forwards at an acute angle, and extending almost to the diaphragm, where it bends abruptly back at the transition to the intestine, which is here furnished with a few[a] comparatively short, but thick pyloric appendages. The intestine runs straight back to the vent. The liver is short and lies almost entirely to the left of the œsophagus and stomach; it extends back to about a line with the pyloric angle. On the right, between the œsophagus and the small lobe which the liver sends out on this side, lie the gall-bladder and, a little further back, the spleen, which in a healthy state is very dark, nearly black, and ellipsoidal, more or less flattened[b]. In the structure of the generative organs we have above remarked a peculiarity characteristic of the Smelts: behind the ovaries or, when they are fully ripe (in the spawning-season), beside their posterior part, the mesoarium joins its ventral margin, which in the preceding genus hangs free in the abdominal cavity, to the lateral wall of the said cavity, thus forming an oviduct open in front (fig. 208, p. 828). The left ovary is the larger and lies more to the front. In the spawning-season it occupies almost the whole length of the abdominal cavity, all the way from the diaphragm. The right ovary lies in the posterior part of the abdominal cavity, and extends forward only a little beyond the insertion of the ventral fins. The testes occupy the same position with relation to each other, and the left testis is also the larger; but the difference in their size is not so great as in the case of the ovaries. The air-bladder is simple, long, and united throughout its length to the dorsal side of the abdominal cavity, but does not extend forward to the diaphragm or back quite to the end of the cavity. From the lower part of its anterior extremity the pneumatic duct runs to the œsophagus.

The skull is weakly ossified, more elongated and shallower than in the Salmons, and without the curvature characteristic of the latter in the sphenoid region. Nor does the parasphenoid bone extend so far back as in the preceding genus: its hind extremity lies outside (under) the front portion of the basilar part of the occipital bone, which part behind this point is tumid on each side, whereas the Salmons here have only a longitudinal, terete carina. This swelling, the anterior part of which belongs to the temporal region, includes the *sacculus* of the labyrinth, with the flat, but long, heart-shaped otolith, which in a Smelt measuring 177 mm. is 5 mm. long. The posterior oculomuscular canal extends about as far back as the parasphenoid bone, and thus belongs to the sphenoid and temporal regions. The basisphenoid bone is wanting, and the wall between the orbits is reduced to a cartilaginous ridge, ascending in front and belonging to the hind part of the ethmoidal cartilage. The maxillaries with their *os supplementare* (*jugale*), the intermaxillaries, the palatines, the vomer, and the pterygoid bones, are arranged as in the Salmons; but the reduction of the vomer and the dentition of the mesopterygoid bones we have already noticed. The bran-

[a] According to KRØYER 3, to DAY sometimes as many as 7; we have most often found 5.

[b] In a male Smelt 133 mm. long the spleen was 6 mm. long during the spawning-season, in two females measuring 139 and 177 mm. the spleen was respectively 5 and 7·8 mm. in length.

chiostegal apparatus differs from that of the Salmons in its fewer rays, 7 or at most 8, the anterior needle-shaped, the last three broad and ensiform. The opercular apparatus is distinguished from that of the Salmons principally by the fact that the preoperculum is attached to the upper part of the hyomandibular bone (which is here elongated in the form of a backward process) only at the very top, in common with the articular knob of the operculum. Below the said process

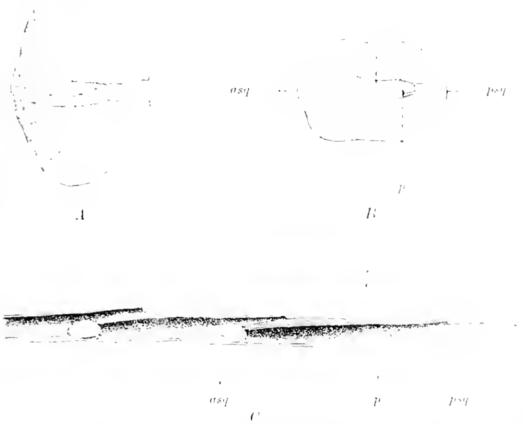


Fig. 218. *A*, Scale from the lateral line of *Osmerus eperlanus* with imperfectly closed duct, magn. 8 diam. For the further elucidation of its structure are added a scale (*B*) from the lateral line of a *Salmo trutta* (♀ 338 mm. long, from Norrköping), also magnified 8 diameters, and a section (*C*) of $2^1/_2$ scales (magn. 10 diam.) from the lateral line of a large Salmon. *t*, duct of the lateral line; *asq*, anterior part of the scale; *psq*, posterior part thereof; *p*, pore in the scale (answering to the deep incision in the scale from the lateral line of the Smelt), through which the nerve of the lateral line passes from one scale to the next, after sending out a ramification with a sensory organ into the duct on the outer surface of the posterior part of the scale.

is a large opening between the preoperculum and the hyomandibular bone, which in front, on the other hand, expands into a disk, forming a stronger support for the palatine arch, and is itself strengthened by a downward ridge at the middle of its inner surface. The spinal column is similar to that of the Salmons; but the haemal arches are not completely closed until they reach the beginning of the caudal part. The series of bones which in the Salmons forms the postclavicular apparatus, is here represented by a small, round and thin, disk-shaped bone at the hind inferior extremity of the clavicle, with its upper part attached inside the lower angle of the posteriorly expanded disk of the latter. The pelvic bones are weak and resemble those of the Salmons.

The scales of the Smelts are thin, on the sides of the body elliptical, with longitudinal axis set crosswise (up and down), on the belly more rounded or of broad oval shape. In texture they resemble the scales of the Salmons, without radiating grooves, but with more or less numerous and dense concentric striae. The indistinct nucleus is eccentric and lies in the anterior (inserted) part of the scale. The lateral line is distinct only on the anterior part of the sides. Its scales are deeply cloven behind, where the canal of the lateral line has its course, and the duct belonging to each scale, and surrounding the canal, in front of this cleft, and on the outside of the scale, is open or at least imperfectly closed — as in the earlier developmental stages of more complete lateral lines — the margins of the primitive canaliculate duct not coalescing, even where one of them overlaps the other (fig. 218, *A*). The scales of the Smelt are further distinguished by the absence of the layer of silvery pigment which elsewhere lines the scales where this colour appears. The silvery lustre is indeed present in a longitudinal band along the sides of the Smelt; but on removing the scales we distinctly see that the coat of pigment lies in the skin under the scales.

The relation to the Salmons has already been expressed in the above generic characters. But this relation, as paleontology seems to indicate, is probably one of development as well, *Osmerus* standing nearer to the common ancestors of the genera. This appears most clearly on a comparison of the average figures expressing the corresponding relations of form in the two genera.

From the above table of averages (p. 853) we easily see that the position of the dorsal fin, expressed in the distance from the tip of the snout to the beginning of the base of this fin, becomes more forward with age — and the averages for the several ages show[a] that this alteration of growth is greatest during the earlier and earliest stages. The said distance decreases both in proportion to the length of the body and to

[a] Cf. SMITT, *Riksmusets Salmonider*, pp. 11 and 25.

the distance between the ventral fins and the tip of the snout. Accordingly too *Osmerus*, as a representative of one of the earlier stages of the family, has greater averages in these respects than the Salmons. This is also the case with the length of the base of the anal fin[a]. A general rule for the whole life of the Salmonoids is that the length of the maxillaries is reduced with age in proportion to that of the body[b], and the same rule applies to the length of the suboperculum in proportion to that of the head or of the head reduced[c], with a slight exception in the last case. The breadth of the interorbital space, on the contrary, increases with age in proportion to the length of the head or of the head reduced[d]. The length of the peduncle of the tail at the ventral margin[e], and the least depth of the tail[f], in proportion to the length of the head or of the head reduced, undergo alterations of growth which at the modification in the life of the Salmons — from fresh water to the sea — change direction: their averages increase as a rule in the earlier and earliest stages, but subsequently decrease, after attaining their maximum at the end of the life in fresh water. Here too *Osmerus* represents the earliest stages.

Arithmetically expressed, this developmental relation appears as follows:

A v e r a g e	*Osmerus.*	*Salmo.*
Distance between the dorsal fin and the tip of the snout in % of the length of the body	47.8	42.1
" " " " " " " " " " " " " " " distance between the ventral fins and the tip of the snout	96.5	86.1
Base of the anal fin in % of the length of the body	11.7	8.4
" " " " " " " " " " " " " head reduced	79.2	55.6
Length of the maxillaries in % of the length of the body	9.3	8.8
" " " suboperculum " " " " " " " head	28.5	25.4
" " " " " " " " " " " head reduced	41.9	37.7
Breadth of the interorbital space in % of the length of the head	25.1	31.8
" " " " " " " " " " " " " head reduced	37.7	47.2
Length of the peduncle of the tail at the ventral margin in % of the length of the body	8.4	12.5
Least depth of the tail in % of the length of the head	23.2	39.1
" " " " " " " " " " " " " head reduced	34.8	58.0

In other points, again, it appears that the Smelts and the Salmons have each taken their own path of evolution, and that the Smelts in several respects — in some like the Charrs — occupy the higher rank in the scale of development. On continuing our search for the most different averages in the Smelts and Salmons, and on comparing the signification thereof with the alterations of growth to which the Salmons are subject, we find the following relations most deserving of notice:

[a] Cf. Smitt, l. c., p. 14.
[b] " " " " p. 10.
[c] " " " " pp. 18 and 22.
[d] " " " " pp. 17 and 20.
[e] " " " " p. 15.
[f] Cf. above, p. 833, the lower table, where these proportions may easily be calculated from the averages there given, and Smitt, *Riksmus. Salmonider*, pp. 19 and 23.

Average		*Osm. ..*	[illegible]	Changes of growth in the true Salmons	[illegible]
Length of the head reduced	in % of the length of the body[a]	14.8	15.2	[illegible]	11.1
Base of the dorsal fin	.. ..	8.0	12.1	.. ..	
Length of the pectoral fins	.. ..	14.[illegible]	16.[illegible]	.. ..	11.[illegible]
Postabdominal length	.. .. [illegible]	22.8	19.[illegible]	.. ..	20.[illegible]
Height of the anal fin	.. ..	7.7	12.3	.. ..	
Least depth of the tail	.. ..	5.1	8.8	.. ..	
Length of the middle caudal rays	.. ..	6.4	7.[illegible]	.. ..	6.[illegible]
Length of the maxillaries	in % of the length of the head reduced[b]	62.8	58.1	.. ..	59.1
Breadth	.. .. [illegible]	11.3	15.4	.. ..	12.1
.. ..	.. .. maxillaries	18.[illegible]	26.7	.. ..	21.0

No immediate descent of the Salmons from the Smelts can thus be assumed.

On examining the relations between the three forms hitherto distinguished in the genus of the Smelts, we find that the Atlantic Smelt (*Osmerus eperlanus*) distinctly appears in some respects to have adopted its own course of development, and that in these respects it has remained nearer to the presumable origin of the genus. But in most points the development seems to have been common to the three forms, and the Pacific Smelt (*Osm. dentex*) is apparently the nearest representative of the original type in the modern fauna. We are besides struck by the analogy in the relations of development to those between the three above-mentioned Charr forms, *Salmo alpinus*, *S. stagnalis*, and *S. salvelinus*, for we find within the genus of the Smelts too a defined natural series of three forms,

Osmerus dentex — *O. spirinchus* — *O. eperlanus*,

as the most general expression of the course of evolution. Several deviations, however, meet us, which may here too be explained as manifestations of the influence of sex on the development, the most Arctic form — *Osmerus spirinchus*[k], known from Alaska, Siberia, and the White Sea — being differentiated in most respects from the other two forms by the predominant influence of the female characters, while *Osmerus eperlanus*, generally speaking, bears the stamp of the male characters.

In order to find an expression for the general alterations of growth within the genus, we have distributed our specimens among four classes according to age, three of these classes fixed by comparatively wide gaps in the decrease or increase of the percentages during growth, the fourth (the oldest) marked by a reversion to the earliest characters, best explained, perhaps, as the result of a growth exceeding the most natural limits of the forms. In certain parts of Sweden a distinction is made in popular language[l] between *nors* (the smaller Smelts) and *slom* (the larger ones), and at a length of 200 mm. there intervenes in the Scandinavian Smelt one of the said gaps, for example in the decrease of the percentage for the relative dimensions of the eyes. At a length of about 150 mm. we observe a similar gap, and at a length of about

[a] Cf. Smitt, *Riksm. Salm.*, p. 9.
[b] l. c., p. 12.
[c] l. c., p. 12.
[d] l. c., p. 14.
[e] l. c., p. 14.
[f] l. c., p. 15.
[g] l. c., p. 16.
[h] l. c., p. 21.
[i] l. c., p. 21.
[j] l. c., p. 23.
[k] The name of *spirinchus* was applied by Lilljeborg (Vet.-Akad. Handl. 1850, p. 304) to the White Sea Smelt, and although Pallas, who first coined the name, by no means restricted it to that form, we have refrained from giving the said form a new name, as *spirinchus* in its old signification cannot be employed for the future as a specific name. In our first classification of the Salmonoids in the Royal Museum (Öfvers. Vet.-Akad. Förh. 1882, No. 8, p. 34 and Gt. Intern. Fish. Exhib. Lond. 1883, Swed. Cat., p. 184), we called this species *Osmerus dvinensis*.
[l] See Artedi, *Descr. Spec. Pisc.*, p. 47 and Nilsson, *Skand. Fn. Fisk.*, p. 433.

260—270 mm. the above-mentioned retrogression begins to assert itself in the changes of growth. The four age-classes may therefore be named: *nors*, *stornors*, *slom*, and *storslom*. Only in the third of these classes have we been able to examine fully comparable specimens of all the forms, in order to obtain an expression for the sexual differences within the genus.

One of the most distinct examples of the general tendency shown by the development of form within the genus — among the many that might be adduced[a] — we find in the averages for the alterations caused by growth in the relative length of the suboperculum. The said length, expressed in percent of that of the head, and reduced to an average for the whole genus *Osmerus*, is 28·5. The several averages, as expressions of the form-series and the changes of growth, are the following:

Average in	*Osmerus dentex.*	*Osmerus spirinchus*	*Osmerus eperlanus.*
	29·8	28·1	27·7
At the age of			
Nors		—	30·7
Stornors	29·8	(27·9)	27·6
Slom ♂	29·2 } 29·8	27·7 } 28·5	27·7 } 26·6
„ ♀	30·4	29·3	25·6
Storslom	—	27·9	25·6

Here the averages decrease with increasing age, and the form-series also shows uniformly sinking averages. No constant sexual difference can be discovered, for the male averages in *O. dentex* and *O. spirinchus* are less, in *O. eperlanus* greater, than the female.

The case is different, when a constant sexual character exercises its influence on the development. This appears, for example, in the relative dimensions of the eyes. The vertical diameter of the eyes, calculated on an average for the whole genus *Osmerus*, is 41·5 % of the length of the maxillaries. The several averages expressing the difference between the forms and the changes of growth, are the following:

Average in	*Osmerus dentex*	*Osmerus spirinchus*	*Osmerus eperlanus.*
	46·1	37·5	40·8
At the age of			
Nors			48·4
Stornors	48·1	(36·8)	41·6
Slom ♂	45·4 } 45·0	38·0 } 38·0	39·7 } 38·2
„ ♀	44·7	37·9	36·8
Storslom		36·3	33·9

Here too the changes of growth show sinking averages; but in the form-series *Osmerus spirinchus* occupies the most advanced rank, as the representative of a fairly distinct female character. Should we desire to see how the relation appears when this form breaks the series by too high an average, we have a clear example in the relative length of the lower jaw. This length, expressed in percent of the length of the head reduced, and calculated on an average for the whole genus *Osmerus*, is 91·9. The averages for the form-series and for the several ages are the following:

Average in	*Osmerus dentex.*	*Osmerus spirinchus*	*Osmerus eperlanus.*
	89·7	96·1	90.6
At the age of			
Nors	–	—	86·4
Stornors	89·3	(93·1)	90·1
Slom ♂	89·8 } 89·8	95·2 } 95·7	91·8 } 92.4
„ ♀	89·8	96·3	92·7
Storslom	—	98·8	96·7

Here we observe a still more prominent sexual difference both in *Osmerus spirinchus* and *O. eperlanus* — and the former together with the females has the highest averages — but *Osmerus dentex*, the least differentiated form, shows no sign of a sexual character in this respect.

Again, should we wish to see how specific characters manifest themselves during the course of development, we can hardly find a better example than among the Smelts. The only characters not infringed by exceptions, i. e. the only constant specific characters — so far as we can gather from our specimens — are the following:

A: 19—20 gill-rakers on the lower part of the first branchial arch, and at most 29 on the whole front surface thereof. Height (longest ray) of the anal fin at most 7·6 % of the length of the body *Osmerus dentex.*

B: 23—25 gill-rakers on the lower part of the first branchial arch, and at least 33 on the whole front surface thereof.
- *a*: Height of the anal fin at most 7·6 % of the length of the body .... *Osmerus spirinchus.*
- *b*: Height of the anal fin at least 8·4 % of the length of the body .... *Osmerus eperlanus.*

The manner in which the height of the anal fin passes through its changes of growth, and affords one

[a] Cf. Smitt, *Riksmuseets Salmonider*, pp. 168—189.

of the external sexual characters, may be expressed in the following table of averages:

Average height of the anal fin in % of the length of the body, in	*Osmerus dentex*	*Osmerus spirinchus*	*Osmerus eperlanus*
	6·9	7·0	9·2
At the age of			
Nors ..			9·6
Stornors	7·1	(7·1)	8·6
Slom ♂	6·8 } 6·8	6·9 } 7·0	8·9 } 9·2
„ ♀	6·9	7·2	9·5
Storslom ..		6·9	9·3

The average in this relation for the whole genus *Osmerus* is 7·7, so that in the first two forms the average falls short of this amount — both of them showing almost the same average — but exceeds it in the last form. In the first two the percentages sink uniformly with increasing age. This is also the case during youth in *Osmerus eperlanus*; but after the *stornors* stage its course of development is reversed — the female characters gain the ascendency in the basin of the Atlantic. Here, as in several other respects, it appears that the course of development was originally common, but has diverged in connexion with a geographical separation, which in the Smelts, as well as in the Salmons, probably dates from the Tertiary Period, from the elevation of the Rocky Mountains in North America[a].

The genus *Osmerus* was established by ARTEDI[b], who included within its limits, however, the modern *Saurus*, a Scopeloid genus.

THE SMELT (SW. NORS, N.).

OSMERUS EPERLANUS[c].

Plate XLI, fig. 1.

Number of gill-rakers on the front of the first branchial arch 33—37, 23—26 of them being situated on the lower part of the arch. Height of the anal fin (length of its longest ray) more than 8 % of the length of the body or than 36 % of the length of the head. Length of the middle caudal rays less than $^3/_4$ of that of the longest anal ray.

R. br. 7(8); *D.* $\frac{(2)3}{8-9}$; *A.* $\frac{(2)3}{12-14}$; *P.* $\frac{1}{10-11(12)}$; *V.* $\frac{1}{7}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* (58)62—64(68); *L. tr.* (supra pinn. ventr.) 13; *Vert.* 60—62.

Syn. *Eperlan de mer* et *Eperlan de riviere*, BELON., *Nat., Div. Poiss.* p. 282 et 284; *Eperlanus*, RONDEL., *Pisc. Fluv.*, p. 196; *Spirinchus* et *Stincus*, GESN., *Paralip.* p. 29; *Spirinchus*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 70; *Osmerus* radiis pinnæ ani septendecim, ART., *Ichthyol.*, *Syn. Pisc.*, p. 21, *Descr. Spec. Pisc.*, p. 45; LIN., *Fna Suec.*, ed. I, p. 118.
Salmo Eperlanus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 310; *Fna Suec.*, ed. II, p. 124; BL., *Fisch. Deutschl.*, part. I, p. 179, tab. XXVIII, fig. 2 (+ var. *S. eperlano-marinus*, p. 182, tab. cit., fig. 1); RETZ., *Fna Suec. Lin.*, p. 348; LACEP. (*Osmerus*), *Hist. Nat. Poiss.*, vol. V, p. 231, PALL. (*Salmo*), *Zoogr. Ross. Asiat.*, tom. III, p. 386; MITCH., Trans. Lit., Phil. Soc. N. Y., vol. I, p. 435; NILSS. (*Osmerus*), *Prodr. Ichthyol. Scand.*, p. 12; EKSTR., Vet.-Akad. Handl. 1834, p. 7; YARR., *Hist. Brit. Fish.*, ed. I, vol. II, p. 75; KR., *Danm. Fisk.*, vol. III, pp. 1 et 1215; CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 371, tab. 620; LLOYD, *Scandin. Adventures*, vol. I, p. 121; NILSS., *Skand. Fna, Fisk.*, p. 433; WIDEGR., *Fiskfn. Fisker. Norrb. L.*, Landtbr. Akad. Handl. 1861, p. 9 (sep.); SIEB., *Susswasserf. Mitteleur.*, p. 271; MOBN, *Finl. Fiskfna* (disp. Helsingf. 1863) p. 65; GTHR, *Cat. Brit. Mus., Fish.*, vol. VI, p. 166; FEDDERS., Tidskr. Fisk. Kblvn, IV (1870), p. 100; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh. p. 162; MALM, *Gbgs. Boh. Fna*, p. 549, SEIDL., *Fna Balt.*, p. 95; WINTH., Naturh. Tidskr., Kblvn, ser. 3, vol. XII, p. 44; FEDDERS., ibid., p. 78; BENECKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 155; MELA, *Vert. Fenn.*, p. 344; tab. X; DAY, *Fish. Gt. Brit. Irel.*, vol. II, p. 121, tab. CXXI, fig. 1; MOB., HEKE, *Fisch. Osts.*, p. 128; NORBACK, *Handl. Fisker., Fiskafr.*, p. 396; BLUF., SUNDM., *Finl. Fisk.*, tab. XV; SM. *Riksm. Salm.*, l. c.; LILLJ., *Sv., Norg. Fna, Fisk.*, p. 630.
Atherina mordax, MITCH., Trans. Lit., Phil. Soc. N. Y., vol. I, p. 446; GILL (*Osmerus*), Smithson. Misc. Coll., No. 283, p. 32; JORD., GILB., Bull. U. S. Nat. Mus. No. 16, p. 293; BR. GOODE, *Fisher., Fish. Industr. U. S.*, sect. I, p. 545, tab. 199.
Salmo (Osmerus) spirinchus, PALL., *Zoogr.*, vol. III, p. 387; CUV., VAL., l. c., p. 387. — nec LILLJ., nec SM.
Osmerus viridescens, LESUEUR, Journ. Acad. Nat. Sc. Philad., vol. I, p. 230; DEK., *N. Y. Fna*, part. IV, Fish., p. 243, tab. 39, fig. 124, CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 388, STOR., Mem. Amer. Acad. Arts, Sc., vol. VI, p.

[a] Cf. SMITT, *Riksmuseets Salmonider*, p. 171, § (5).
[b] *Ichthyol.*, *Gen. Pisc.*, p. 10.
[c] A Latinized form of the French *éperlan*, which according to RONDELET refers to the pearly lustre of the coloration.

327, tab. XXV, fig. 4. [illegible] *Cat. Brit. Mus., Fish.*, vol. VI, p. 167.

Eperlanus vulgaris, GAIM., *Voy. Isl., Groenl.*, tab. 18, fig. 2.

In the largest Swedish lake, Wener, the Smelt frequently attains a length of a foot or about 3 dm.[a] to the extreme tip of the caudal fin. In Lake Mälar too it is frequently of a fair size, about 27 cm. in length[b]; but in the smaller lakes it seldom exceeds a length of 10—20 cm. As we have mentioned above, the Scandinavian fishermen distinguish by size and odour between two kinds of Smelt, calling the larger kind *slom*. The line between these two kinds is drawn at a length of about 2 dm. According to NORBÄCK the Smelt

at a length of about	6	cm. weighs about	13—17	grammes,
„ „ „ „ „	9—12	„ „ „	34—43	„
„ „ „ „ „	18—20	„ „ „	85—127	„
„ „ „ „ „	30	„ „ „	300	„ .

PENNANT'S largest specimen was 33 cm. long and weighed 227 grammes[c].

The body is rather elongated and of a compressed, fusiform shape, the upper and lower contours being slightly and similarly arched. According to the ripeness or emptiness of the sexual organs the greatest depth of the body, which is situated at the beginning of the dorsal fin, varies between 14 and 18 % of the length of the body. The greatest thickness, which lies nearer to the back than to the belly, and is fairly uniform from the opercular region to the dorsal fin, varies between $8\frac{1}{2}$ and 11 % of the length of the body or between 48 and 70 % of the greatest depth. The least depth of the body (of the peduncle of the tail) varies between 6 (or a little more) and $4\frac{1}{2}$ % of the length. The form of the body is thus subject to considerable variations, and is as a rule deeper in the females than in the males[d]. The back, including the forehead, is broadly rounded, as well as the belly, which at the ventral fins even approaches to flatness.

The head resembles a compressed cone, the point being formed by the tip of the lower jaw; and its length from the articular knob of the maxillaries[e] is somewhat less than $\frac{1}{4}$ (21—24 %) of the length of the body. The convex snout resembles an obliquely cut cone, and consequently the sharp margin of the upper jaw forms an ellipse. Its length is about 26—30 % of that of the head[f], the percentage rising with fair uniformity during growth, and its breadth across the articulation of the maxillaries is only slightly less. The longitudinal diameter of the eyes is somewhat greater than the vertical, measuring in young Smelts about $\frac{1}{4}$, in old about $\frac{1}{6}$, of the length of the head, or in the former nearly $\frac{2}{5}$, in the latter about $\frac{1}{4}$, of the length of the head reduced (from the articular knob of the maxillaries to the hind margin of the preoperculum). In the former their longitudinal diameter sometimes is more than $\frac{1}{4}$ greater than their distance from the articular knob of the maxillaries, in the latter it sometimes sinks to $\frac{3}{4}$ of this distance. The least breadth of the interorbital space increases even relatively with age from about 22 to about 28 % of the length of the head, or from about $\frac{1}{3}$ to $\frac{2}{5}$ of the length of the head reduced. The nasal cavities lie just behind the articular knob of the maxillaries, the distance from the middle of the tip of the snout to the front margin of the anterior nostril being, however, nearly twice that from the hind margin of the posterior nostril to the front margin of the eye. The two nostrils on each side of the snout are small, the posterior somewhat larger than the anterior, but usually covered to a great extent by the backward dermal fold containing the thin ridge that divides the nostrils. The intermaxillary bones are about equal in length to the eyes; and the length of the maxillaries, which increases even relatively with age, varies between about 9 ($8\frac{1}{2}$) and 11 % of that of the body, between 42 ($40\frac{1}{2}$) and 50 % of that of the head, or between 62 (60) and 67 % of that of the head reduced. The supplementary (jugal) bone of the maxillaries is behind lancet-shaped, in front elongated to a point. Its anterior part lies loose in the dermal fold uniting the maxillary bone to the cheek. The lower jaw is of a flat, boat-like shape, in front curved uniformly, but rather slightly upwards.

[a] TENOW gives even 4 dm. (See *Vermlands och Dals Ryggradsdjur*, p. 108).

[b] Underd. Bet. m. Försl. t. Fiskeristadga 1883, p. 158; LILLJEBORG, l. c., p. 631.

[c] *Brit. Zool.* (London 1776), p. 274.

[d] In *Osmerus dentex* and *O. spirinchus* the sexual difference seems to be reversed. Cf. SMITT, l. c., p. 176.

[e] For the sake of uniformity in a comparison with *Coregonus* we have measured the length of the body etc., here as in *Riksmuseets Salmonider* (l. c.), from the articular knob of the maxillaries, and not from the middle of the tip of the snout.

[f] In *Riksmuseets Salmonider* the length of the snout in the Smelt is measured from the articular knob of the maxillaries, and therefore less.

Its length, which shows with fair uniformity even relative increase with age, varies between $12^1/_2$ and $16^1/_2$ % of that of the body, between about 60 and 76 % of that of the head, or between about 86 and 98 % of that of the head reduced. The mouth and pharynx with their dentition have already been described. The gill-rakers are set in one row of 34—37 on the first branchial arch, and are setiform, fine, dense, and long. The pseudobranchiæ compose a narrow, longitudinal band on each side, made up of about 10 short, transversely set threads, just behind the boundary between the palatine arch and the branchial cavity, and running straight back from the upper insertion of the first branchial arch. The operculum is quadrilateral, trapezoidal, with the upper margin shortest, the posterior slightly concave at the top, and the inferior straight. The length of the last-mentioned margin, which is directed obliquely backwards and upwards as in the Salmons, varies in different individuals between about 32 and 24 % of that of the head. The suboperculum also resembles that of the Salmons, being rather narrow but of uniform breadth, and rounded at the lower posterior corner. The interoperculum is triangular, most pointed in front. The preoperculum is rounded at an obtuse angle. The gill-openings are large, extending up above the middle of the superior opercular margin and down to a level with the centre of the eyes. The branchiostegal membranes are broad and thick, free both from each other and the isthmus; but at the extreme front they cross, the left overlapping the right. The first two (three) branchiostegal rays are slender, setiform; the other five sabre-shaped, gradually increasing in breadth backwards (upwards).

The dorsal fin begins at a distance from the articular knob of the maxillaries that increases with age from about 46 to 50 % of the length of the body. Its base varies between about $7^1/_2$ and $8^1/_2$ %, and its greatest height (the length of the 3rd or 4th ray) between about 14 and 15 %, of the length of the body. Above it is obliquely truncate, with the upper posterior margin straight or somewhat convex. The adipose fin is of the same shape as in the Salmons, but of a distinctly fibrous texture. It is situated above the posterior part of the anal fin, at a distance from the caudal fin measuring about $^1/_{10}$—$^1/_8$ ($9^1/_2$—$12^1/_2$ %) of the length of the body. The anal fin begins at a distance from the articular knob of the maxillaries equal to about 70 % ($69^1/_2$—$72^1/_2$ %) of the length of the body, the percentage being generally greatest in the females. The length of its base varies between 14 and 11 %, and its greatest height (the length of the 3rd—5th ray) between 10 and $8^1/_2$ %, of the length of the body. Its inferior margin is somewhat concave. The caudal fin is deeply forked, the length of the middle rays being only slightly greater than (sometimes equal to) the least depth of the tail, or about $^2/_5$ (varying between 35 and 43 %) of the length of the longest caudal rays, which varies between about 17 and 15 % of that of the body.

The pectoral fins are set as in the Salmons, rather low. When folded, they are of an obliquely pointed shape; when expanded, oval. Their length varies between 16 and 14 % of that of the body. The third (second branched) ray is commonly the longest. The ventral fins are of a broader shape, and are always shorter. Their length varies during growth between $14^1/_2$ and 12 % of that of the body. Their distance from the tip of the snout (i. e. from the articular knobs of the maxillaries) is generally the same as that of the dorsal fin. The preabdominal length is as a rule more, the postabdominal length less, than $^1/_4$ of the length of the body, the former varying between about 29 and 26 %, the latter between about 22 and 23 % thereof.

The structure of the scales we have already described. Below we shall see how the scales of the lateral line indicate the origin of those of *Argentina* and *Scopelus*, as a transition stage in this respect between the said genera and the Capelin. During the spawning-season both the males and females are covered with a granulate dermal eruption, which varies, however, considerably both in prominence and extent.

The internal organs and the most important peculiarities of the skeleton have also been described in the preceding pages.

The coloration is principally characterized, here as in the following genus, by the thinness and transparency of the scales; and this transparency is communicated in some degree both to the dorsal musculature and the head, the vertebræ as well as the cerebral parts being visible in the living fish. The back and the upper portion of the head are pale green or sometimes dashed with bluish gray, and down the sides, especially in the breeding males, this colour passes into a lustrous violet. Along the middle of the sides runs a silvery band, and this silvery lustre extends to the shoulder-girdle, the opercula, and the cheeks. Under the scales the skin is strewn on the upper parts of the body with fine spots of bluish black pigment, more scattered but larger in the silvery band. Down the sides these spots become still more dispersed, until they disappear on the belly. The snout, which is otherwise transparent, and the tip of the lower jaw bear the densest and largest spots of pigment. The silvery peritoneum gleams through the ventral sides. The lower part of the tail is transparent, of the same colour as the back, only paler (yellower), and the median line of the belly is partly transparent, partly more or less milk-white. The iris is of a silvery lustre, but the upper part of the eyeball is coated with a thick, bluish black pigment, which sometimes advances over the top of the iris. In the fins the membrane is transparent, and the rays are of a lighter or darker gray, darkest in the caudal and pectoral fins, and, after these, in the anterior part of the dorsal fin.

One of the most noticeable characteristics of the Smelt — which it possesses, however, in common with the Capelin — is its peculiar odour. This is most powerful in young specimens, and comes nearest to the smell of the cucumber, though not without a trace of violet perfume. It is at all events far from pleasant to the ordinary individual, and its seat being the dermal mucus of the fish, it communicates itself to everything with which the Smelt comes in contact.

The Smelt has an extensive range in the North Atlantic from east to west, for *Osmerus mordax* (*viridescens*), the form belonging to the east coast of North America, can hardly be regarded as a species distinct from our common Smelt. On the Atlantic coasts and in the rivers that fall into the Atlantic Ocean, its occurrence is, however, confined, generally speaking, to the zone bounded by the 40th and 60th degrees of latitude[a], though in the Baltic it is found further north, up to the head of the Gulf of Bothnia. South of France it is unknown, and it is not common south of the north-west of that country; but from this region, including the British Isles and the Continent, up to the south-east of Norway, throughout the greater part of Sweden, in Finland, and in Russia, it occurs, and in suitable localities is common, within the basins of the North Sea and the Baltic. In Russia, according to GRIMM[b], it has also spread to the basin of the Volga. It is really an anadromous fish, ascending the rivers in order to spawn, and in the southern part of its range its occurrence is almost exclusively restricted to tidal waters. But in many places it has become a stationary fresh-water fish. In the lakes of Jutland it is fairly common, according to KRØYER, who had also procured specimens from Roskilde Fjord, and records a statement as to its occurrence in Lake Fur (Zealand); but with these exceptions the Smelt is said to be wanting on the Danish islands. In Norway, according to COLLETT, it is found only in Christiania Fjord and in fresh water south of the Dovre Fjeld, though not west of Lake Nord in Telemark; and on the west coast it is said to be wanting[c]. According to the reports sent in to the Fisheries Commission of 1881—83 the Smelt is wanting in Sweden only within the Governments of Jönköping[d], Kronoberg, Gothland, Blekinge, and Halland. Throughout Finland the Smelt is common, up to lat. 66 N. (MALMGREN); but in the White Sea it is replaced, as we have mentioned, by *Osmerus spirinchus*. A singular gap in its geographical range appears in the Baltic within the Sound, where it is wanting or at least extremely rare on the Scanian coast, off Bornholm, and on the coast of Blekinge. The gap reminds us of a similar break in the range of the Common Sea-Snail[e], though the Smelt is by no means an Arctic species. It is especially common in Russia, North Germany — particularly in the Haffs — and the Netherlands; and the Smelt fisheries of the Seine and Thames are to Paris and London what the fishery in the Norrström is to Stockholm. In Irish waters the Smelt seems to be wanting.

"The Smelt is of a stupid and sluggish temperament", wrote EKSTRÖM, and this opinion has afterwards been reiterated by other writers — "silly as a Smelt," is a common Swedish saying. But why it is thus stigmatized more than other fishes, we cannot say. Gathered in shoals during the spawning, when it is ruled by sexual instincts alone, it is easy to catch like many other fishes; and this is probably the origin of its reputed stupidity. It is a voracious fish-of-prey — which may easily be seen by its teeth — and its form of body

[a] According to GAIMARD (l. c.) the Smelt occurs on the coasts of Iceland; but FABER had no information on this head.

[b] *Fishing and Hunting in Russian Waters*, p. 20.

[c] OLSEN (*Piscatorial Atlas*) states, however, that the Smelt occurs in Bucke Fjord off Stavanger.

[d] Yet it is found in Lake Wetter.

[e] Cf. above, p. 289.

indicates at least no lack of agility. But out of the water it soon dies, no more tenacious of life than the Herring. It is a migratory fish like the Salmons, though not in so high a degree, roving at the spawning-season from salt water to fresh, or, in the lakes, from deep water to the shallows. As the spawning-season approaches, it assembles in large and dense shoals; but at other times it leads a more solitary life, being frequently taken in the Herring-nets used in the Baltic, but not in any great number. It feeds principally on fish, small or large — at least up to half of its own size — and especially on Herring-fry and the young of its own species. Other kinds of food, however, such as crustaceans (shrimps and Gammaroids), worms, and larvæ, do not come amiss.

According to YARRELL the marine Smelt of the English coasts repairs to fresh or brackish water, and remains there from August to May. In the Norrström off Stockholm a female 196 mm. long and a male 188 mm. long, both quite ready to spawn, were taken on the 4th of November, 1892; but as a rule the Smelt does not muster in Sweden for its breeding expeditions until the end of March or even later. From the island-belt of Södermanland EKSTRÖM wrote, "In March or April, according to the earlier or later breaking up of the ice, the Smelt ascends to rivers, straits, or shores where there is some current, always choosing, however, water of some depth with a clean, sandy bottom. It generally rises towards evening and continues its journey the whole night, but at daybreak again retires for the most part to deep water. A remarkable circumstance is that, whereas all other fishes prefer to spawn in fine weather, in the Smelt the case is just the reverse. In squally and snowy weather it is most eager in its ascent, the violent gusts of wind and snow that occur during the said months being hence known as *nors-il* (Smelt squalls). Males and females swim in company during the spawning, and are so densely massed that they seem merely to rub their bodies together in order to rid themselves of the roe, which is deposited on the bottom beneath." The young start first, but do not ascend so far up the rivers as the older fish, and often spawn in the lakes on shallow shores. Each shoal completes its spawning operations in a few days; but one shoal follows in the wake of another, and thus the spawning continues as a rule from the latter part of March to the first weeks of May. The greater part of the shoal is composed of females, and after the spawning the shore and the bottom are strewn with numbers of dead Smelts which have struggled in vain to disburden themselves of the roe[a]. The ova are light yellow; their diameter was estimated by BENECKE at 0·6—0·8 mm., and their number in a female 18—20 cm. long by NORBACK at 50,000, by OLSEN at about 36,000. They attach themselves in a singular manner to the objects on which they fall after impregnation. According to CUNNINGHAM[b], the outer membrane of the ovum, the so-called *zona radiata*, "is differentiated into two layers, the outer of which is somewhat thinner than the internal. In the zona radiata externa the pores are larger and farther apart than in the interna. But the important fact, which I believe no one has previously observed, is that the external zona separates very readily from the internal, and, rupturing at one portion of the ovum, peels off, becoming turned inside out in the process, and, remaining attached over a small circular area, forms the suspensory membrane", by means of which the ovum is attached to any external object.

The eggs are hatched, according to BLANCHÈRE, in 8—10 days, according to FEDDERSEN in 12 days, and according to SUNDEVALL in 18 days, a discrepancy of observation which in all probability depends on the different temperature of the water during the period of incubation. On their first exclusion the fry are elongated, according to SUNDEVALL 5 mm. long, and perfectly transparent; they are characterized by the unusually backward position of the vitelline sac, the distance between it and the insertion of the pectoral fins being more than half of that between these fins and the tip of the snout. EHRENBAUM[c] gives some personal observations on the growth of the larval Smelts. In the first month after the hatching, according to him, they grew to a length of 14—18 mm.; in the second he found them to be 27—34 mm. long, in the third 32—37 mm., in the fourth 35—44 mm., in the fifth 44—60 mm. Still, in August, according to YARRELL, they already measure as much as about $7^1/_2$ cm. The Smelt attains maturity in the following spring, or, according to NORBACK, even at a length of 43—60 mm.

[a] FAITH in KRØYER (l. c.) and FEDDERSEN in the *Tidskr. f. Fiskeri*, vol. IV (1870), p. 102.

[b] Proc. Zool. Soc. Lond. 1886, p. 292, tab. XXX.

[c] Sonderheil. Mittheil. Sekt. Küst., Hochs. Fisch., Jahrg. 1892, p. 12.

The rank odour emitted by the Smelt offends the taste of many; but the flesh is good, and the belly between the spawning-seasons full of fat. Among epicures it is esteemed as a delicacy, after the disagreeable smell has been removed by very simple culinary methods. The fish must also be carefully gutted, especially if in breeding condition, to rid it of the numerous intestinal worms, which penetrate even into the air-bladder. It is best fried and served with lemon-juice or vinegar, but is often boiled or stewed in sauces. It is also split and dried for future consumption, and in this state may be eaten without further preparation[a]. Another method is to soak the dried fish in lye, and afterwards dress it for table like other stockfish. In addition to its utility as human food, the Smelt also possesses importance as one of the best baits for predatory fishes of a greater size; and in several localities where it is taken in too great a quantity for immediate use, it is even made into guano.

Of the Smelt-fishery EKSTRÖM writes, "It is during the spawning-season that the Smelt is taken in any quantity, the fishery being commonly conducted in the following manner. Across the straits or the rivers to which the Smelt ascends in order to spawn, fences are built of green spruce branches, arranged so as to leave gaps at the deepest parts of the channel. At these gaps the fisherman stations himself with a scoop-net large enough to fill the opening and breaded of meshes so fine that the Smelts cannot slip through. This net, which is distended on staves, he lets down into the opening, and takes up after a longer or shorter interval according to the numbers of fish that come up, the take being then turned out of the net into a coble held in readiness. When the Smelt spawns on shores or off headlands, it is taken with drag-nets, which differ from an ordinary seine only in the comparative fineness of the meshes. This fishery is pursued only at night, bonfires being not unfrequently lit on shore by the fishermen, in the belief that the fish, enticed by the glare, come nearer land." The well-known Smelt-fishery in the Norrström off Stockholm is carried on with large hoop-nets (fig. 219), such as are in general use at many places among the island-belt of Stockholm, to secure all kinds of small fishes for bait. These hoop-nets, usually about 3—3½ m. in diameter, are let down and hoisted up from a boat, with the aid of a long pole erected obliquely upwards in the stern; and a hand-net is employed to scoop the fish out of the large net. The Smelt is also caught on the hook with a bait of shrimps, sand-hoppers (Gammaroids), worms, or bits of fish; but this method is successful only when used for the large Smelts, the *slom* or *norskung* as they are called in some parts of Sweden when they occur in solitary specimens among the smaller Smelts.

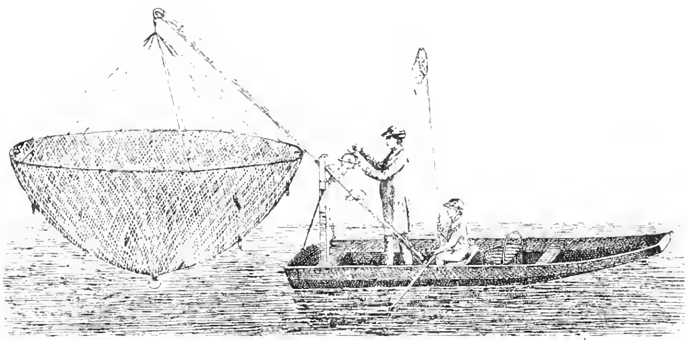


Fig. 219. Smelt-fishing with hoop-net from a boat.

Man is not the only enemy which the Smelt has to fear; it often falls a victim to predatory fishes and waterfowl. Although its great fecundity can, no doubt, compensate in most cases the losses inflicted by an active fishery, still it is advisable to protect the young fish.

In lakes where the Smelt is wanting, it may easily be introduced, and is very useful, especially as food for other fishes, in particular for the Pike-perch, as NILSSON has pointed out. The impregnated eggs may be transported from one lake to another, or with a little care the spawning Smelt may be conveyed alive during the cool season in vessels filled with pure water.

[a] "It used to be split and dried and was thus considered to add a peculiar relish to the morning dram of spirits". DAY.

Genus MALLOTUS[a].

No canines: small, fine teeth, hardly distinguishable to the naked eye, set in one row in the anterior part of the lower jaw, on the intermaxillaries, the maxillaries, the head of the vomer, the anterior extremity of the palatines, the mesopterygoid bones, and the tongue. Length of the maxillaries as a rule 57[b]—63 %, and that of the lower jaw as a rule 75[c]—90 %, of the length of the head reduced. Number of rays in the anal fin 20—24, 17[d]—20 being branched: and the base of the anal fin longer than that of the dorsal. Cæcal diverticula at the pylorus short and few (about 4—6). Scales small, about 200 in a row along the sides of the body, and the lateral line complete, at least to the perpendicular from the end of the anal fin.

Between *Mallotus* and *Osmerus* stands the Arctic American *Eulachon* (*Thaleichthys pacificus*), with scales only slightly smaller than those of the Smelt and dentition feeble as in the Capelin[e]. Thus we cannot expect to trace the descent of the Capelin immediately from the Smelt or the reverse. In several respects, it is true, we find that the Smelts represent an earlier stage of development, more nearly approximated to the presumable original form. One of the most prominent differences between the two genera lies, for example, in the shape of the anal fin, the height of which is always more in the Smelts, less in the Capelins, than half its base. Now in the former[f] we find in the averages a difference both of age — the young have a relatively higher anal fin than the old — and of sex — the females have a relatively higher anal fin than the males — both of which relations point to the transition from *Osmerus* to *Mallotus*. In most other respects, however, *Mallotus* comes nearer to the original form, such as we may assume this form to have been, judging by the manner in which the characters appear. Thus, for example, *Mallotus* has a narrower snout than *Osmerus*, the breadth of the snout across the articular knobs of the maxillaries being less in *Mallotus*, more in *Osmerus*, than $^1/_4$ of the length of the head or $^1/_3$ of the length of the head reduced. In *Mallotus* as in *Osm. eperlanus* the percentages for these relations also rise with increasing age. The sexual distinction is, however, different here: in the Capelins (as in *Osm. dentex* and *Osm. spirinchus*) the snout is as a rule narrowest in the females, in *Osm. eperlanus* in the males. Another character wherein *Mallotus* also represents a lower grade of development, may be found in its adipose fin, which is of uniform height, long and low, and which, like the embryonic fins that we have remarked in several preceding genera, is furnished with a countless number of fine supporting fibrils. The feeble dentition approximates *Mallotus* more closely to the following subdivision of the Salmonoid family, although the immediate transition from *Osmerus* to the said subdivision passes through other genera, as for instance *Nelma* (*Stenodus*) and *Hypomesus*.

Only one species of the genus is known[g].

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[a] Greek μαλλωτός = Lat. *villosus*, hairy.

[b] In exceptional cases 55.

[c] „ „ „ 72.

[d] „ „ „ 16.

[e] *Eulachon* is besides remarkable for its fatness. In a dried form it is a food of good flavour and, when lit, burns like a lamp.

[f] Most distinctly, judging by the Royal Museum specimens, in *Osmerus dentex* and *Osm. spirinchus*.

[g] The difference given in *Riksmusei Salmonider* between the Capelins of the Old and New Worlds has proved, on examination of a greater number of specimens from Greenland, to be untenable.

THE CAPELIN (SW. LODDAN).

MALLOTUS VILLOSUS

Plate XLI, figs. 2 (♂) and 3 (♀).

Milters and spawners widely different, the former with the length of the pectoral fins more than 15 % of that of the body, with the anal base, which is elevated in an arcuate curve beyond the ventral line, more than 16 % of the length of the body and perceptibly greater than the length of the head reduced, and also with the scales in a longitudinal row above the lateral line and in another along each side of the belly prolongated and pointed or at least distinctly larger than the scales on the rest of the body.

R. br. 8—10[a]; *D.* $\frac{(2)3}{10-13}$; *A.* $\frac{3-4(5)}{(16)17-20}$; *P.* $\frac{1}{15-19(20)}$; *V.* $\frac{1}{7}$; *C.* *c* + 1 + 17 + 1 + *c*; *L. lat.* ca 200; *L. tr.* ca $\frac{19-20}{14-16}$ supra pinn. ventr.; *Vert.* 67—70[b].

Syn. Anchoras et *Capelinas*, PARKHURST in HAKLUYTS *Voyages* 1598—1600, vol. III, p. 133; EGEDE, *Grønl. N. Perlustr.*, p. 50; STRÖM, *Søndm. Beskriv.*, part. I, p. 293; LEEM, *Beskr. Finm. Lapp.*, p. 323; OLAFS., *Reis. Isl.*, part. I, p. 358, tab. XXVIII *Angmarset*, CRANZ, *Hist. Grønl.* (ed. suec. 1769), part. I, p. 124. *Capelan de l'Amérique septentrionale*, DUH., *Pêches*, part. II, p. 149, tab. XXVI, figg. 1—8.

Salmo Eperlanus, MÜLL., *Zool. Dan. Prodr.*, p. 48 (ex STRÖM).

Clupea villosa, MÜLL., ibid., p. 50 (ex OLAFS.); VAHL, RATHKE (*Salmo*) in MÜLL., *Zool. Dan.*, part. IV, p. 45, tab. CLX; FABER, *Fisch. Isl.*, p. 174; RICHARDS. [*Salmo* (*Mallotus*) ex CUV.] *Fna Bor. Amer.*, part. III, p. 187; GAIM. (*Mallotus*), *Voy. Isl., Groenl.*, tab. 18, fig. 1; CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 392, tab. 622 et 623; MGRN, *Finl. Fiskfna* (disp. Helsingf.), p. 66; GTHR, *Cat. Brit. Mus., Fish.*, vol. VI, p. 170; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 163; ibid. 1879, No. 1, p. 86; N. Mag. Naturv. Chrnia, Bd. 29 (1884), p. 106; MELA, *Vert. Fenn.*, p. 345, tab. X; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 291; STORM, Norsk. Vid. Selsk. Skr., Trondhj. 1883, p. 28; BR. GOODE, *Fischer., Fischer.-Industr. U. S.*, sect. I, p. 544, tab. 201; SMITT, *Riksm. Salmonid.*, p. 189; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. II, p. 646.

Salmo arcticus, FABR., *Fn. Grønl.*, p. 177; NILSS. (*Osmerus*), *Prodr. Ichthyol. Scand.*, p. 11; KR. (*Mallotus*) in GAIM., *Voy. Scand., Lappon., cett.*, tab. 16, fig. 1; ID., *Danm. Fisk.*, vol. III, p. 23; NILSS. (*Osmerus*), *Skand. Fna, Fisk.*, p. 441.

Salmo groenlandicus, BL., *Naturg. Ausländ. Fisch.*, pt. VIII, p. 99, tab. CCCLXXXI, fig. 1; CUV. (*Mallotus*), *Règne Anim.*, ed. 2, tom. II, p. 306.

Salmo socialis, PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 389,

Osmerus microdon, CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 385, tab. 621.

The male Capelin is as a rule not more than 19 cm. in length to the end of the caudal lobes, and the female not more than 17 cm.; but LILLJEBORG mentions males of a length of 22 cm., and females of a length of 18 cm. According to the method in which our measurements are here taken, from the articular knobs of the maxillaries to the end of the middle caudal rays, the length of the body in our specimens does not exceed $17\frac{1}{2}$ cm. for the males or 16 cm. for the females.

The great difference between the sexes, which is so characteristic of the genus that we have included it in the above diagnosis — no other character is necessary, only one species of the genus being known — appears in the very form of the body. The Capelin is elongated and, in contradistinction to the Smelt, as a rule of more uniform depth and more compressed. In the adult males we have found the greatest depth, at the beginning of the dorsal fin, to vary between about 14 and 15 % of the length of the body, and the greatest thickness, which is fairly uniform above the lateral line from the shoulder-girdle to the end of the true dorsal fin, between $7\frac{1}{2}$ and $8\frac{1}{4}$ % of the same. In the adult females the corresponding percentages have varied from 11 to 13 and from 5 to 8 respectively. In the males the greatest thickness has varied between 53 and 60 %, in the females between 43 and 62 %, of the greatest depth. The least depth of the body shows on an average the same sexual difference, being in the females about 5 %, in the males about $5\frac{1}{2}$ %, of the length of the body. The dorsal edge is broadly convex, and the dorsal profile almost straight from the very occiput[c], not beginning to descend towards the base of the caudal fin until past the dorsal fin proper. Below the lateral line the sides gradually converge

[a] Sometimes up to 11, according to KRØYER.

[b] Sometimes 65, according to KRØYER.

[c] In all our fresh, but dead specimens there appeared in the median line of the back, just behind the head, a compressed swelling, due to a callosity of the central sinew in the *musculus gracilis*, where the latter broadens towards its point of attachment on the occiput.

towards the ventral margin, which is narrower, but terete. The ventral profile in front runs almost parallel to the dorsal, beginning to rise towards the peduncle of the tail at the origin of the anal fin, in the females uniformly, but in the males with a break caused by the arcuate expansion of the base of the said fin.

The shape of the head reminds us most of a three-sided pyramid, two sides of the pyramid being formed by the cheeks, which approach each other below, and the third by the flat forehead and occiput. Its length, which is greatest in the females and the young, varies between 23 and 19 % of that of the body, and the length of the head reduced, from the articular knobs of the maxillaries to the hind margin of the preoperculum, similarly between $15^1/_2$ and 13 % of the length of the body. The horizontal profile of the tip of the snout is broadly rounded, but its breadth at the articulation of the maxillaries is considerably less than in the Smelt, measuring only 16—20 % (in exceptional cases 21 %) of the length of the head. The length of the snout, on the other hand, is greater than in the Smelt, being about 33—30 % of that of the head. The eyes are also comparatively larger than in the Smelt: in adult Capelins their longitudinal diameter, which is somewhat greater than the vertical, is about 24—23 % of the length of the head. The postorbital length of the head is consequently always less in the Capelin (about 44—48 %) than half the length of the head, while in the Smelt it is more than half of the same. The forehead is flatter, but its breadth, like that of the snout, is on an average less than in the Smelt, being only about 24—22 % of the length of the head, and in exception to the general rule in the family, it is the males that here represent the earlier stages of development. In the opercular apparatus the operculum itself is of the same shape as that of the Smelt, but the sinus at the hind margin is indistinct or wanting. The suboperculum is somewhat larger than in the Smelt, and more nearly resembles the quadrant of an ellipse. The lower posterior angle of the preoperculum is almost a right angle. That portion of the margin of the upper jaw which is formed by the intermaxillaries measures only about $^5/_8$—$^5/_7$ (63—74 %) of the longitudinal diameter of the eyes; but the length of the maxillaries is about the same as in the Smelt, on an average about 41 %, varying between 38 and 44 %, of that of the head. The length of the lower jaw, on an average less than in the Smelt, is about 57 %, varying between 55 (exceptionally 53) and 60 (exceptionally 62) %, of that of the head; but the more essential difference in the shape of the lower jaw between these two genera is due partly to the downward convergency of the sides of the head in the Capelin, the halves of the lower jaw being thus brought nearer to each other, partly to the less marked curvature in an upward direction of the point of the lower jaw, which, however, projects, even in the Capelin, beyond the tip of the snout. As regards the distribution of the teeth in the mouth, palate, and pharynx the Capelin in all essential respects resembles the Smelt; but all the teeth of the Capelin are of uniform size and small, about equal in size to the maxillary teeth of the Smelt. On the true hyoid bone (*os linguale* or *glossohyale*) lies an elliptical row of teeth within the fleshy margins of the tongue, with one or two teeth set inside the ellipse, and on each mesopterygoid bone the row of teeth is not situated, as in the Smelt, at the very inner margin, the bone having grown further inwards to form a more complete bottom for the orbit. The gill-rakers resemble those of the Smelt, but are as a rule somewhat more numerous, 35—39 on the front of the first branchial arch, and 25—30 of these on the lower part of the same. The pseudobranchiae lie just behind the orbits and above the dermal fold that bounds the palate behind. They consist of 15 or 16 short lamellae, set in an oblique transverse row. The gill-openings are large, extending from about half the upper edge of the operculum to a line with the anterior margin of the eyes, and the two branchiostegal membranes are entirely free from each other, crossing only to an extremely small extent in front, where the left membrane overlaps the right, but where each is covered by an outer fold of the skin, the right fold lying outside the left. The first (lower) four branchiostegal rays are slender and subulate, the last (upper) 4—6 gradually become flatter and broader (sword-shaped) behind (upwards).

The dorsal fin begins at a distance from the articular knobs of the maxillaries that measures about 50—55 % of the length of the body, farthest back as a rule in the females. Its base measures about $^1/_{10}$ (9—12 %) of the length of the body, and is generally somewhat less (but sometimes, especially in the males, somewhat greater) than its height as expressed by the length of the longest (3rd and 4th, i. e. first branched) rays. When erected, the fin is of an obliquely quadrangular shape, with somewhat convex upper margin, and with the hindmost ray measuring about $^2/_3$ of the longest ray. The shape and structure of the adipose fin have already been noticed. It is situated above the posterior three-fifths of the base of the anal fin, but the distance between it and the caudal fin (about 7—11 % of the length of the body) is in general perceptibly greater than that between the anal fin and the latter. The anal fin begins at a distance from the articular knobs of the maxillaries in the males equal to about $^2/_3$ (66—68½ %), in the females nearly $^3/_4$ (71—72½ %), of the length of the body. The sexual difference in the base of this fin we have already remarked. The length of its base is in the males about 17—19 %, in the females about 13—15 %, of the length of the body. Its lower margin is arcuate, and its height (the length of the longest, the 5th or 6th ray) is always less than half[a] (38—47 %, exceptionally 49 %) of its length (base). The caudal fin is as a rule somewhat less deeply forked than in the Smelt, the length of the middle rays being about 43—53 % of that of the longest ones and usually greater than the least depth of the tail, only exceptionally, and then in the males, equal to the latter. The length of the middle rays varies between about 5½ and 6½ % (exceptionally 7 %), and the length of the longest rays between about 12 and 14 %, of that of the body.

The pectoral fins are set low, as in the Smelt, and the great sexual difference lies not only, as we have mentioned above, in the length of the fins, but also in their breadth. In the males, when the fins are folded, one of them overlaps the other under the belly to a considerable extent. When expanded, the two fins together form in the males almost a semicircle. In the females they are of a broad oval shape. Their length varies in the males between about 15[b] and 16½ %, in the females between about 10 and 13½ %, of that of the body. As a rule even their relative length increases with age, the females thus representing the lower grades of development. The ventral fins resemble the pectoral both in shape and sexual difference, though the latter is less marked, and the ventral fins of the males together compose, more correctly speaking, a half-ellipse. Their length is also on an average equal to that of the pectoral. They are inserted almost vertically below the beginning of the true dorsal fin, comparatively further back in young Capelins than in old and in the females than in the males, the average preabdominal length being in young females 31½ %, in old females 32½ %, in the males 30½ %, of the length of the body, and the average postabdominal length in the females 18½ %, in young males 18½ %, in old males 17½ %, of the length of the body.

The scales are thin and small, as we have mentioned above, but in essential respects (fig. 220, *a*) resemble those of the Smelt, both as regards shape and

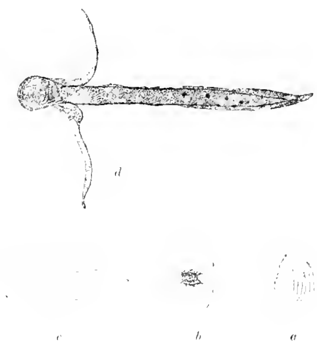


Fig. 220. Scales from the left side of a *Mallotus villosus*, 12½ times the natural size. *a*, one of the ordinary scales below the lateral line in a female; *b*, a scale from the lateral line of a female; *c*, one of the larger scales at the base of the anal fin in a male; *d*, one of the villiform scales in the lateral band of a male, with the epidermal covering preserved, and with lobes of the torn dermal follicle (corium) on each side.

texture, only that the concentric striæ are few and scattered (usually no more than 5 or 6 behind the indistinct nucleus of the scale, 3 in front of the same), and interrupted at the top and bottom of the scale. The scales of the lateral line (*b*) have the same open incision in the hind part, and the duct is simply canaliculate, nowhere closed by the elevated margins. The rule for the growth of the scales in the lateral line being that the duct is at first canaliculate, these scales accordingly occupy in the Capelin a lower developmental rank than in the Smelt. In the males, as we have mentioned above, scales of a special shape appear

[a] In the Smelts always greater, 68—84 % in *Osmerus eperlanus*.

[b] In exceptional cases we have found the pectoral fins of a male to measure only 14·7 % of the length of the body.

in four longitudinal bands[a], one on each side of the body above the lateral line, and one along each side of the belly, at the boundary between the ventral side and the side of the body, beginning below the posterior part of the pectoral fins, when these fins are at rest, interrupted at the ventral fins, but recommencing at about the middle of their length and extending along the base of the anal fin. On the elevated base of this fin, as well as on the lower margin of the peduncle of the tail, the remaining scales (*e*) are larger than on the rest of the body and more or less oblique, with one corner more or less elongated. In the above-mentioned longitudinal bands the scales are elongated to a villiform shape, but covered to the very tip with skin, in which lie scattered pigment-cells, most numerous and most constant at the tip of each scale, rare and most scattered on the proximal part thereof. Comparatively large scales form a lobe on each side of the vent, and this lobe is distinguishable even in the female.

The coloration in essential respects resembles that of the Smelt. In the Capelin too the upper parts of the head and body and the hind part of the tail are transparent. The back is green; the sides are silvery with black dots, but the operculum and suboperculum yellowish (with a golden or brassy lustre); the belly is white. Our figures, however, depict the spawning-dress, in which the back is darker, and the head sometimes entirely covered with a sooty black pigment. Below the above-mentioned villous bands of the males runs a more or less prominent, yellowish streak. The fins are transparent, of a light grayish colour; the caudal fin is darkest, especially at the base, the peduncle of the tail being also more or less blackish.

The internal organs too are similar to those of the Smelt. The liver is small, only the middle and the left lobes being present. It extends back to about a line with the middle of the pectoral fins. The caecum-like stomach extends almost back to the anterior extremity of the pelvic bones. The pylorus is furnished with 6 or 7 rather large appendages, four directed forwards and three backwards, two of the latter on the right side of the intestine. The pyloric coil and the intestine are as in the Smelt. The spleen is narrow and ribbon-shaped, lying to the right, at about the middle of the stomach, between the forepart of the intestine and the air-bladder, which is comparatively short and occupies a little more than the middle third of the dorsal margin of the abdominal cavity. The testes are double, but the right is considerably smaller than the left, and only the left ovary is present, its inward oviduct resembling that of the Smelt. The peritoneum is sooty black inside, but its outer coat is silvery white.

The Capelin is a boreo-arctic species from the northern regions both of the Atlantic and the Pacific. Off Spitzbergen none of the numerous Swedish expeditions has met with the Capelin; but at certain times it is extremely common on the coasts of Norwegian Finmark, Iceland, Newfoundland, Greenland, Alaska, the Aleutian Islands, and Kamchatka. From the White Sea the Royal Museum of Stockholm has received the species through Lieutenant H. Sandeberg. Its occurrence in shoals on the Norwegian coast does not really extend beyond Trondhjem Fjord; farther south it is more and more scattered, and the Capelins from Christiania Fjord sent to the Royal Museum in 1842 by Professor Esmark must rank as a rare find. On the other side of the Atlantic the Capelin goes farther south, one of the consequences of the Arctic current which follows the coast of North America. According to Jordan and Gilbert its range extends to Cape Cod; but Bean states that it does not occur much south of Halifax in Nova Scotia, and is never met with on the coast of the United States. Richardson found the species in Coronation Gulf, whence it appears that in this quarter the range of the Capelin extends between the Atlantic and the Pacific; but off the extreme north of Asia it has never yet been seen.

To all the above-mentioned points in which the Capelin resembles the Smelt, we should add its rank odour, which calls to mind that of stale cucumbers. In its manner of life too the Capelin is very like the Smelt. But it is of a more pelagic nature, and never enters quite fresh waters. Its haunts and its life between the spawning-seasons are little known; but according to Juel[b] it is frequently met with in summer

[a] According to Fabricius these bands are sometimes wanting, even during the spawning-season, and the Esquimaux of Greenland have a special name (*Sennersuitsut*) for such males. That the scales in these bands only gradually develop the villiform shape, being at first triangular, appears from the remark on Capelin No. 22 in my *Riksmuseets Salmonider*.

[b] Norsk Fiskeritidende, 1892, p. 4.

by whalers out at sea in the Arctic Ocean. FABRICIUS states that at this time it is less rash than during the spawning-season, and seeks to evade its pursuers by leaping out of the water. In some fjords it loiters long after the spawning is over. This has been observed in the upper part of Varanger Fjord[a], and also in St. Mary Bay (Newfoundland), where, during the winter-fishery under the ice, Capelin just devoured have been found in the stomach of Cod taken in January[b]. It attracts all the more attention during the spawning-season, when it gathers in immense shoals and repairs to shallow water. This takes place generally late in winter and early in summer, off Norwegian Finmark, according to SARS, in April, May, and June, on the coast of Greenland, according to FABRICIUS, in May, June, and July. But this rule is subject to many irregularities, which are of importance not only for the fishery, but also to shed light upon similar variations in the appearance of the Herring. For several years, seemingly at periodic intervals, the Capelin deserts its usual spawning-places; in other years it comes at an unusual season, seemingly, as in the case of the Herring, earlier at the beginning of a period. Thus Sheriff SOMMERFELT (1799) writes of the Capelin[c], "that else they have the experience here that it has abandoned the coasts of Finmark for many years, up to 16 or 20, in succession"; and to the quintennial reports of the sheriff (1830—1840), according to which the 'Capelin-fishery' (i. e. the Cod-fishery with a bait of Capelin) had not been practised on the coast of Finmark, JUEL appends the remark[d]: "As old fishermen state, however, the Capelin did appear off the coast in one of these periods of five years, but came early (in December) and departed in March, so that no fisherman seized the opportunity. Subsequently the Capelin came later and later in the year." Similar irregularities meet us in the Herring's approach to the coast. They very probably depend in an eminent degree, as SARS assumed, on variations in the "physio-meteorological conditions," perhaps too on variations in the supply of food and in the numbers of the Capelin's enemies. But as yet we can only record them among the lessons of experience; their explanation we must leave to future research. How important it would be to Norway to ascertain the causes of these irregularities, we may easily gather from the results of the so-called Capelin-fishery, which depend on the said irregularities, and which in 1875, according to SARS, were estimated at nearly twenty million Cod, but in some of the preceding and the following years at only five or six million.

During its wanderings the shoal is incessantly harassed by all kinds of enemies in search of food. In their efforts to escape the Capelins crowd so close together that the fish in the middle of the shoal are even lifted above the surface, where they wildly lash about on the backs of those beneath them. When the weather is calm, the Capelin shoal looks like a tumbling, glittering wave on the surface. Above it hover flocks of kittiwakes (*Larus tridactylus*), which time after time swoop down and seize a fish; and round the shoal blow whales (the common rorqual, *Balænoptera musculus*, and the lesser rorqual, *Balænoptera rostrata*[e]). But the Capelin's most eager pursuers are Cod and Coalfish[f]. Meanwhile the shoal makes for the coast, which it follows till it finds a suitable spawning-place. Often enough it comes so near land that the fish may be scooped up in a hand-net from the beach, or even leap ashore to escape their pursuers. As a rule they swim against the wind, a sea-wind keeping them from the coast, and a land-breeze alluring them thither. Enormous are the numbers in which the Capelin appears during these migrations, and many are the accounts thereof. Thus COLLETT states that the Capelins often spread in shoals many miles long, touching the coast almost simultaneously at the extreme end of Western Finmark and in Varanger Fjord. "The females go first in a separate shoal," writes FABRICIUS, "and seek out places suitable for their progeny; the males follow and seek out the eggs, to impregnate them with their milt[g].

[a] SARS, *Loddefisket ved Finmarken*, Indber. Depart. f. d. Indre, 1879, p. 11.

[b] HIND in BEAN, l. c.

[c] The quotation is taken from JUEL, l. c., p. 9.

[d] L. c., p. 11.

[e] These two according to SARS. According to COLLETT the Capelin is also eaten by the humpbacked whale (*Megaptera boops*).

[f] Besides these, according to COLLETT, *Anarrhichas minor* and *lupus*, *Hippoglossus vulgaris*, and several more.

[g] According to ATWOOD (Proc. Bost. Soc. XIV (1872), p. 134) the males lead the way, and the females follow them to the spawning-place, but in comparatively small numbers, one female to ten males.

When the females have left the place, the bottom is so entirely covered with their eggs that it gleams with a yellow colour; but when the males have shed their milt on the ova, the water is milky white, and the bottom no longer visible." PALLAS mentions "as a curious fact" that several fish, two, three, or even ten, cling so fast together with the aid of the villous lateral line that, if one of them be taken up, the others follow with it, as if they were glued to each other. He adds, "Even in the sea they are seen swimming together in this manner, and this union between the sexes is perhaps necessary for the fertilization of the spawn." As we have seen, the males alone are furnished with the villous bands; and PALLAS' observation can therefore refer only to the emission of the milt by the mutual pressure of the companion fishes, a supposition which bears out the statement that the males and females swim in separate shoals. LANMAN, however, gives an account[a] that points to a different conclusion. "The female," he writes, "on approaching the beach to deposit its spawn, is attended by two male fishes, who huddle the female between them, until the whole body is concealed under the projecting ridges, and her head only is visible. In this position all three run together, with great swiftness, upon the sands, when the males, by some inherent imperceptible power compress the body of the female, between their own, so as to expel the spawn from the orifice at the tail. Having thus accomplished its delivery, the three capelins separate, and paddling with their whole force through the shallow water of the beach, generally succeed in regaining once more the bosom of the deep; although many fail to do so, and are cast upon the shore, especially if the surf be at all heavy." If the observation be correct, the spawning may thus be performed in two essentially different manners.

On the coast of Finmark the spawning, says SARS, "commonly takes place at a depth of 4—20 fathoms, though it may possibly be performed on rocky bottoms and in deeper water as well, on which head, however, we have as yet no trustworthy observations[b]." "In Varanger Fjord," writes COLLETT, "there is a good and sure spawning-place off the mouth of the Jakob Elf. At the flood the Capelins ascend high up the river, as far as the water is brackish enough." After the breeding numbers of Capelins, especially old males, float in a dying state at the surface, or are cast ashore in great heaps. We have above seen a similar mortality, though not so great, attend the spawning of the Smelt.

In 1879 Capelin fry were first observed by SARS on the 17th of June off Vadsö, after a fresh east wind with a strong landward current. They were then, he says, evidently just hatched, none of the specimens collected measuring more than 8—10 mm.; but the hatching-place certainly lay further east, no Capelin roe having been observed during the said year, either off Vadsö or at the other two places in Varanger Fjord examined by SARS. At this stage the fry were transparent as water, with a very thin body, edged with a transparent vertical fin, and with a shapeless, broad head, furnished with large, silvery eyes. They were found in very great numbers, swimming about at the surface. They were extremely sensitive, and died very soon after leaving the water, however carefully they were handled. Afterwards Capelin fry were repeatedly observed by SARS, even far up Varanger Fjord; and at the beginning of July they proved to compose the principal food of the Coalfish. The Cod has also been found by COLLETT to have its stomach full of Capelin fry. When one year old, according to COLLETT, the Capelin is about 1 dm. long.

Capelins large and small have thus to serve as food for the fishes which give rise to the greatest fisheries of the world, both in Norway and Newfoundland. The Capelin allures them in its train to the fishing-grounds; but when it has spawned and again returns to sea, it entices them away. It is the best bait that can be used for Codfish in general. As human food it does not find favour with fastidious palates, on account of its unpleasant smell; but the Greenlanders dry it, and in this condition it is one of their most important foods. It is taken with hoop-nets and seines. In Finmark, according to JUEL, the Capelin seine has 38 meshes to the *aln* (2 ft.), i. e. a mesh $16^1/_2$ mm. in diameter.

The food of the Capelin consists mainly of small crustaceans. It finds a plentiful diet in the Arctic

[a] U. S. Comm. Fish. and Fisheries, Rep. II (1872 and 1873), p. 225.

[b] The above-mentioned observations of PALLAS, however, point to this conclusion; and in consideration of the great density of the Capelin shoals even out at sea, JUEL remarks (l. c., p. 4), "The greater number of the Capelins thus spawn probably in deep water."

seas, with their wealth of *Schizopoda*, *Hyperidæ*, and *Copepoda*, the multitudinous minute animals collectively known by the Norwegians as *Kril*. It often seems, however, as FABRICIUS remarked, to live on its own roe as soon as deposited; even in the females we have found the stomach crammed with eggs similar to those dropped from the oviduct and still left in the abdominal cavity[a].

In the Glacial clay the Capelin occurs[b] in the same way as *Gadus saida* (see above); but the matrices are usually still more characteristic, following in their outer contours the shape of the Capelin, and still commoner. They are found in scattered localities throughout Norway, from the extreme north to the neighbourhood of Christiania, sometimes 200 feet, if not more, above the level of the sea.

A fish of such economical importance has, of course, received many names from the fishermen, who in their undiscriminating interest imagine that they increase our knowledge of the species by distinguishing between a number of forms. From Finmark SPARRE-SCHNEIDER[c] enumerates the *Lodde*, *Vaslodde*, *Harlodde*, *Fjordlodde*, *Blanklodde*, etc. From olden times different names have been given to the sexes; and even in 1882 SPARRE-SCHNEIDER found it impossible to convince the fishermen that the male and the female belong to the same species. The male has been known as the *Jernlodde*[d] and *Fackselodde*[e], the female most commonly as the *Sildelodde*.

GENUS THYMALLUS.

Teeth in the mouth scattered and small, set in a single row on the intermaxillaries, the maxillaries, and in the lower jaw, in a small card on the head of the vomer, in two rows on the anterior part of the palatines, disappearing with age on the tongue, cardiform on the pharyngeals. Length of the maxillaries 38—48 %, and of the lower jaw 66—75 %[f], *of that of the head reduced. Length of the base of the dorsal fin more than 15 % of that of the body and greater than that of the head reduced. Pyloric appendages well-developed and numerous (about 20—30). Scales middle-sized, less than 100*[g] *(75—93) in the lateral line, which is complete.*

The Grayling genus, *Thymallus*, occupies, as we have already mentioned, in many respects a remarkable intermediate position between the Salmons and the Gwyniads. But in the transition to the Salmons there is another connecting-link, the genus *Brachymystax*[h], which in comparison with *Thymallus*, has stronger teeth, persistent on the tongue, smaller (more numerous) scales, and a shorter dorsal fin (with at most 14 rays). Apart from this genus, and also excluding *Oncorhynchus* from the comparison, the said intermediate position of the Graylings is best expressed by the following relations:

[a] Positively to determine the species of eggs contained in the stomachs of specimens that have lain for years in spirits, is a task we will not undertake; but the resemblance to the eggs of the Capelin itself is striking.

[b] M. SARS: *Foss. Dyrel. Qvartærper.* Univ. Progr. Chrnia 1864, p. 25. COLLETT, *Glac. Mergelb. fra Bejeren*, Tromsø Mus. Aarsb. III.

[c] *Zool. Iagttag. fr. Vardø.* Tromsø Mus. Aarsb. 1882, p. 23.

[d] Really *Jarlodde* or *Jadrlodde*, i. e. *Edged Capelin*, from *Jadar*, *Jar*, or *Jær* (e. g. in Jæderen), Engl. *edder*, Sw. *gjärde*.

[e] Old Norwegian *Fax*, mane, fringe.

[f] Exceptionally (in young specimens) 76 %.

[g] *Thymallus gruber*, var. *baicalensis*, according to DYBOWSKI (Verh. Zool. Bot. Ges. Wien, Bd. XXIV (1874), p. 391), has 92—108 scales in the lateral line.

[h] GTHR, *Cat. Brit. Mus., Fish.*, vol. VI, p. 162. To this genus should probably be referred both the Siberian *Salmo coregonoides*, PALL. and the Dalmatian *Thymallus microlepis*, STEIND. (= *Salmo obtusirostris*, var. *oxyrhynchus*, STEIND.). Both these species, however, instinctively suggest the possibility of hybridism — the former = *Thymallus* + *trutta*, the latter = *Thymallus* + *fluviatilis*. Cf. SMITT: *Riksm. Salmon.*, p. 199, not. 4.

Average		Salmon	Grayling	Gwyniad
Length of the maxillaries	in % of the length of the head	39	31	27
" " " "	" " " " " " " reduced	59	42	37
" " " lower jaw	" " " " " " " head	59	52	42
" " " " "	" " " " " " " reduced	90	60	56
Interorbital breadth of the forehead	" " " " " " "	17	14	11

The Graylings' closest approach to the Salmons appears in the following relations:

Average		Gwyniad	Salmon	Grayling
Number of rays in the anal fin		15	11	12
Base of the anal fin	in % of the length of the body	11	8	9
Distance between the adipose fin and the caudal fin	" " " " " " "	9	11	11
" " " " anal " " " " "	" " " " " " "	9	12	11

To the Gwyniads the Graylings come nearest in the following relations:

Average		Salmon	Gwyniad	Grayling
Postabdominal length	in % of the length of the body	20	25	26
Height of the dorsal fin	" " " " " " "	13	15	15
Length of the ventral fins	" " " " " " "	12	14	14
" " " middle caudal rays	" " " " " " "	7	5	5
" " " suboperculum	" " " " " " head	25	29	29
" " " head reduced	" " " " " " "	67	74	73

In the size and texture of the scales the Graylings also stand nearer to the Gwyniads, and partake, together with the latter genus, in the approximation of the Salmonoid type to the Cyprinoid.

The development of the dorsal fin in the Graylings, their most distinctive character, has the result that the average distance between this fin and the snout is only about 35 % of the length of the body. In this respect *Thymallus* stands alone in the Salmonoid family. The opposite extreme we find in *Mallotus*, where the said average is more than 50 % of the length of the body.

The name of *Thymallus* (*Θύμαλλος*) dates from ÆLIAN — about 120 A. D. — and has reference to the thymy smell which some have supposed the fish to emit. In LINNÆUS it was a specific name; CUVIER raised it to a generic rank[a].

Excluding the two nominal species *Thym. ontariensis* and *Thym. Mertensii*, which have been recognised by VALENCIENNES[b] alone, and which have already been repudiated by GÜNTHER[c], and also excluding the obscure *Thym. Grubei*, DYB. and *Thym. brevirostris*, KESSL. from Southern Siberia and Central Asia, there hardly remain more than two species of the genus *Thymallus* that can lay claim to recognition. Of these two the North Siberian *Thym. arcticus* (*Pallasii*)[d] is especially remarkable as representing in by far the most respects the characters of youth and of the females, while in others — even in the most distinctive character of the genus, the length of the base of the dorsal fin — it has attained a more advanced development than our common species.

[a] *Règne Animal*, ed. 2, tome 2, p. 306.
[b] CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, pp. 452 and 453.
[c] *Cat. Brit. Mus., Fish.*, vol. VI, p. 200.
[d] *Thymallus signifer*, RICHARDSON, from North America, is probably identical with this species, though for the present we must leave this question open. See SMITT, *Riksm. Salmon.*, p. 206.

THE GRAYLING (SW. HARREN).

THYMALLUS VULGARIS.

Plate XLII, fig. 1.

Number of gill-rakers on the whole of the first branchial arch more than 21[a], *on the lower part of the arch more than 13*[b]. *Length of the head more than 61 % of the preabdominal length. Length of the snout more than 24 % of that of the head or than 32 % of that of the head reduced, and the breadth of the snout more than 74 % of the length of the maxillaries. Least depth of the tail less than 42 % of the length of the head or than 57 % of the length of the head reduced.*

R. br. 10[c]; *D.* $\frac{4-7}{13-16}$ (= 17—22); *A.* $\frac{2-4}{8-11}$ (= 10—14); *P.* $\frac{1}{(11)13-15(16)}$; *V.* $\frac{(1)1}{(9)10-11}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* (65)74—93; *Lin. tr.* $\frac{8}{8}$1 (supra pinn. ventr.); *Vert.* 61[d].

Syn. Θύμαλλος, ÆLIAN., *De nat. anim.*, lib. XIV, cap. XXII; *Thymallus*, BELON, *Nat., Divers. Poiss.*, p. 276; + *Umbre de rivière*, ibid., p. 280; *Thymus*, RONDEL., *De pisc. fluv.*, p. 187 + *Umbra fluviatilis*, ibid., p. 172; GESN., *De Aquat.*, pp. 978 et 1032; WILLUGHB., *Hist. Pisc.*, pp. 187 et 188. *Coregonus* maxilla superiore longiore, pinna dorsi ossiculorum viginti trium, ART., *Ichthyol.*, *Gen. Pisc.*, p. 10; *Syn. Pisc.*, p. 20; *Descr. Spec. Pisc.*, p. 41; LIN., *Fna Suec.*, ed. I, p. 119. *Trutta*, No. 15, KLEIN, *Hist. Pisc. Nat.*, Miss. V, p. 21, tab. IV, fig. 5.

Salmo (Coregonus) Thymallus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 311; BL., *Fisch. Deutschl.*, part. I, p. 158, tab. XXIV; RETZ., *Fna Suec. Lin.*, p. 349; COUCH. (*Coregonus*), *Hist. Fish. Brit. Isl.*, vol. IV, p. 280.

Thymallus vulgaris, NILSS., *Prodr. Ichthyol. Scand.*, p. 13; YARR., *Brit. Fish.*, ed. 2, vol. II, p. 136; KR., *Danm. Fisk.*, vol. III, p. 35; LLOYD, *Scandinav. Advent.* p. 127; NILSS., *Skand. Fna, Fisk.*, p. 447; WIDGRN, Landtbr.-Akad. Handl. 1858, pp. 180 et 207; SIEB., *Susswasserf. Mitteleur.*, p. 267; MGRN, *Finl. Fiskfna*, (disp. Helsingf.), p. 64; NYSTR., *Iaktt. Fnan Jemtl. vattendr.* (disp. Ups. 1863), p. 15; WDGRN, Landtbr.-Akad. Tidskr. 1863, pp. 202 et 203; GTHR, *Cat. Brit. Mus., Fish.*, vol. VI, p. 200; CANESTR., *Fna Ital., Pesci*, p. 23; LUNEL, *Hist. Nat. Poiss. Bass. Lém.*, p. 120, tab. XIII; COLL., Vid.-Selsk. Forh., Chrnia 1874, Tillægsh., p. 171; ibid. 1879, No. 1, p. 91; OLSS., Vet.-Akad. Öfvers. 1876, No. 3, p. 135; 1882, No. 10, p. 50; FEDDERS., Nat. Tidskr., Kbhvn, ser. 3, vol. XII, p. 78; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 543; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 153; MELA, *Vert. Fenn.*, p. 345, tab. X; MÖB., HCKE, *Fisch. Osts.*, p. 129; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 131, tab. CXXIV; NORB., *Handl. Fisker., Fiskafv.*, p. 400, fig. 120; SMITT, *Riksm. Salmon.*, Vet.-Akad. Handl., Bd. 21, No. 8, p. 198; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 664; MELA, SUNDM., *Finl. Fisk.*, tab. XXV.

Thymallus vexillifer, AGASS., *Poiss. d'eau douce*, tab. XVI, XVII, XVII[b]; CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 438; HCKL., KN., *Susswasserf. Oesterr. Mon.*, p. 242; FATIO, *Fne Vert. Suisse*, vol. V, p. 286.

Thymallus gymnothorax, CUV., VAL., l. c., p. 445, tab. 625; GTHR, Jahresb. Ver. Vaterl. Naturk. Würtemb., Jahrg. IX (1853), p. 341; RAPP, ibid., Jahrg. X, p. 161.

Thymallus gymnogaster, CUV., VAL., l. c., p. 446, tab. 626 + *Thym. Æliani*, p. 447.

The Grayling attains in Sweden a length of 5 or 6 dm. and a weight, at least in ordinary cases, of at most 2 kilo.[e] The form of the body is fairly elongated and compressed. The greatest depth, which occurs at the beginning of the true dorsal fin, is about $^1/_5$ (18—21 %), but sometimes more than $^1/_4$ (26 %), of the length of the body, and the greatest thickness in old specimens is about 46 % of the said depth; but during youth, at a length of $^3/_4$ dm., when the dark transverse bands are still present, the body is more terete, the greatest thickness being about 56 % of the greatest depth. The least depth, just in front of the caudal fin, is about 6—7$^1/_2$ % (seldom 8 %) of the length of the body. The dorsal and ventral profiles are as a rule fairly similar to each other, the back rising from the shallow (seen from the side, pointed) snout to the beginning of the dorsal fin in a curve equal to that in which the ventral profile descends for the same distance, and behind this point the depth of the body decreases with fair uniformity. But when the ventral muscles are powerfully contracted, it often happens that the anterior

[a] In young specimens 21 or 20.

[b] In young specimens 12.

[c] 9—11, according to LILLJEBORG.

[d] 60, according to KROYER.

[e] From the Governments of Westernorrland, Jemtland, and Westerbotten it was indeed reported to the Fisheries Commission of 1881—83 that the Grayling there attains a weight of 8—10 Sw. lbs. ($3^1/_3$—$4^1/_4$ kilo.); but the greatest length adduced at the same time, 1·7 Sw ft. (5 dm.), seems hardly to admit of such a weight, except perhaps in the case of gravid females.

curve of the back becomes more elevated, while the ventral profile is rendered more or less straight. In front the dorsal margin is broadly convex or, on the head, even flat; but towards the beginning of the dorsal fin it gradually becomes more or less compressed; behind the dorsal fin it is again flattened. The ventral margin in front of the anal fin is broadly convex, at the ventral fins even flat; behind the anal fin it is flat, like the dorsal margin of the peduncle of the tail. The sides of the body are slightly convex.

The length of the head from the articular knobs of the maxillaries is about equal to the greatest depth of the body, but varies conversely to the latter, from about 21 to 20 % of the length of the body in young Grayling, and from 20 to $18^1/_2$ % thereof in old. The head is wedge-shaped, with compressed or only slightly terete cheeks. The most characteristic feature in its appearance consists in the shallow (sometimes even sharp) and broad tip of the snout, which in a horizontal direction is truncate or slightly curved, but is occasionally somewhat prolongated like a beak, if only to a short distance, and which, when the mouth is closed, always projects beyond the point of the lower jaw. The eyes show the peculiarity that the pupil, as in the Gwyniads, is anteriorly somewhat pointed, at an angle. Their size varies with age, the longitudinal diameter being in young specimens about 29 %, in old about 16 %, of the length of the head. The nostrils are set somewhat nearer to the eyes than to the tip of the snout, the anterior on each side being raised in a tubular form, the posterior, which lies just behind, resembling a transverse slit, covered by a dermal fold from in front. The lips are quite fleshy, especially on the intermaxillaries; and the form of the broad, but short gape is essentially determined by the said bones. These bones are reduced each to a thin, triangular disk, transversely set and consisting principally of the articular process, only the lower, toothed margin, which is also the true corpus of the bone, being somewhat thickened. The maxillaries are terete in the anterior, inward part (the articular process); but behind this point they are disk-shaped, curved like a sword, but of fairly uniform breadth. The teeth extend along about the middle third of their inferior margin. The oblong jugal bone is about $^2/_3$ as long and $^1/_2$ as broad as the maxillary. The length of the maxillaries is less than in any preceding Salmonoid genus, varying between 35 and 27 % of that of the head, or between 48 and 38 % of that of the head reduced. Together with the jugal bone the maxillary bone varies in breadth between about $^1/_4$ (in the young) and $^2/_5$ (in old specimens) of its length. The lower jaw is deep at the middle, but at the broad anterior margin shallow, almost sharp. Its length is about 54—48 % of that of the head or 76—66 % of that of the head reduced. The distribution of the teeth in the mouth and pharynx we have already touched upon. The teeth are all alike, of a blunt conical or cylindrical shape, in contradistinction to the pointed and more or less curved teeth of the preceding genera. The characteristic features of the gill-rakers we have also noticed. In the upper jaw we find a well-developed transverse fold (palatal curtain), partially concealing the vomerine teeth, behind the intermaxillary teeth. The lower jaw is not without a similar fold, but this is very low. The pseudobranchiæ are rather large, the length of their longest lamella (at the middle) being about equal to the vertical diameter of the pupil. The gill-openings are large, extending from the middle of the upper opercular margin down to the isthmus in about a line with the anterior margin of the eye, where they cross each other for a little distance, the left fitting into the double fold of the right, as we have observed in *Mallotus*. All the branchiostegal rays are flat, the anterior (lower) curved in an ensiform shape. Behind they gradually increase both in length and breadth. The operculum is obliquely quadrangular, with the upper posterior corner rounded, the posterior margin more or less concave, and the inferior margin obliquely ascending in a backward direction along the suboperculum, the length of which measures at this margin about 26—31 % of that of the head, and the breadth (height) of which is about half that of the operculum. The lower posterior corner of the suboperculum is sharply rounded. The hind margin of the preoperculum is broad, and its lower posterior corner almost rectangular.

The dorsal fin begins at a distance from the tip of the snout (the articular knobs of the maxillaries) that measures on an average 36—34 % (exceptionally 38 or 33 %) of the length of the body. The average length of its base, which increases even relatively with age and is greater as a rule in the males than in the females, varies between about 18 and $28^1/_2$ % (in old males exceptionally 25 %) of that of the body. Its shape shows great variations. Sometimes (especially in young specimens and the females) it is of fairly uniform height or highest in the anterior part (the 6th—8th ray), the height being about 11—14 % of the length of the body. Sometimes again (at least in old males) the posterior part of the fin (the 16th—21st ray) rises to a height of as much as $^1/_4$ of the length of the body. The adipose fin is of the same shape as in the Salmons, forming a curved lobe of fairly uniform breadth. It lies nearly vertically above the end of the anal fin, the distance between it and the first upper supporting ray of the caudal fin being about $^1/_8$—$^1/_9$ of the length of the body. The anal fin also resembles that of the Salmons. It begins at a distance from the tip of the snout (the articular knobs of the maxillaries) which measures on an average about 71 % of the length of the body. The length of its base is 8—9 % (exceptionally 7 or 11 %), and its greatest height (the length of the first or second branched ray) during youth about 8—10 %, in old females about 10—11 %, and in old males sometimes $13^1/_2$ %, of the length of the body. Its hind inferior margin is convex. The caudal fin is deeply forked, with pointed lobes. Its middle rays, the relative length of which decreases with age from about 7 to 4 % of the length of the body, always measure less than half, sometimes only one-third, of the length of its longest rays.

The pectoral fins are set low, with almost horizontal base. They are obliquely pointed, and their length is about 14—17 % of that of the body. The ventral fins are as a rule somewhat shorter, but sometimes even longer, than the pectoral. They are also broader and more obtuse. The distance between them and the tip of the snout (the articular knobs of the maxillaries) is about 46—48 % of the length of the body. The preabdominal length is on an average 28 %, the postabdominal length 26 %, of the length of the body.

The scales are most like those of the Cyprinoids, both in texture and shape. They are not only larger (fewer), but also thicker than those of the Salmons, and are furnished with radiating grooves. These are especially deep in the anterior (inserted) part of the scale, to which part they give an undulating appearance, and the truncate margin of which they render sinuate, forming 3—5 indentations. They are very short at the posterior, rounded margin of the scale, where they leave only slight notches. The lateral line follows a fairly median course, in front somewhat nearer to the back than to the belly. The middle part of its scales project at the inserted margin in a rounded form. The ordinary scales cover the whole body, but leave most of the fins, the head, and a greater or less portion of the breast naked[a]. The base of the caudal fin is, however, clothed with smaller and thinner scales, and this covering follows the caudal rays, especially the longest ones, the scales here growing gradually smaller outwards and being of a linguiform shape, calling to mind in their structure the scales we have seen above in *Mallotus*.

Its varied and shifting colours render the Grayling a handsome fish. Dark and light phases of colour follow with different environments, and the Grayling, like so many other fishes, has a particular festal dress. The ground-colour of the back is brown or grayish, shading into blue, green, or a purplish lustre in different lights. The sides are lighter, those of the head with a metallic lustre, those of the body with a silvery lustre or a tinge of yellow. The belly is of a more or less pronounced silvery white. Along the sides of the body, between the back and belly, run a number (up to 16) of dark, parallel stripes, marking the limits between the regularly arranged rows of scales; and besides there lie sharply defined, dark spots, reminding us of the coloration of the Salmons, irregularly scattered on the sides of the head and varying in occurrence, but sometimes distributed in longitudinal rows, especially on the forepart of the sides. The fins of the ventral side are yellowish or ashy gray at the base (sometimes throughout), towards the top (especially the posterior ones) violet. The caudal fin, as well as the adipose fin, is bluish gray, violet, or even of the same dark hue as the back. Most prominent is the coloration of the large dorsal fin, which is of an iridescent violet or lake, with three or four rows of dark, quadrangular spots, generally ocellated in lake, on the fin-membrane between the light rays. In the spawning-dress all these colours are heightened, and the body gleams with a golden lustre.

The peritoneum is white. The short œsophagus passes into a very thick-walled stomach[b], which extends

[a] At the median line the belly is usually covered with scales (even if these are only small) forward to a line with the insertion of the pectoral fins; but on each side and in front throughout the whole ventral side the skin is naked. The variations in the extent of this scaleless part led VALENCIENNES to establish the species *gymnothorax* and *gymnogaster*.

[b] In a male 55 cm. long the wall of the stomach is 6 mm. thick.

to about a line with the anterior extremity of the pelvic bones, where it bends abruptly forward, so that the end of the pylorus lies in about a line with the termination of the first third of the pectoral fins when at rest. The anterior bend of the intestine with its numerous pyloric appendages runs upwards and slightly to the right, but turns with equal abruptness just behind the diaphragm, whence the intestine proceeds without further curvature to the vent. Almost exactly in a line with the insertions of the ventral fins, the intestine passes into the rectum, which is lined, as in the Salmons, with large, annular, transverse folds. The liver is comparatively small, and lies only in the left side of the body. It extends back hardly to a line with the tips of the pectoral fins when folded. The spleen lies obliquely to the right of the stomachic bend and behind this point, directed towards the left. Its size varies, as in the Salmons, according to the greater or less development of the generative organs[a]. The air-bladder is thin-walled, but large, extending along the whole dorsal margin of the abdominal cavity.

The Grayling is strictly a mountain fish, and prefers clear, rapid streams and their dead water, with a bottom of sand or gravel. The best place to look for it is, therefore, in waters where falls alternate with deep pools or broads. But it also roves into lakes, and is found even in the sea, where the water is brackish and of a temperature suited to its requirements. As a general rule we may say that, where the common Trout can thrive, the Grayling is also at home; but they are seldom met with in company. The geographical range of the Grayling also embraces the greater part of Europe. Whether it occurs in Asia, and how far its range extends there, is as yet uncertain, for the Graylings brought home from the Yenisei by NORDENSKIÖLD's expedition in 1876, proved to belong to the closely related species which PALLAS once named *Salmo arcticus*, and which is probably identical with the North American Grayling.

In Europe the Grayling is most plentiful in Lapland, the alpine tracts of Central Europe, and England. According to LÆSTADIUS' manuscript (1831) it is fairly common in all the rivers and lakes of Tornea Lappmark, up to the extreme north of Sweden (Kilpisjärvi, 69° N.). According to FJELLNER (MS in the Royal Museum) it is plentiful in Juckasjärvi. It seems to occur more sparingly in the lower parts of the Lapland rivers. In Jemtland, according to OLSSON, it goes up to the Norwegian frontier. In Lake Fla and in Ströms Vattudal it is an important food-fish. The Harr Lakes (*harr* = Grayling) on the Fulafjäll in Northern Dalecarlia derive their name from its abundance in their waters; and throughout the Dal Elf it is fairly common. It also occurs in the Klar Elf, most plentifully in its upper (northern) parts and in the lakes on its course. According to HOGBERG's notes in 1835 (MS in the Royal Museum), a certain form is here known as *Sandharr*, which appears to be a small Grayling about 22 cm. long. According to NORBACK a distinction is drawn between the *Flodharr* (River Grayling), which is short and thick, with convex back and of dark coloration, and which prefers comparatively still water, and the *Strömharr* (Stream Grayling), which is longer and more slender, of more slender frame and lighter coloration, and which frequents falls and the water beside them. WIDEGREN assigns the Grayling to Lake Wener. From Lake Wetter the Royal Museum received this fish through HALL in 1832, and AROSENIUS forwarded specimens in 1834 from the Motala River off Norrköping[b]. Further south the Grayling is rarer in Sweden; but it occurs in Smaland and in Halland[c], at least in the Laga River, where it is known, according to TRYBOM, as the *Haspa*.

In Norway its range is no less extensive, but apparently still more sporadic. South of the Dovre Fjeld it is found, according to COLLETT, only in the waters of the Öster Valley and the Gudbrand Valley, but there is rather plentiful. Along the west coast it is wanting, but finds its way through the Lesjeverks-water on the Rauma Elf almost to the mouth of this river in Rumsdal Fjord. From this point north to Finmark the Grayling is known only from some waters in the parish of Lierne (North Trondhjem), in the Vefsen Elf (Nordland), and in the valley of the Maal Elf. It is common, however, in many, though not in all, of the rivers in Finmark. According to MELA it is common throughout the greater part of Finland, but wanting in the southern districts, where it occurs but sparingly in Nyland alone. Towards the head of the Gulf of Bothnia it is common, both inside and outside the island-belt; but

[a] KRÖYER found it small and round. In a male 55 cm. long, with testes hardly ripe, it is oblong, rather blunt behind, pointed in front, and 58 mm. long.

[b] SMITT, *Riksm. Salmonid.*, tab. metr. VIII.

[c] Underd. Bet. Ny Fiskeristadga, 1883, p. 155. See also LILLJEBORG, l. c., p. 674.

in the central and southern parts of this gulf it is rarer, occurring down to Aland and the islands off Abo. In Denmark, where the Grayling is called *Stalling*, it occurs in a number of rivers from the south to the middle of Jutland. According to FEDDERSEN, however, its numbers are there rapidly decreasing, an observation which has also been made in other countries, for example in North Germany.

In European Russia, according to GRIMM[a], the Grayling is met with in the small rivers, and the upper parts of the large rivers, that flow into the Arctic Ocean, the White Sea, the Baltic, the Black Sea, and the Caspian. In Central Europe, where the Grayling has the centre of its geographical extension in the Alps, it occurs, according to E. SCHULTZE[b], in the basins of the Danube, Rhine, Weser, Elbe, Oder, Vistula, and Pregel. Westward its true range extends over Switzerland to the mountainous tracts of Eastern and South-eastern France. AUSONIUS (about 400 A. D.) knew the Grayling from the Moselle[c]; and according to SELYS-LONGCHAMPS[d] it is common, at least in some of the small streams, in the mountainous interior of Belgium. On one or two occasions it is said to have been found in Holland[e]. Southward the Grayling goes to Lombardy, Venetia, Piedmont, and Istria (CANESTRINI, l. c.). In England the Grayling probably has its original home to the west[f] and north and in Wales; but at the present time, according to DAY, it is commonest in the more southern rivers, the Avon, Itchen, and Test. It has been introduced in recent times into several Scotch waters. In Ireland it is wanting.

Even old writers, at least from GESNER's time, were fairly well acquainted with the habits of the Grayling, and had learnt to compare them to those of the Trout. At most times it lies stationary and alone, in the shelter of some jutting stone or in the shade of an overhanging tree; but it darts off like an arrow, when frightened, and is as speedy to seize any victim that comes its way, often leaping out of the water to capture an insect. But sometimes it shows sociable tendencies, and in Juckasjärvi, according to FJELLNER, it assembles in shoals during June and July. Small cascades it easily surmounts by leaping, but it is deficient in the Salmons' power of passing high falls. Large Grayling keep to the deepest part of the water, the smaller ones stay nearer shore.

The spawning-season usually occurs soon after the breaking up of the ice, and may thus vary in Sweden between April and June. In the lakes of Lapland, however, it sometimes happens, according to TRYBOM[g], that the breeding Graylings repair to the mouths of brooks, where there is open water some time before the ice breaks up. In southern countries the spawning begins earlier: in Italy, according to CANESTRINI, from January to April. v. SIEBOLD describes in the breeding fish a firm, but smooth, dermal eruption on the scales, whose limits, however, remain distinct. This eruption is wanting in the sterile individuals, which are further distinguished by a paler coloration. The Grayling too discards its ordinary caution during the spawning-season. According to HECKEL and KNER the fish swim in pairs to the spawning-place, where they scoop a hollow for the eggs with their caudal fin, the eggs being covered after impregnation with gravel or pebbles; and where the spawning has taken place in March, the ova are hatched in June[h]. According to FJELLNER live roe is found between the stones in the rapids of the Torne Elf in July, and in August the fry swim about in the river. The diameter of ripe eggs, lying loose in the abdominal cavity, ready to be deposited, we have found to be $2^{3}/_{4}$—$2^{1}/_{2}$ mm. But BENECKE assigns to them a size of about 4 mm., presumably when they have swelled after impregnation. According to NORBACK the living female contains 5,000—6,000 ova to every pound of her own weight. The fry grow rapidly; in England, according to DAY, they are 4 or 5 inches long at the end of July or the beginning of August. But the Grayling, it is stated, does not attain maturity until three or four years old.

In spite of its feeble dentition the Grayling is distinctly a fish-of-prey; and it is no dainty feeder. Worms and the larvae of insects, mollusks, crustaceans,

[a] *Fishing and Hunting on Russian Waters*, p. 12.
[b] *Geogr. Verbr. Susswasserfisch. Mitteleur.*, Stuttgart 1890, p. 4 (sep.).
[c] *Mosella*, l. 90.
[d] *Faune Belge*, p. 22.
[e] In the little river Geul, according to v. D. ENDE, *Versl. Werkz. Vereenig. Bevord. Inl. Ichthyol.*, Deel. I, p. 39.
[f] "The very best stream in the world for Grayling is the Teme" (a tributary of the Severn), according to BULLOCK, see BUCKLAND, *Nat. Hist. Brit. Fish.*, p. 331.
[g] Nordisk Aarsskrift for Fiskeri, Iste Aarg. (1883), p. 303.
[h] According to DAY the fry are excluded in 12—25 days.

and small fishes, in short nearly all the animal life offered it by the water where it lives, enter into its diet: and in its greedy haste it swallows leaves and fir-cones that fall into the water, mistaking them for insects. It seems to be especially partial to caddis-worms (the larvæ of Stone-flies), the coverings of which are generally to be found in its stomach. But mollusks are also one of its favourite foods; in a male 55 cm. long the stomach was full of entire shells, an inch long, of pond-snails (*Limnæa*). Fishes of the Minnow's size fall a prey to the full-grown Grayling. Grayling large and small are besides roe-eaters. When the Salmons spawn, they keep watch, and feed on the ova; but in requital they are harassed by the Salmons, in whose maw many a Grayling has perished. This probably explains how, where food is plentiful, Grayling and Trout can thrive in company, but where food is scarce, the former must give way.

As the habits of the Grayling in essential respects resemble those of the Trout, the same fishing methods are used for them both. The Grayling, like the Trout, readily takes a fly, and in many places gives the fly-fisher good sport; but owing to its weak jaws a certain amount of care is necessary not to tear the hook out and lose the fish. Less fastidious anglers use a bait of worms and small fishes, for example Minnows. But the Grayling is taken most commonly and in the greatest quantity with net and seine.

The flesh of the Grayling has always been held in esteem. It is white, of good flavour, and easy of digestion, suitable for even weak stomachs. It is therefore set higher even than that of the Salmon. "*Ein Aesch ist ein Rheingraf, ein Salm ist ein Herr,*" is an old saying to be found in GESNER. The Grayling is best in autumn and winter, worst, of course, just after the spawning. Not only its flesh has enjoyed a good reputation; in ancient medicine its fat (*oleum Aeschiae*) was widely employed. When the fish is in good condition, the whole intestinal canal is embedded in rich fat, and the oil extracted from this has been used especially in eye and ear diseases and to cure cutaneous diseases and burns. LINNÆUS states that the Lapps employ the gastric juice of the Grayling in the preparation of cheese, to curdle the reindeer milk, simply laying the whole intestinal canal in the milk.

Besides *Haspa*, a name which may perhaps be explained by the use of *Asp* among the Swedish fishermen both for large Cyprinoids and large Gwyniad-fishes, NILSSON and LILLJEBORG mention from Lake Wetter *Val*, and from Norrköping *Öreval*, as names applied to the common Grayling.

Before proceeding to the Gwyniads, we may briefly mention a genus whose geographical range approaches near to the limits of our fauna, though it has not yet been found in Scandinavia.

GENUS STENODUS.

Teeth small and disappearing during growth, but at first set in two or three rows on the intermaxillaries and in the anterior part of the prominent lower jaw, in a card on the tongue, and in a dense, continuous, two-armed card on the anterior part of the palate (the head of the vomer and the front of the palatine bones). Length of the maxillaries about 50—43 %, and of the lower jaw about 78—70 %, of that of the head reduced. Breadth of the snout across the articular knobs of the maxillaries about equal to that of the interorbital space, which is about $^1/_4$ (less than 23 %) of the length of the head. Base of the dorsal fin as a rule somewhat shorter than that of the anal and less than 13 % of the length of the body, but more than $^1/_2$ of the length of the head reduced. Pyloric appendages well-developed. Scales middle-sized, about 90—110 in the lateral line, which is complete.

This genus occupies an especially remarkable intermediate position between the Smelt and Vendace groups. In external appearance it so closely resembles the latter that the confusion between them which has made its way into literature is easily explainable. But *Stenodus*, which becomes as large as the largest Salmons, does not correspond in its characters to the Scandinavian Vendaces until it has attained a size far greater than that reached by them. In the structure of the ventral fins *Stenodus* is approximated to *Argentina*, the outermost ray, which in the rest of the family appears merely as a more or less rudimentary supporting ray, being here so developed that two simple rays may with ease be counted in these fins.

The genus is strictly Arctic, belonging both to Asia and America; but just as the Huch, a species inhabiting the Danube, has its nearest relation, not to say identical species, in the Siberian *Salmo fluviatilis*, so in the basins of the Volga and Ural there lives a *Stenodus* hardly to be distinguished in species from the Siberian form, which in its turn seems to be identical with the American. However this question of species be determined, we are here interested only in

THE NELMA OR SIBERIAN WHITE SALMON.

STENODUS NELMA.

Fig. 221.

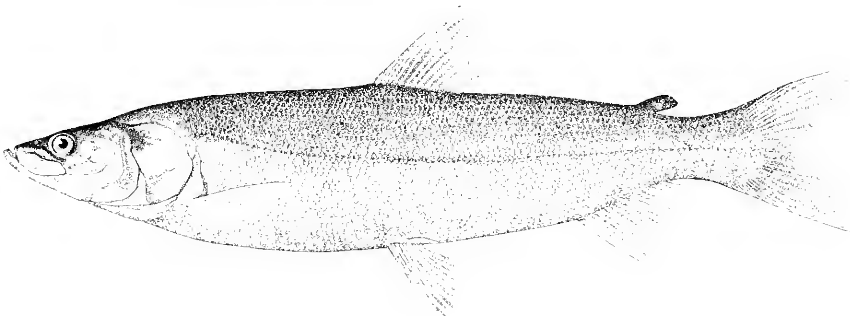


Fig. 221. *Stenodus nelma*, ♀, from the lower part of the Dwina. Taken by Lieutenant H. SANDEBERG on the 29th Sept., 1877. $^1/_4$ of the natural size.

R. br. (9)10; *D.* $\frac{3-5}{10-12}$[14—16]; *A.* $\frac{3(4)}{(12)13-15}$[(15)16—18(19)]; *P.* $\frac{1}{14-16(17)}$; *V.* $\frac{2}{(9)10-11}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 88—109.

Syn. (?) *Salmo leucichthys*, GYLDENSTADT, Nov. Comm. Acad. Sc. Petrop., tom. XVI (1771—72), p. 533; cett. vide SMITT, *Riksm. Salmonid.*, p. 207; adde GRIMM, *Fish., Hunt. Russ. Wat.*, pp. 12 et 20.

Salmo Nelma, PALL., *Russ. Reis.*, pt. II, p. 716; cett. vide SMITT, l. c.; adde GRIMM, l. c., LILLJ. (*Stenodus*), *Sv., Norg. Fisk.*, vol. II, p. 698.

(?) *Salmo Mackenzii*, RICH., *Narr. Voy.*, FRANKL. 1819—22, App., p. 707; cett. vide SMITT, l. c.

Coregonus clupeoides, LILLJ., Vet. Akad. Handl. 1850, p. 304; cett. vide SMITT, l. c.

The Nelma is a fish highly esteemed and much employed in Russia. As we have already mentioned, it probably belongs to the same species in South-eastern Russia as in the Arctic parts of that empire. The southern form — which is perhaps distinguished by a somewhat smaller head, less than $^1/_5$ of the length of the body — was named by GYLDENSTADT *Leucichthys*, a translation of the Russian *Bjelaja Rybiza* or *Beloritza*, the white fish, referring to its coloration. In the Arctic Ocean it lives like the Salmons, and at the end of winter, according to PALLAS, ascends the rivers in multitudes. PALLAS supposed it to be wanting in the Yenisei; but NORDENSKIÖLD's Expedition of 1876 brought home fine specimens from that river. But most of the Royal Museum specimens are from the Dwina, where they were taken at Archangel by Lieutenant H. SANDEBERG; and to judge by these specimens it appears as if the spawning took place in spring or summer, for in those caught at the end of September[a] the generative organs were extremely little developed. That it is as marked a predatory fish as the Grayling, was shown by one of these specimens, the stomach of which contained five but partially digested Roach.

As NILSSON has remarked, it is by no means impossible that the Nelma may sometimes rove from the Arctic Ocean to the fjords or rivers of Norwegian Finmark; but it has never yet been found there. According to GRIMM the annual take of *nelma* and *leucichthys* in European Russia amounts to about 100,000 *pud* (1,638,050 kilo.) and has a value of more than 1,200,000 roubles (£190,000).

[a] See SMITT, *Riksm. Salmon.*, tab. mett. VIII.

GENUS COREGONUS.

All the teeth of the mouth, except those on the tongue, as a rule soon disappearing during growth, or soon concealed in the gums, or persistent as scattered, fine, villiform, mobile teeth, or entirely wanting. Length of the maxillaries 50 (exceptionally 52)–32 %, and of the lower jaw 70 (exceptionally 74)–49 %, of that of the head reduced. Breadth of the snout across the articular knobs of the maxillaries perceptibly less than that of the interorbital space, which is at least ¼ (exceptionally 24 %) of the length of the head. Base of the dorsal fin less than 15 % of the length of the body, but more than half the length of the head reduced. Pyloric appendages well-developed. Scales middle-sized, about 86–90 (exceptionally about 76–110) in the lateral line, which is complete.

The dental reduction which we have seen in the preceding genera — in the strength of the teeth in *Mallotus*, and both in their strength and number in *Thymallus* — has advanced still further in the Gwyniad genus (*Coregonus*) towards the Cyprinoid type. The direction of the reduction is indeed not the same as in *Thymallus*, the teeth on the tongue being persistent, and sometimes even more developed than in *Mallotus*. But else the reduction is a continuation of that which we have seen in *Thymallus*, and in their form, the jaw-teeth, where they are present, come nearest to those of the Graylings. The maxillaries and the vomer are always toothless in *Coregonus*; but on the inner (hind) surface of the intermaxillaries and on the anterior part of the palatines the Gwyniads proper are usually furnished with teeth, on the former bones set in a thin transverse row and mobile as in *Mugil*, on the latter firm and pointed, but small. Among the true Gwyniads we find only dermal papillæ instead of teeth in the lower jaw; but among the Vendaces small teeth sometimes occur in the anterior part of the lower jaw, as well as on the intermaxillaries[1]. In the pharynx, however, we find teeth, numerous though small, not only on the so-called pharyngeals, but also on the upper parts of the posterior branchial arches[2].

The reduction of the teeth is partly compensated, as usual, by the apparatus composed of the gill-rakers (fig. 222), which are subject in *Coregonus* to great variations, probably connected with variations in the diet of these fishes. The rule is apparently that, where the diet consists of large objects, principally fish, the

Fig. 222. *A*. gill-rakers (45) and branchial lamellæ on the first left branchial arch in a Vendace (*Coregonus albula*).
B. „ (60) on the first left branchial arch in a Pelet (*Coregonus cyprinoides*).
C. „ (45) on the first left branchial arch in an Asp-Gwyniad (*Coregonus asprus*).
D. „ (27) on the first left branchial arch in a
E. „ (25) Gwyniad (*Coregonus lavaretus*).
F. „ (20) on the first left branchial arch in a Palen (*Coregonus polcur*).

Figs. *B*—*F* after WIDEGREN.

[1] SMITT, l. c., tab. nostr. VIII, *Coregon.*, note to specimen No. 5.

[2] See above, p. 523, note *a*.

rakers are scattered and short, but that, where the diet is composed of small objects, principally *Entomostraca*, they are finer, denser, and longer, thus forming a more perfect filtering-apparatus. Now as the diet is commonly altered with the age of the Gwyniads, we may as a rule expect to find a corresponding change in the gill-rakers[a]. But Gwyniad forms occur, for example the Siberian *pelet* (among the Vendaces) and *muksun* (among the true Gwyniads) or the so-called *asp* of Lapland, which attain a considerable size, but have persistently dense and numerous gill-rakers. Some forms, again, show an increase with age in the number of the gill-rakers[b]. The variations do not therefore follow in absolute succession the changes of growth. They rather shows a certain independence in their appearance, an independence which in some forms has rendered them available as characters, at least in their extremes, especially as they are accompanied in most cases by an external character, a difference in the shape of the snout.

By the last-mentioned character two groups have long been distinguished within the genus *Coregonus*, one of them having its best-known representative in our Vendace, the other in our Gwyniad. To the former group AGASSIZ[c] gave the name of *Argyrosomus*, characterized essentially by the projection of the point of the lower jaw beyond the tip of the snout, whereas the form-series of the true Gwyniads advances to a greater development and protrusion of the tip of the snout, culminating in the form hence known as the *näbbsik* (*Beaked Gwyniad*, *Coregonus oxyrhynchus*). The limit between the two groups it is indeed impossible sharply to define, on account of the transition forms; but in its two extremes the altered shape of the snout is due to a very considerable difference in the form and position of the intermaxillaries. We have already remarked in the case of *Thymallus* a considerable reduction of the intermaxillaries, to small, flat and thin, triangular disks, set transversely in front of the tip of the snout and the incurved articular processes of the maxillaries, slightly thickened at the lower margin alone, where lie the alveoli of the single row of teeth, which are directed inwards (backwards), more or less vertically to the plane of the disk. In the Vendaces this structure recurs, only that the teeth are as a rule wanting, the disk is still thinner and rests more entirely on the front of the inward, terete tip of the maxillary bone. This part of the maxillary bone sometimes, as in the Scandinavian Vendace, bears outside the protuberance which articulates with the ethmoidal cartilage, a separate process, directed downwards (forwards), with which the inner (hind) surface of the intermaxillary bone articulates, and by means of which the said bone is raised when the mouth is opened. The breadth (height) of the intermaxillary bone does not exceed $^{2}/_{5}$ of the breadth of the snout across the articular knobs of the maxillaries, and its sharp inferior margin then forms the osseous framework in the sharp, transverse margin of the tip of the snout. In the true Gwyniads the intermaxillary bone on each side of the snout is higher, the depth of the snout being always more than $^{2}/_{5}$ of its breadth across the articular knobs of the maxillaries, and more robust, with teeth or rudiments thereof in the above-mentioned position. It is also more firmly articulated with the under surface of the tip (articular process) of the maxillary bone. This articulation is formed in the following manner: the upper margin of the intermaxillary bone is hollowed into a groove which surrounds the said lower margin of the maxillary not only in front, but also more or less far back (outwards) on that part of the latter bone which forms the upper lateral margin of the mouth. The intermaxillary bone thus assumes a more or less vertical position when the mouth is closed; and when the tip of the snout is prolongated — which often appears as a change of growth — the under margin of this bone is turned more and more in a backward direction.

The scales of *Coregonus* are thin and cycloid, as a rule thinner than those of the Grayling, with not very distinct radiating grooves, though both the anterior and posterior margins of the scales are generally corrugated and notched thereby. The scales of the lateral line, here as in the Grayling, commonly have the anterior margin elongated to a triangle at the middle.

The internal organs resemble those of the Salmons; but the pyloric appendages are shorter and still more numerous (KRÖYER counted about 200). The peritoneum is silvery white.

The genus has the same geographical extension as the Graylings. It is most numerous, and appears in its most developed forms, in the Siberian rivers, which

[a] See for example the four Gwyniads, 206—350 mm. long, which are included in SMITT, *Riksm. Salmon.*, tab. metr. X, Nos. 170—173.

[b] See for example SMITT, l. c., p. 278, the averages for *Coregonus Nilssoni* and *Cor. Wartmanni*.

[c] *Lake Superior*, p. 339.

most of the forms ascend from the Arctic Ocean, and in the great lakes of North America. But even in Scandinavia it ranks among the fishes most important from an economical point of view. The number of the species it is as yet impossible to determine, for the variability of the forms is as great here as among the Salmons, and has given rise to the establishment of numerous, merely nominal species.

The name of *Coregonus* was coined by ARTEDI[1] and has reference to the anterior angle of the pupil.

THE VENDACE (SW. SIKLÖJAN, BABBONEN).

COREGONUS ALBULA.

Plate XLII, fig. 2.

Lower jaw projecting beyond the shallow (sharp) tip of the snout, at which the breadth (height) of the intermaxillaries is less than 2/5 of the breadth of the snout across the articular knobs of the maxillaries. Length of the base of the anal fin less than 14 % of the length of the body. Least depth of the tail less than 8 % of the length of the body or 45 % of the length of the head, but more than 47 % of the length of the base of the anal fin. Vertical diameter of the eyes more than 71 % of the breadth of the interorbital space, which is less than 30 % of the length of the head and usually less than the length of the upper jaw, which is more than 1/3 of the length of the head or 2/5 of that of the head reduced.

a: True *Siklöja* (var. *albula*): *distance between the dorsal fin and the tip of the snout usually more than 42 % of the length of the body, and the postabdominal length less than 62 % of that distance. Gill-rakers on the first branchial arch more than 40. Least depth of the tail at most 71 % of the length of the base of the anal fin. Length of the head, even in full-grown specimens, as a rule more than 19 %, and of the head reduced more than 15 %, of that of the body.*

b: *Sikrimma* (var. *rimba*): as above, but: *length of the head as a rule less than 19 %, and of the head reduced less than 15 %, of that of the body.*

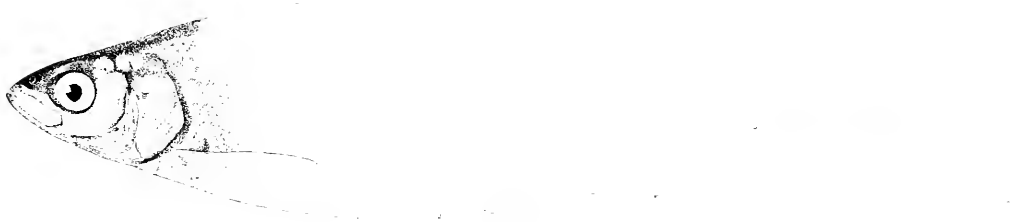


Fig. 223. *Coregonus albula*, 10/11 of the natural size, ♂, from Stora Nyckelviken (Lilla Värtan) in the neighbourhood of Stockholm. Caught on the 12th Aug., 1879.

[1] *Philos. Ichthyol.*, p. 72. κόρη, *pupil*, and γωνία, *angle*.

R. br. 7—8; *D.* $\frac{3(4)}{8-9(10)}$ (11—13); *A.* $\frac{3(4)}{10-12(13)}$ (13—16(17)); *P.* $\frac{1}{(12)13-15(17)}$; *V.* $\frac{(1)1}{9-11}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* (70)75—90(94); *L. tr.* $\frac{8(9)}{7(8)}$ 1; *Vert.* 58[a].

Syn. Marena, SCHONEV., *Ichth. Slesv. Hols.*, p. 46 (vide KR., *Danm. Fisk.*, vol. III, p. 93). *Vandesius*, SIBB., *Scot. Ill.*, pt. 2, lib. III, p. 26. *Coregonus* edentulus, maxilla inferiore longiore, ART., *Ichthyol.*, *Gen.*, p. 9, *Syn.*, p. 18 (excl. synon.), *Spec.*, p. 40; LIN., *Fn. Suec.*, ed. I, p. 119. *Ånims-rimma*, LIN., *It. Wgoth.*, p. 231. *Coreg.* spec. II, GISLER, Vet.-Akad. Handl. 1753, p. 196.

Salmo Albula, LIN., *Syst. Nat.*, ed. X, tom. I, p. 310; RETZ., *Fn. Suec. Lin.*, p. 349; BL., SCHN., *Syst. Ichthyol.*, p. 411; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 413; NILSS. (*Coregonus*), *Prodr. Ichthyol. Scand.*, p. 17; EKSTR., Vet.-Akad. Handl. 1834, p. 16; CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 520, tab. 633; LLOYD, *Scand. Advent.*, vol. I, p. 135; NILSS., *Skand. Fn., Fisk.*, p. 465; SUNDEV., Stockh. L. Hush.-Sällsk. Handl., H. 6 (1855), p. 81; WGRN, Landtbr.-Akad. Handl., vol. 18 (1858), pp. 180 et 206; ID., Öfvers. Vet.-Akad. Forh. 1862, p. 591, tab. IX, fig. 1; ID., Landtbr.-Akad. Tidskr. 1863, pp. 201, 203, 211; SIEB., *Susswasserf. Mitteleur.*, p. 265; MGRN, *Finl. Fiskfn.*, p. 54; GTHR, *Cat. Brit. Mus., Fish.*, vol. VI, p. 192; COLL., Vid. Selsk. Forh. Chrnia 1874, Tillægsh., p. 170, ibid., 1879, No. 1, p. 91; OLSS., Öfvers. Vet.-Akad. Förh. 1876, No. 3, p. 138; MALM (*Argyrosomus*), *Gbgs. Boh. Fn.*, p. 547; FEDDERS. (*Coregonus*), Naturh. Tidskr. Kbhvn. ser. 3, vol. XII, p. 80; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 152; MELA, *Vert. Fenn.*, p. 352, tab. X; MÖB., HCKE, *Fisch. Osts.*, p. 133; TRYB., Nord. Aarsskr. Fisk., 1 Aarg. (1883), p. 295; NORB., *Handl. Fisker., Fiskafe.*, p. 407; REUT., SUNDM., *Finl. Fisk.*, tab. VI; SMITT, Vet.-Akad. Handl., Bd. 21 (1886), No. 8, p. 212, cett.; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 706.

Salmo Vimba, LIN., *Syst.* l. c., p. 311; RETZ., l. c., p. 350; ASCAN., *Icon. Rer. Nat.*, cah. IV, tab. XXIX; NILSS. (*Coregonus*), *Prodr.*, l. c.; CUV., VAL., l. c., p. 514, tab. 632; NILSS., *Skand. Fn., Fisk.*, p. 462; GTHR, l. c., p. 193; SMITT, l. c.

Salmo Maraenula, BL., *Fische Deutschl.*, pt. I, p. 176, tab. XXVIII, fig. 3; JARD., Edinb. Journ. Nat., Geog. Sc., vol. III, p. 4, tab. 1; JEN., *Man. Brit. Vert. Anim.*, p. 432.

Coregonus clupeoides, NILSS., *Prodr.*, p. 18; *Skand. Fn., Fisk.*, p. 467.

Coregonus vandesius, RICH., *Fn. Bor. Amer.*, pt. III, p. 213; GTHR, *Cat.*, l. c., p. 194.

Coregonus Willughbii, JARD., *Illustr. Scot. Salm.*, tab. 6; YARR., *Brit. Fish.*, ed. 2, vol. II, p. 146.

Coregonus brevis, MAKLIN, Öfvers. Finsk. Vet.-Soc. Förh., vol. XI (1868—69), p. 19.

The Scandinavian Vendace is usually a small fish, in most cases of the Bleak's or the Baltic Herring's size, seldom as large as the oceanic Herring, and attaining a maximum length of about 3 dm. But in other places, as in some of the North German lakes, it grows to a length of at least 3½ dm. In form and in coloration it reminds us both of the Bleak and the Herring. The body is fusiform but compressed, in the true Vendace — and among our forms most in the Wetter form — elongated as in a Bleak, with the greatest depth, at the beginning of the dorsal fin, about 19 % of the length, but in the *sikrimma*[b] as a rule deeper, with the greatest depth sometimes 24 % of the length. In the former the greatest thickness of the body is about ⅔, in the latter about ⅗, of the greatest depth; but gravid females of the former approach the proportions of the latter. The dorsal and ventral margins are broadly convex or even flat, the former being the broader, but for some distance immediately in front of the dorsal fin somewhat sharpened to a faintly marked carina. The upper and lower contours are similarly arched, except in gravid females, where the ventral profile, as usual, is more sharply curved in the abdominal region. The average least depth of the tail in the true Vendace is about 6½ % of the length of the body, 31 % of that of the head, 42 % of that of the head reduced, or 60 % of that of the lower jaw. In the *sikrimma* these averages are respectively 7⅓ %, 37 %, 49 %, and 75 %.

The head is pointed, somewhat more compressed than the abdominal region, especially below, across the lower jaw, the cheeks thus converging distinctly in a downward direction. The frontal profile at first forms an unbroken continuation of the dorsal arch, but becomes straighter, owing to a slight depression above the eyes. The inferior profile of the head is somewhat more sharply curved. The length of the head is about ⅕ of that of the body, but varies partly with age, the oldest specimens having, as usual, comparatively the smallest head, partly in inverse proportion to the depth of the body, the *sikrimma*, which has the deepest body, having the smallest head. The variations run between 23 and 18 % of the length of the body. The same rule applies to the variations in the length of the head reduced, which run between 17½ and 13 % of the length of the body. The decrease in the averages during growth, a decrease which is generally uniform, is also expressed in the difference of form given above between *albula* and *vimba*; and though this difference is not quite constant, it may still be employed as a character in the great majority of cases, if attention be paid to the age of the fish. The eyes are furnished, as in most of the Thrissomorphs, with a well-developed, adipose membrane, surrounding the

[a] 56—58, according to GÜNTHER.

[b] *Sikrimma* = Gwyniad-Zarthe, *Siklöja* = Gwyniad-Bleak.

whole iris, but broadest at the anterior corner of the eye. The pupil is fairly circular, with only a faint angle in front. In adult Vendace the eyes occupy with fair exactness the second quarter of the length of the head, though the anterior corner of the eye encroaches upon the first quarter thereof, the average longitudinal diameter of the eye being thus about 25 %[a] of the length of the head, but the length of the snout only about 21½ % of the same. The vertical diameter is somewhat less, in *albula* on an average about 23 %[b], in *rimba* 22½ %, of the length of the head. The breadth of the interorbital space, which rises only a little above the upper margin of the eyes, is in *albula* about equal to the longitudinal diameter of the eyes[c], in *rimba* somewhat greater[d]. The average breadth of the snout across the articular knobs of the maxillaries is 19 % of the length of the head. The two nostrils on each side of the snout are situated as in the preceding species, somewhat nearer to the orbit than to the tip of the snout. The hind margin of the anterior nostril is raised in the form of an obliquely cut tube; the posterior nostril, which is larger, may be closed from in front by means of a semicircular dermal flap. The maxillaries — as they appear externally — are of uniform breadth, curved like a sabre, and bluntly rounded at the hind extremity. Their average length from the top of the articular processes is in *albula* about 35 %, in *rimba* about 34 %, of that of the head, or in the former about 48 %, in the latter about 45 %, of that of the head reduced. Their breadth is on an average ⅓ of their length. Their supplementary (jugal) bone is similar in shape to their lateral part and nearly ¼ of its length, being elongated to a point in front. The average length of the lower jaw is in *albula* about 51 %, in *rimba* about 49 %, of that of the head, or in the former about 70 %, in the latter about 66 %, of that of the head reduced. The dentition of the mouth and the gill-rakers (41—48, exceptionally 39 or even 38) we have already noticed. The transverse palatal folds (vela) are well-developed, especially in the lower jaw. The gill-openings extend along about the last third of the upper opercular margin and down to about a line with the anterior margin of the eye, to which point the branchiostegal membranes are free both from each other and the isthmus, though they cross at the extreme front, in the same manner as in the preceding genera. The branchiostegal rays are thin and flat, more or less curved in a sabre-like form. The operculum is obliquely quadrangular, with the lower anterior corner most pointed and most elongated. Back from the articular process runs a ridge, faintly marked in the bone itself, but more distinctly indicated by a darker colour. Within the right angle of the preoperculum lies a pore, marked by a darker colour, and belonging to the inner osseous ridge of the preoperculum, which ridge it pierces, but covered by the adipose membrane that here, as usual, covers the ramifications of the lateral line. This pore is always distinct in Scandinavian Vendace and generally in young Gwyniads (as in young Nelmas); but in adult specimens of the larger *Coregoni* (as in the Nelma) it becomes more and more indistinct, usually invisible.

The dorsal fin is of the shape commonest among the Salmonoids, trapezoidal, the first branched ray being the longest in the fin. The distance between it and the tip of the snout[e] is on an average about 43½ % of the length of the body, usually somewhat greater than in the closely allied Siberian form *Coregonus Merkii*. The base of the fin measures on an average in *albula* about 9 %, in *rimba* about 10 %, of the length of the body, and its height (the length of the longest ray) in the former about 14 %, in the latter about 15 % of the same. The anal fin differs but little from the dorsal, but is longer and lower, most so in *rimba*, its base measuring on an average about 11 or 12 %, its height about 8½—9½ %, of the length of the body. Its distance from the tip of the snout is on an average 69½ % of the length of the body. It terminates, like the adipose fin, at a distance from the caudal fin that is on an average $\frac{1}{10}$ of the length of the body. The caudal fin is deeply forked, most so in *rimba*, the average length of the middle rays being about 5½—5 %, of the longest rays about 17—19 %, of the length of the body.

The pectoral fins are obliquely pointed, and their length is on an average 16—15 % of that of the body.

[a] The changes of growth run between about 32 and 23 %.

[b] The changes of growth run between about 27 and 20 %.

[c] On an average 25·7 % of the length of the head.

[d] On an average 27·7 % of the length of the head.

[e] We may remind the reader that here, as in the following Gwyniads, the snout is measured from the articular knob of the maxillary bone.

The ventral fins are broader and truncate, and their average length is about $11^1/_2$—13 % of that of the body. The distance between the latter fins and the tip of the snout is on an average about 47 %, the preabdominal length about 28 %, and the postabdominal length about 24 %, of the length of the body.

The scales of the body we have already noticed. Only the head and the fins are naked. The lateral line runs from the temples along the posttemporal bone on each side, descending at the top of the gill-opening, but its backward course on the sides of the body is almost perfectly straight, with only a slight downward curve at the extreme front.

The coloration is green, shading into steel-blue, on the back, silvery white on the sides, of a more or less pure milk-white on the belly. The back, as well as the occiput and snout, is slightly transparent, but far less than in the Smelt. The tip of the snout and the point of the lower jaw are usually coloured with a black pigment, which extends in a thinner coat to the maxillaries and to the margin of the follicle of each scale on the body. The gill-covers commonly gleam with a brassy lustre, especially at the top. The adipose fin is of the same colour as the back. The dorsal and caudal fins are of a more or less dark gray, the other fins light and transparent. The iris is silvery white, the eyeball coal-black at the top.

The Vendace is really a Baltic fish, with the centre of its range in the Baltic Sea and the lakes of the countries — principally the eastern ones — bordering on the Baltic. But, if modern opinions as to the specific determination be correct, it also occurs in Scotland, to which country, says tradition, it has been introduced from abroad. The Irish lakes (Loughs Neagh, Erne, Derg, and Corrib) contain a form, *Coregonus pollan*, so closely resembling the Vendace that the specific distinction between them can hardly be maintained. The Pollan as a rule has fewer gill-rakers (34—38 on the front of the first branchial arch) and fewer anal rays (12—13). At an earlier age than the other Vendaces the Pollan approaches in the depth of the snout the proportions which we have already remarked as most characteristic of the true Gwyniads[a]. The most distinctive character of the Pollan, however, is the short base of the anal fin, which measures at most about $^1/_{11}$ of the length of the body, and is so short that the least depth of the tail is at least $^3/_4$ thereof. In this respect, as in many others, the Pollan composes one extreme in the form-series of the Vendaces (the *albula* group), the opposite extreme consisting of the Siberian *Seldetkan* or *Coregonus Merkii*. Strangely enough, this difference in form within the Vendace group answers to the difference we have above observed between the Salmons of the Atlantic and Pacific basins. The *Oncorhynchus* group of the Pacific differs from the *Salmo* group of the Atlantic mainly in the greater length of its anal fin; and the nearer the range of the *albula* group approaches to the Pacific, the longer is the base of its anal fin. We find the following average relations between the length of the base of the anal fin and that of the head reduced:

Average	Pollan	Albula.	Vimba	Seldetkan.
Length of the base of the anal fin expressed in % of that of the head reduced	62.5	73.9	82.5	90.3

These averages can hardly be the expression of a mere accident, for they are attended with similar results in several other relations; and there is thus a distinct connexion here between the difference in form and the geographical separation. Even in Scandinavia the true *albula* and the *vimba* show some geographical separation, the former being commonest to the extreme north and in Lake Wetter, the latter in the Mälar valley and the basin of Lake Wener; but our most typical specimens of *vimba* are from Finland. These two forms are besides different, as we have seen above, in most of the average proportions; but the changes of growth and the sexual distinctions reduce the differences to such an extent that constant characters can hardly be adduced.

The Vendace occurs in all the provinces of Sweden, except Gothland, Blekinge, Halland, and Bohuslän[b]. From Norway it was described and figured even by Ascanius, but it is found only in Lake Mjösen and some of the small lakes to the extreme south-east. In Finland it is as common as in Sweden, up to about the 69th degree of latitude. In the Arctic Ocean it is wanting; but from Western Russia and the Baltic Provinces its range extends over North Germany to Hol-

[a] Smitt, *Riksmusets Salmonider*, p. 233.

[b] Cf. *Underd. Bet. Forsl. Ny Fiskeristadga* 1883, p. 159.

stein. When KRØYER wrote his *Danmarks Fiske*, he knew nothing of its presence in Denmark, but in 1868 he received it from Foussingo Sø near Randers, and in the following year FEDDERSEN received it from Jul Sø, another of the Jutland lakes. At about the same date it is said to have been met with in Ulse Sø and Sothorup Sø (Zealand). In South Germany, France, Belgium, and Holland it is unknown.

The Vendace is no true marine fish, but it occurs in fairly great number in the island-belts of the Gulfs of Bothnia and Finland, at least to the islands of Södermanland, where it cannot be reckoned, however, according to EKSTRÖM, among the common fishes.

The Vendace is thus found in very different places, both in brackish water and in fresh. It lives in lakes large and small, deep and comparatively shallow. At certain times it repairs to running water. It is a gregarious fish, and is consequently taken at times in great quantities, while it also supplies food to several large fishes-of-prey. Out of the water it is not tenacious of life, but, if treated with care and furnished with cool water, it may be kept alive long enough in aquaria[a]. To wind and weather it is very sensitive. Excessive heat or cold drives it to deep water; and in stormy weather it takes refuge under the lee of the land. In spring it roves about in more scattered companies. In summer it shoals in the lakes during July and August, making its way in large armies towards the surface and into shallow water, to seek its food, which consists principally of *Entomostraca*, insects, and small mollusks. During autumn and still later in the year it spawns, its active movements at the surface rendering it easy of observation. In the Norrström at Stockholm numbers of small Vendace are taken in spring with hoop-nets below the bridge of Norrbro; but in autumn the larger Vendace are caught in traps just above the bridge. The end of September and the beginning of October is the best season for the last-mentioned fishery. Two traps (*ryssjor*) have been set, one in 2 feet of water, the other in 3, with the tail end fastened to a stake, so that the current keeps the trap straight, with the mouth down the stream. The fisherman who has employed these traps for many years declares that the Vendace always follow the same course, going hardly a foot or two to the right or left. The Vendace swim up the stream only when the water runs from Lake Mälar to the sea, especially when there is rather a strong current; yet it sometimes happens, though usually only one or two days a year, that a single day's take in these traps may amount to 190 kilo. of Vendace, averaging about 5 or 6 to the kilogramme, which fetches at first hand 50—70 *öre* (6 $\frac{3}{4}$ — 9 $\frac{1}{2}$ d.). The Vendace are then on the way to their spawning-place. "In the inner island-belt," writes SUNDEVALL, "off Vaxholm for example, the Vendace is taken both in summer and autumn, but does not seem to go far out. On one occasion 90 *lispund* (765 kilo.) had been secured at a single haul of the seine off Forsvik (Ingarö) in the month of November; otherwise it is only seldom that a few specimens are caught there." From Södermanland EKSTRÖM states that, in the month of December or about the time when the lakes freeze, the Vendace resorts to shallower water, where it spawns on a stony or sandy bottom, the spawning seeming, however, to be of long duration, for Vendace not quite spent are caught with ice-seines in the middle of January. In the Government of Norrbotten, according to WIDEGREN, the spawning-season of the Vendace begins at the middle of October. "It then makes its way 6—12 miles up the mountain streams, and deposits its roe on a stony or sandy bottom. Off the town of Luleå the Vendace enters the bays and creeks at the middle of October, and spawns on a muddy bottom in 2—6 fathoms of water. Off Muonioniska Village the spawning takes place at the end of November." In Lake Wener WIDEGREN found that the Vendace spawns from the end of October in 10 fathoms of water, resorting chiefly to the shallows among the islands round Lurö and Kallandsö. In Lake Wetter, on the same authority, it breeds about the 24th of October near the bottom and at a depth of 60 fathoms. "The greatest number spawn," he says, "in deep water along the east coast from Grenna to the island of Jungfru. The shoals first met with at the spawning-places consist exclusively of males. This would seem to be the case with the true Gwyniads as well, for those first taken are always males. After the spawning, which ends at the middle of December, no more Vendace are taken in deep water, though they probably pass the whole winter in the depths. Early in spring they seem to have migrated to the extreme south of the lake, and are never found in very deep water, but remain throughout the sum-

[a] We have kept large Vendace alive for a fortnight in a glass jar filled with the ordinary water supplied by the Stockholm Waterworks.

mer, from May to October, in about 30 fathoms of water off the west coast. The fry, 4—6 inches long, also stay during the greater part of the year in deep water, but in late summer often ascend the inlets on the north-east coast, between Hals and Hofvanäs Point." Where several lakes communicate with each other, the Vendace commonly roves from the lower to the upper in order to spawn.

The ova are fine and rather numerous, somewhat, though not firmly, adhesive. The ripe eggs which have already dropped into the abdominal cavity are about $1\frac{1}{2}$ mm. in diameter. In females 19—20 cm. long their average number was estimated by COLLETT at 3,600 to each female[a]. When only 7 cm. long[b], probably in its second year, the Vendace has reached maturity.

The Vendace is caught only in nets and the like—as we have mentioned above, in traps and hoop-nets. It takes a hook extremely seldom, and then the bait must be a tempting fly. Its flesh is good. "In places where Vendace are taken in any considerable quantity," writes EKSTRÖM from Mörkö, "the flesh is salted and in this state supplies the poorer classes with a great part of their winter food. Here, where only few are taken, the fish is generally eaten fried, and in this form its fine and rich flesh is a real dainty." In Swedish restaurants and even in the homes of the upper classes the Vendace is better known for its roe, which is made in Norrland into a kind of caviare, under the name of Bleak roe (*lojrom*).

The Vendace has many Swedish names. The *rimma* cannot be regarded as a separate species, and the Vendace is often confounded with young Herring and goes by the same names. In Wermland it is also called *sil* and *stinta*, in Westerbotten *sillack*. Its other names in Northern Sweden are *Smaling* (*Smärling*) and *Rabboxen*, a word which reminds us of *Ræputschka*, the current name for the species in Western Russia, the Livonian *Repsen*, the Esthonian *Rebus*.

THE GWYNIAD (SW. SIKEN).

COREGONUS LAVARETUS[c].

Plate XLII, figs. 3 and 4.

Tip of the snout more or less deep, truncate or conical, the depth (the breadth of the intermaxillaries in a vertical direction) being more than $^2/_5$ of the breadth across the articular knobs of the maxillaries. Point of the lower jaw not projecting beyond the tip of the snout. Length of the maxillaries more than twice their breadth.

R. br. (7)8—9(10); *D.* $\frac{3-4}{(9)10-12}$[(12)13—16(17)]; *A.* $\frac{(2)3-4}{10-13(14)}$[13—16(17)]; *P.* $\frac{1}{(12-13)14-16(17)}$; *V.* $\frac{(1)1}{(9)10-11(12)}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* (72)75—100(106); *L. tr.* $\frac{9-11}{8-9(10)}$1; *Vert.* 62[d].

Syn. *Lavaret*, BELON, *Nat.*, *Div. Poiss.*, p. 278. *Lavaretus* + *Bezola* + *Farra* (l. *Ferra* l. *Pala*), RONDEL., *Univ. Aquat. Hist.*, part. II, pp. 162—164 + *Oxyrynchus* (p. p.), p. 195. *Albula nobilis* + *parva*, GESN., *Hist. Anim.*, lib. IV, pp. 33 et 34. *Albula nobilis*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 12. *Guiniad*, WILLUGHB., *Hist. Pisc.*, p. 183. *Coregonus* maxilla superiore longiore plana, pinna dorsi ossiculorum quatuordecim, ART., *Ichthyol.*, *Gen. Pisc.*, p. 10; *Syn. Pisc.*, p. 19; *Descr. Spec. Pisc.*, p. 37; LIN., *Fn. Suec.*, ed. I, p. 118; GISLER, Vet.-Akad. Handl. 1753, p. 195. *Coregonus* maxilla superiore longiore conica, ART., *Gen.*, p. 10; *Syn.*, p. 21.

Salmo Lavaretus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 310; ASCAN., *Icon. Rer. Natur.*, cah. III, p. 6, tab. XXX; BL., *Fisch. Deutschl.*, part. I, p. 163, tab. XXV (+ *Salmo Thymallus latus*, p. 170, tab. XXVI + *Salmo Maraena*, p. 172, tab. XXVII + *Salmo Wartmanni*, part. III, p. 161, tab. CV); RETZ., *Fn. Suec. Lin.*, p. 348; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 395 (+ *Muksun*, p. 398 + *Polcur*, p. 400); NILSS. (*Coregonus*), *Prodr. Ichthyol. Scand.*, p. 15; YARR., *Brit. Fish.*, ed. 2, vol. II, p. 142; KR., *Danm. Fisk.*, vol. III, p. 55; CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 466 (+ *Cor. Palea*, p. 477 + *Cor. Reisingeri*, p. 496 + *Cor. Nilsoni*, p. 497 + *Cor. sikus*, p. 500); NILSS., *Skand. Fn.*, *Fisk.*, p. 458; WIGRN, Öfvers. Vet.-Akad. Förh. 1862, p. 583 (+ *Cor. megalops*, p. 589); MGRN, *Finl. Fiskfn.*, p. 49 (+ *Cor. Widegreni*, p. 52); GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VI, p. 178 (+ *Cor. lapponicus*, p. 181 + *Cor. gracilis*, p. 182 + *Cor. richardsonii*, p. 185 + *Cor. maxillaris*, p. 189 + *Cor. humilis*, p. 190); COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh.,

[a] BENECKE reckoned 10,000 to each female and estimated their diameter at about 2 mm., assumably in large specimens.

[b] Cf. SMITT, *Riksmusets Salmonider*, tab. metr. VIII, *Coreg.* No. 46.

[c] The name is Old French from the neighbourhood of Geneva, and is derived by RONDELET from *lavare*, to wash: "quod nunquam sordidus sit, sed bene ablutus sit, ob munditiem et candorem nomen habere videtur."

[d] 58—62, according to GÜNTHER; 60—62, according to KRØYER; 57—64, according to FATIO.

p. 166; ibid. 1879, No. 1, p. 89. Id., N. Mag. Naturv., Bd. 29, p. 108. Malm, *Gbgs. Boh. Fn.*, p. 516. Feddersen, Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 79. Smitt, Intern. Fisch. Ausst. Berlin 1880, Schwed. Kat., p. 17. Benecke, *Fisch., Fischer. u. Fischz. O. W. Preuss.*, p. 150. Mela, *Vert. Fenn.*, p. 347, tab. X (+ *Cor. Nordmanni*, p. 350). Smitt, Öfvers. Vet. Akad. Förh. 1882, No. 8, p. 37. Gt. Intern. Fish. Exhib. London 1883, Swed. Cat., p. 188. Nordqv., *Handl. Finl. Fiskerier*, p. 404; Mob. u. Heinck., *Fische d. Ostsee*, p. 151. Smitt, Vet.-Akad. Handl., Bd. 21, No. 8 (1885), p. 248. Benecke in M. v. d. Borne, *Handb. Fischz. u. Fischer.*, p. 144. Collett, *Norg. Fisk.*, vol. II, p. 733.

Salmo Oxyrinchus, Linn., *Syst.*, l. c., p. 311; Pall., l. c., p. 403 (? + *Salmo microstomus*, p. 405). Nilss. (*Coregonus*), *Prodr.*, p. 14; Ekstr., Vet.-Akad. Handl. 1834, p. 12. Kr., l. c., p. 76. Cuv., Val. (*oxyrhynchus*), l. c., p. 488 (+ *Cor. conorhynchus*, p. 485); Nilss., *Fn.*, l. c., p. 453. Sundev., Stockh. L. Hush.-Sällsk. Handl. 1855, pp. 81 et 90; Lloyd, *Scand. Advent.*, vol. I, p. 129. Widegr., l. c., p. 577. Sieb., *Süsswasserf. Mitteleur.*, p. 259 (+ *Cor. Maraena*, e Bl., p. 263); Günth., l. c., p. 173 (+ *Cor. Lloydii*, p. 174); v. Bemm. in Herklots, *Bouwst. Fn. Nederl.*, part. III, p. 386. Coll., l. c., 1874, p. 165; Malm, l. c., p. 514. Winther, Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 44; Feddersen, ibid., p. 80; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 126, tab. CXXI, fig. 2. Nordq., l. c., p. 406. Mob., Heinck., l. c., p. 150; Benecke (M. v. d. Borne), l. c., p. 143.

Coregonus clupeoides, Lacep., *Hist. Nat. Poiss.*, vol. V, p. 697. Günth., l. c., p. 188; Day, l. c., p. 127, tab. CXXII = *Cor. La Cepedei*, Parn., Ann. Nat. Hist., vol. I (1838), p. 162 cum fig. (+ *Cor. microcephalus*, p. 163 cum fig.); Yarr., l. c., p. 151.

Coregonus Fera, Jur., Mém. Soc. Phys., D'Hist. Nat., Genève, tom. III, part. 1, p. 190, tab. 7 (+ *Cor. hiemalis*, p. 200, tab. 8); Rapp, Jahresh. Ver. Vater. Naturk. Württemb., Jahrg. X, p. 151, tab. VI (+ *Cor. Wartmanni*, e Bl., p. 148, tab. V + *Cor. acronius*, p. 158); Sieb., l. c., p. 251 (+ *Cor. Wartmanni*, e Bl., p. 243 + *Cor. hiemalis*, e Jur., p. 254); Lunel, *Hist. Nat. Poiss. Bass. Lém.*, p. 106, tab. XI (+ *Cor. hiemalis*, e Jur., p. 114, tab. XII).

Coregonus generosus, Peters, Monatsber. Akad. Wiss. Berlin 1874, p. 790.

Coregonus macrophthalmus, Nüsslin, Zool. Anz., Jahrg. V (1882), p. 164 = *Cor. exiguus*, Klunz., Jahresh. Ver. vat. Naturk. Württemb., Jahrg. 40 (1884), pp. 110 et 117.

Coregonus Sulzeri, Nüssl., l. c., p. 253.

Coregonus dispersus (= *Cor. Wartmanni*, e Bl., + *Cor. annectus* + *Cor. exiguus*, e Klunz.) + *Cor. ballens* (= *Cor. Asperi* + *Cor. Schinzii* + *Cor. acronius*, e Rapp + *Cor. hiemalis*, e Jur.) + *Cor. Suidteri*, Fatio, *Fn. Vert. Suisse*, vol. V, p. 67, cett.

Adn. De synonymis americanis, quum specimina piscium pauciora solum vidi, haereo quid dicam. Vix tamen *Coregonum album* (Le Sueur, Richardson, vide *Fn. Bor. Amer.*, part III, p. 195, tab. 89, fig. 2 = *Cor. clupeiformem*, Mitch., vide Jordan et Gilbert, Bull. U. S. Nat. Mus., No. 16, p. 299) a *Lavareto* pycnocentro nostro diversum credam; neque *Coregonus quadrilateralis* (Rich., l. c., p. 204, tab. 89, fig. 1) a *Prosopio*[d] [illegible] differre [illegible].

The Gwyniad with its numerous variations has proved no less troublesome to the systematist than the Salmon. A great proportion of the names enumerated above have been applied, we may almost say, indiscriminately, for though different forms have, no doubt, been distinguished — and these in many localities very well marked — their natural relations to each other have not been understood.

The Gwyniad is so like the Vendace in most essential respects that a detailed description is unnecessary. The most striking difference lies in the form of the snout, and the cause of this difference, the shape and position of the intermaxillaries, we have already investigated. But the Gwyniad attains a much greater size than the Vendace. In Lake Superior Gwyniad weighing 23 lbs. (nearly $10\frac{1}{2}$ kilo.) are taken, and in Sweden[a] the Gwyniad attains a length of about 9 dem. and a weight of about $6\frac{1}{4}$ kilo. Specimens of this size are, however, restricted to the northern provinces, the Baltic, and the largest lakes, as for instance Wener and Wetter; in the smaller lakes, where it is more or less entirely landlocked, it is always of less considerable dimensions, hardly larger than the largest Vendace, and retains more or less of the characters of youth. Merely from this we can gather that the Gwyniad's true home lies in the north and in salt water, as well as in the rivers flowing into the sea.

To gain a correct understanding of the relations between the numerous forms in which the Gwyniad appears under different conditions in Scandinavian waters, it is necessary to include in the comparison at least two of the Siberian forms that belong to the same series of development. Both these forms were suspected by Pallas, who first described them, to be identical in species with our common Gwyniad; but one of them, the *muksun*[b], shows the development of the type to the greatest size of body conjoined with a persistency of the resemblance to the Vendace, while the other, the *polcur*[c], represents the opposite extreme in the evolution of the type, being approximated to the so-called *tschir* (*Salmo* — *Coregonus*[d] — *nasus*, Pall.), which is principally distinguished by its short and deep (high) maxillaries.

[a] See Underd. Bet. Forsl. Ny Fiskeristadga 1883, p. 159.
[b] See Smitt, *Riksm. Salmon.*, l. c., tab. IV, fig. 65.
[c] Smitt, l. c., tab. VI, figg. 98 et 99.
[d] *Prosopium*, Milner.

Like the Vendace forms the *muksun* has long and dense gill-rakers; but the *poleur*, like the *tschir*, short and scattered ones. Furthermore the *muksun* has a comparatively shallow snout, the *poleur* a comparatively deep snout. The two forms as well as the typical Gwyniad live together in the Siberian rivers and the Arctic Ocean off their mouths; and the difference between them coincides in an eminent degree with the distinction drawn by the fishermen in several Swedish lakes between the different kinds of Gwyniad in their catch. The *muksun* type they call *blasik* or *gronsik* (in Norrland *asp*, when large, or *siklöja*, when small); while the *poleur* type bears the names of *sik*, *fetsik*, *storsik*, *hvitsik* or *bottensik*. The typical *nabbsik* (Houting), with its conically prolongated snout, also belongs in fact to the *poleur* group. The shape of the snout has probably been employed time out of mind by the Swedish fishing population as a character for separate varieties of Gwyniad; but in 1831 LÆSTADIUS directed attention to the gill-rakers of the *asp* as a distinction from the *sik*[a]. That WIDEGREN had also observed the last-mentioned character, appears from the drawings which he left at his death in 1878, and which we have been enabled here to reproduce (fig. 222, *B—F*, above, p. 891).

These two groups of the true Scandinavian Gwyniads we distinguished in 1879 by the names of *Coregonus Wartmanni* and *Cor. lavaretus*[b]; and they are sometimes well marked even where they occur in the same lake (figs. 224 and 225). As an example we may adduce the Royal Museum collections from Lake Stor (Storsjön) in Jemtland. Seven *blasikar* and six *fetsikar* show the following constant differences:

	Blåsikar.	*Fetsikar.*
Number of gill-rakers on the first branchial arch of each side	31—45	20—24
Depth of the snout in % of the length of the head	8.6—9.8	11.1—12.3
" " " " " " " " " " " reduced	11.1—13.2	14.8—16.7
" " " " " " " " breadth of the snout	50.0—62.5	66.6—87.5
" " " " " " " " length of the maxillaries	27.3—35.7	40.0—46.2
Length of the lower jaw in % of the length of the head	47.1—44.0[c]	40.9[e]—39.3
" " " " " " " " " " " " reduced	62.9—59.5[d]	59.3—51.5
" " " maxillaries " " " " " " " lower jaw	60.0—66.7	68.1[f]—73.0

But on examining the *Fetsik* fry of this lake, we find that, even at a length of 70—80 mm., only the first three characters hold good. Thus at the outset of their development the two forms stand nearer to each other, even after the external shape of the body has assumed the character of the group. As is more distinctly shown by our figures, the *blasikar* of this lake belong to the group characterized in GÜNTHER[g] by "snout vertically truncated," the *fetsikar*, on the other hand, belonging to the group[h] in which "the snout is obliquely truncated, with the nose protruding". The same difference appears, however, between true *blasikar* as well, for example in Lake Ring, where, to the best of our knowledge, only *blasikar* are found[i]. It is still more difficult to maintain the distinction between the two groups where they occur together in the great Swedish lakes or in the sea. The Royal Museum collection of Gwyniads from Lake Wetter shows the most varying form of snout[j], exemplifying almost all conceivable transition forms between shallow-snouted Gwyniads (which we have called *tapinorhynchi*[k]) —not represented, however, by fully typical speci-

[a] "The *Asp* occurs in all the large lakes, up to Kilpisjarvi in Torneå Lappmark. Spawns in autumn, in the rivers in October. Is exactly like the *Sik*, but differs in the gills, whose spines in the *Asp* are long and fine." L. L. LÆSTADIUS, MS in the Royal Museum.

[b] See the Swedish Special Catalogue at the Fisheries Exhibition in Berlin 1880. Besides the Gwyniads included in this catalogue, my tables of measurements (published in 1886 in Vet.-Akad. Handl.) were accessible in manuscript, and in the course of a public discussion I cited the results of these tables, results which render the specific determination within the *lavaretus* group so untrustworthy that we have rather to deal with local varieties (See GIGLIOLI, Annali dell'industria e del commercio 1880 (Roma 1881), num. 29, p. 38).

Subsequently NÜSSLIN (1882), KLUNZINGER (1884), and FATIO (1885—90) have arrived at the same conclusion, with respect to the connexion between the characters derived from the appearance of the gill-rakers and those drawn from the form of the snout, as I maintained on the said occasion and published in 1882 in Öfvers. Vet.-Akad. Forh. But they adhere to the older opinion according to which several species may be determined with certainty, by means of these characters, within the *lavaretus* group.

[c] 43·5 in a single specimen.

[d] 58·8 in a single specimen.

[e] 44·4 in a single specimen.

[f] 62·5 in the youngest specimen.

[g] *Cat. Brit. Mus., Fish.*, vol. VI, p. 187.

[h] l. c., p. 178.

[i] Cf. for example SMITT, *Riksm. Salmon.*, tall. V, figg. 78—81, representing four *blasikar* (*Coregonus Nilssonii*) caught at the same time

[j] See SMITT, l. c., tall. IV, figg. 69—71 and tall. V, figg. 73—75.

[k] From ταπεινός, *low*, and ῥύγχος, *snout*.

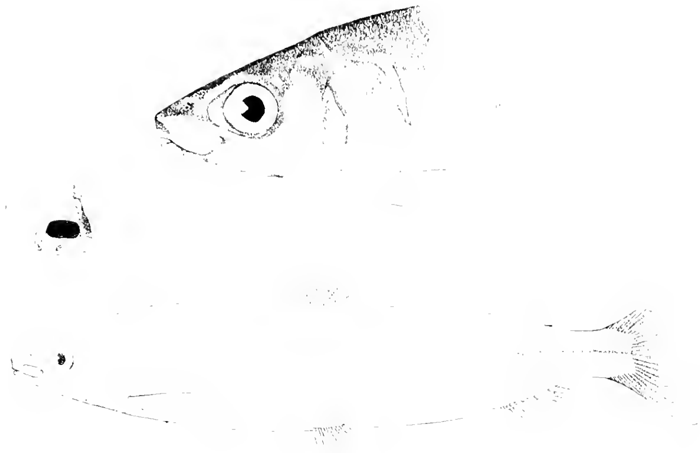


Fig. 224. *Blåsik* (*Coregonus Widegreni, forma Nilssonii*), $^1/_2$ of the natural size, ♂, taken in Lake Stor (Jemtland) on the 13th Sept., 1877 by Mr. R. Lundberg, Inspector of Fisheries. *a*, head of the same specimen, natural size; *b*, snout of the same, seen from in front, natural size.

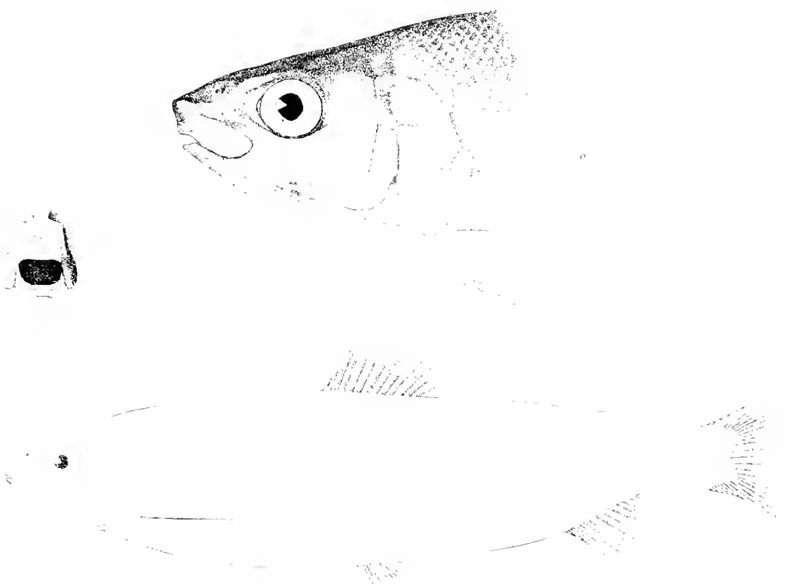


Fig. 225. *Etsik* (*Coregonus lavaretus*), $^1/_2$ of the natural size, ♂, taken in Lake Stor (Jemtland) on the 13th Sept., 1877 by Mr. R. Lundberg, Inspector of Fisheries. *a*, head of the same specimen, natural size; *b*, snout of the same, seen from in front, natural size.

mens — and deep-snouted (*hypselorhynchi*[a]), or between narrow-snouted (*stenorhynchi*[b]) and broad-snouted (*eury-rhynchi*[c]), without these differences being always attended by analogous differences between dense gill-rakers (*pycnocentri*[d]) and scattered (*manocentri*[e]). To this we must add that among the comparatively pycnocentrous Gwyniads of Lake Wetter specimens occur (fig. 226) which differ in hardly any respect from the form of the manocentrous Gwyniads, e. g. in Lake Stor (fig. 225). An examination of the Lake Wener Gwyniads has yielded the same result; but in both these lakes, as well as in the sea and in the large rivers flowing into the sea, there appears a still more prominent alteration in the form of the snout, an alteration which has given rise to the name of *näbbsik* (*Beaked Gwyniad*, Houting; fig. 227), the *oxyrhynchus* of old writers. This alteration consists partly in the prolongation and thickening of the ethmoidal cartilage, but mainly in an agglomeration of connective tissue and fat. It is analogous to the elongation of the point of the lower jaw in the Salmons, and cannot in itself justify any specific distinction, whether it appears in the narrow-snouted Gwyniads[f] or in the broad-snouted[g]. Its reaches its highest development in old Gwyniads from the depths of Lake Wener, which do not differ, however, in other respects from their companions, the broad-snouted Gwyniads of the same lake. But the Houting form was first observed in the North Sea on the Belgian, Dutch, and German coasts, whence it ascends the Rhine, Weser, and Elbe in order to spawn, and in the south of the Baltic, where it enters the Haffs and the Oder.

However variable the shape of the snout may appear, it is still the most trustworthy guide to the determination of the forms—as the fisherman's experience has long since taught him — although the characters cannot be well defined. This indefiniteness of character we can easily understand, for we can range the different forms in an almost unbroken series according to their varying degrees of resemblance to one or other of the above-mentioned extremes, the *muksun* and the *peleur*.

The shape of the snout also affects the length of the jaws, from which we may derive important characters. The appearance of the form-series at once suggests that the pycnocentrous forms should have longer jaws, and the changes of growth[h] show that during youth the relative length of the jaws undergoes a reduction. But in old Gwyniads from Lake Wener — the form which in GÜNTHER bears the name of *Coregonus maxillaris*, the German *Madui-Maraene* — we observe a retrogression towards the characters of youth, a retrogression which ranges this form, as regards the length of the maxillaries, even when the tip of the snout is prolongated to the Houting type (*Cor. oxyrhynchus*), beside the pycnocentrous *asp* from Lapland. The other extreme of the series — the *peleur* form, which, as we have mentioned, really belongs to Siberia and Northern Russia, but also occurs in the northernmost rivers of Sweden — sometimes has the maxillaries so reduced that we have conferred on this modification the special name of *brachymystax*[i].

The shape of the body is the same as in the Vendace, but in general somewhat deeper, deepest as a rule in the *peleur* and the forms that come nearest it, the manocentrous forms as a rule having a deeper body than the pycnocentrous. The greatest depth of the body varies in adult Gwyniads between about 22 and 25 % (in gravid females as much as 27 %) of its length; in the *peleur* the percentage is usually 26 or 27. In young Gwyniads measuring 37—143 mm. we find the greatest depth to increase with growth from $15^1/_2$ to $19^1/_2$ of the length. But on account of the temporary variations due to the periodical tumidity of the generative organs, the greatest depth of the body, here as in most cases, is ill adapted to express its characteristic form. Far more important in this respect is the least depth of the body. This is seldom so small as in the

[a] ὑψηλός, *high*.
[b] στενός, *narrow*.
[c] εὐρύς, *broad*.
[d] From πυκνός, *dense*, and κέντρον, *spine*.
[e] μανός, *scattered*.
[f] SMITT, l. c., tafl. IV, figg. 69 and 70.
[g] l. c., fig. 67.
[h] l. c., tab. metr. XIII, $^b/_6$ and $^c/_6$ in Nos. 362—364 and 397—403.
[i] Answering in essential respects to a form which inhabits the depths of the Lake of Constance, and which has been named *Coregonus acronius*. But this latter form, judging by the two specimens we have examined (see SMITT, l. c., tab. metr. X, Nos. 162 and 163), has much longer pectoral and ventral fins and a shorter snout.

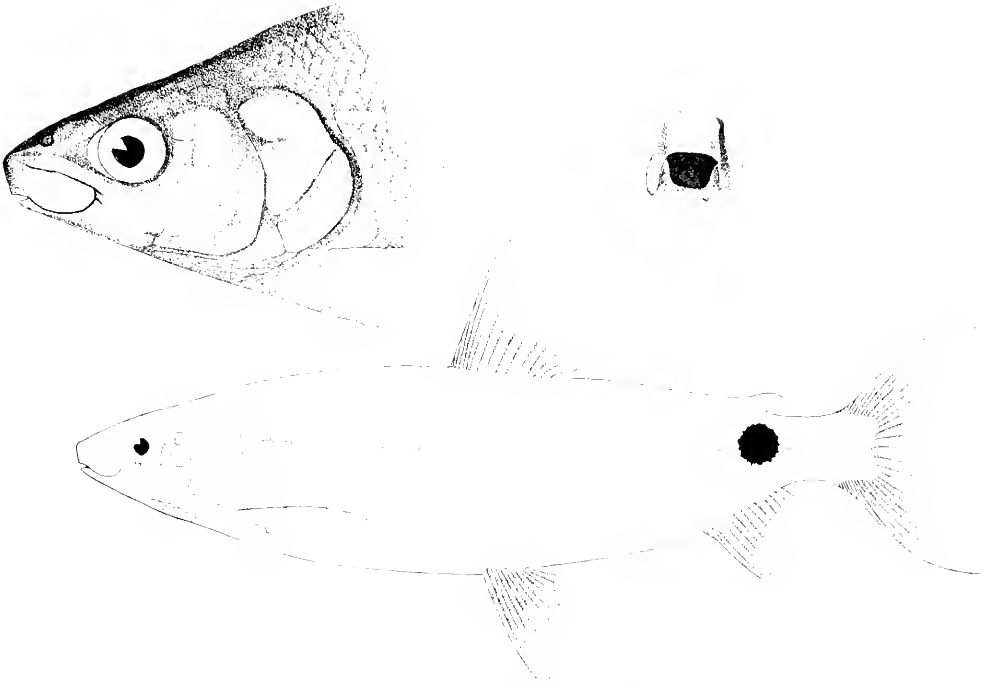


Fig. 226. *Coregonus lavaretus, pycnocentrus*, $^1/_2$ of the natural size, ♂, taken in Lake Wetter, Nov., 1863, by Widegren. *a*, head of the same specimen, natural size; *b*, snout of the same, seen from in front, natural size.

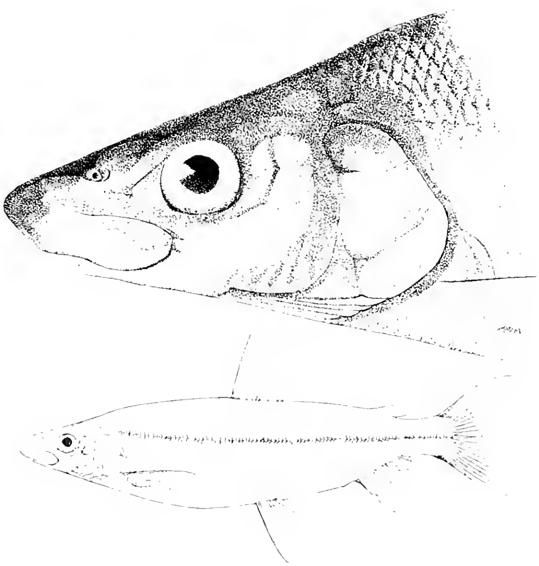


Fig. 227. *Coregonus lavaretus, oxyrhynchus*, spawning ♂, taken in Lake Wener at Stora Ekön. $^1/_4$ of the natural size; *a*, head of the same specimen, natural size.

Vendace, varying on an average about 7 % (in *poleur* about 8 %, in *tschir* nearly 9 %) of the length of the body, between 33 and 40 % (in *poleur* 41—45 %, in *tschir* 52 %) of the length of the head, or between 44 and 52 % (in *poleur* 56—61 %, in *tschir* 73 %) of the length of the head reduced. Some Gwyniad forms may indeed be said to be characterized by a shallow tail (an elongated body); but it should be observed that this character is also a character of age. Consequently it happens that, in certain lakes, especially in Lake Bolmen in Småland, where it has longest been known, but also in many other lakes from Lapland to Småland, we meet with a Gwyniad form (NILSSON'S *Coregonus lavaretus*, MALM'S forma *bolmensis*) which differs, so far as we know, constantly from the allied forms in the shallow peduncle of its tail. But in other waters, for example in the system of small lakes in Småland which falls into the Baltic through the River Mörrum, this very form is developed into the form with deeper tail, which else has its most typical representative in the Lake Ring Gwyniad (VALENCIENNES' *Coregonus Nilssonii*). The *blasikar* in the uppermost of the said lakes — Helga and Bergunda[a] — in most respects afford an instructive example of the changes of growth through which the Gwyniad passes in the less advanced stages of its form-series. In particular they show how the least depth of the body, the most distinctive character of *bolmensis*, increases with age so as to approach the typical *Coregonus Nilssonii*. In Åsnen, a lake of greater size and situated nearer the outlet of the system, the *Nilssonii* type[b] is developed at an earlier age (a smaller length) than in the two said lakes. In this locality it therefore seems that *Cor. bolmensis* should really be regarded as a young stage of *Cor. Nilssonii*, which in other places, for example in Lake Bolm, may persist as a separate form.

The deeper form of the body is most often accompanied by a special arrangement of the scales that gives the fish a singular appearance. When the skin is distended, the rows of scales part from each other[c], and the exposed portion of each scale becomes hexagonal instead of semicircular. The Gwyniad then displays a striking resemblance to the Grayling. In the *blasikar* — but especially in the typical Lake Ring Gwyniad — we also find a special form of scale, at least in the rows nearest to the lateral line, the free (hind) margin of the scale becoming more or less elongated at the middle (forming a rounded obtuse angle instead of a circular arc). But in all the Gwyniads examined by us this difference also appears between the scales on the sides of the tail and those on the forepart of the body. The character assigned by LILLJEBORG to *Coregonus Nilssonii*, that the exposed part of the scale in the rows nearest to the lateral line is more than half as long as high, may be found in most Gwyniads, at least in solitary scales.

While it often happens, especially among the *blasikar*, that the comparatively great size of the eyes is persistent longer than usual — a relation which WIDEGREN expressed by establishing a separate species, *Coregonus megalops* — the *fetsikar* run to the opposite extreme, the reduction in the relative size of the eyes during growth proceeding more rapidly and advancing further than usual. The form produced in this manner we have called *microps*, less in order to indicate the importance of the difference as such, than because it is usually accompanied by an increased fatness which has rendered the form economically important. It occurs, according to the collections of the Royal Museum, in the Gulf of Bothnia, the rivers of Norrland, Lake Wener, and Bohuslän. MALMGREN sent home specimens of a similar form from Lake Ladoga. The same importance is shared by another form, from the Angerman and Torne Elfs, which is characterized by a comparatively small head, and which we have therefore named *microcephalus*.

None of these forms seems quite to deserve the rank of an independent variety. They sometimes appear to occur alone, but as a rule at least two are found in the same lake or river — Lake Wener possesses at least 7 of these forms — and that they intermingle during the spawning, is more than probable. But as a rule a distinction may be drawn between them in the following manner:

[a] SMITT, l. c., tab. metr. XI, Nos. 210—215.

[b] l. c., Nos. 216 and 217.

[c] A striking example of this is SIEBOLD'S figure of *Coregonus acronius* (*Susswasserf. Mitteleur.*, taf. II), monstrously swollen owing to the expansion of the air-bladder when the fish was drawn up from deep water: but the same appearance is almost as marked in gravid females. We have above seen a similar difference in the appearance of the scales among the Perches for example: — cf. the Carass Perch (fig. 3, p. 29) with the common Perch.

A: *Shallow-snouted*, as a rule with *dense gill-rakers*: depth of the tip of the snout at the rostral protuberances (a_3a_4, see fig. 228) less than 15 % of the length of the head reduced (*ad*, see fig.); gill-rakers on the first branchial arch *as a rule* more than 30.

- *a*: Length of the maxillaries more than 30 % of that of the head. Gill-rakers on the first branchial arch more than 50. (A Siberian form) *Coregonus muksun*
- *b*: Length of the maxillaries less than 30 % of that of the head. Gill-rakers on the first branchial arch less than 50 *Coregonus Wartmanni.*
  - *α*: Depth of the tip of the snout less than 61 % of its breadth (a_1a_2, see fig.).
    - *aa*: Least depth of the peduncle of the tail less than 36 % of the length of the head — Cor. holmensis.
    - *bb*: Least depth of the peduncle of the tail more than 36 % of the length of the head.
      - *αα*: Gill-rakers on the first branchial arch less than 40 — Cor. Nilssonii.
      - *ββ*: Gill-rakers on the first branchial arch more than 40 — Cor. aspius.
  - *β*: Depth of the tip of the snout more than 61 % of its breadth — Cor. Wartmanni.

B: *Deep-snouted*, as a rule with *scattered gill-rakers*: depth of the snout at the rostral protuberances more than 15 % of the length of the head reduced; gill-rakers on the first branchial arch *as a rule* less than 30.

- *a*: Length of the maxillaries more than 30 % of that of the head *Coregonus [illegible]*
  - *α*: Length of the maxillaries less than 76 % of that of the lower jaw — Cor. maxillaris.
  - *β*: Length of the maxillaries more than 80 % of that of the lower jaw — Cor. oxyrhynchus.
- *b*: Length of the maxillaries less than 30 % of that of the head.
  - *α*: Length of the lower jaw greater than the least depth of the tail *Coregonus lavaretus.*
    - *aa*: Length of the head more than 18 % of that of the body.
      - *αα*: Vertical diameter of the eyes more than 24 % of the length of the head reduced — Cor. lavaretus.
      - *ββ*: Vertical diameter of the eyes less than 24 % of the length of the head reduced — Cor. microps.
    - *bb*: Length of the head less than 18 % of that of the body — Cor. microcephalus.

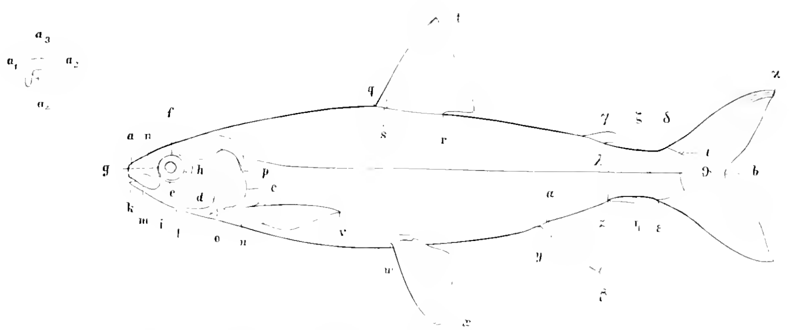


Fig. 228. Outline drawing of a Gwyniad (*Coregonus Nilssonii*), showing how the measurements in the table of averages are taken.

Line *ab* = length of the body.
ac = „ „ „ head.
ad = „ „ „ „ reduced.
a_1a_2 = breadth of the snout.
a_3a_4 = depth „ „ „
ag = length „ „ „
gh = longitudinal diameter of the eyes.
ef = vertical „ „ „ „
ai length of the maxillaries.
mn breadth „ „ „
kl = length of the lower jaw.
op = length of the suboperculum.
aq distance between the dorsal fin and the tip of the snout.
qr base of the dorsal fin.
st height „ „ „ „
uv length of the pectoral fins.
aw preabdominal length.
aw distance between the ventral fins and the tip of the snout.
wx length of the ventral fins.
wy postabdominal length.
ay = distance between the anal fin and the tip of the snout.
yz = base of the anal fin.
αβ height „ „ „ „
γδ dorsal margin of the peduncle of the tail
λϑ length „ „ „ „ „ „
zε ventral margin „ „ „ „ „ „
$\zeta\eta$ least depth „ „ „ „ „ „
ϑb length of the middle caudal rays.
ιz „ „ „ longest rays in the upper caudal lobe.

β: Length of the lower jaw less than the least depth of the tail . . . *Coregonus polcur.*

aa: Length of the maxillaries more than $^1/_4$ of that of the head and than 36 % of that of the head reduced — Cor. poleur.

bb: Length of the maxillaries less than $^1/_4$ of that of the head and than 36 % of that of the head reduced — Cor. brachymystax.

Instead of describing these forms at length we shall refer the reader to the two following tables of averages, the first intended to show both the difference of form and sex and the changes of growth in the three forms, of which we have examined a sufficient number of male and female specimens of various ages to enable us to trace the last-mentioned changes.

Average	Nilssonii ♀		♂		Wartmanni ♀		♂		Lavaretus ♀			♂	
Length of the body expressed in millimetres (*ab* in fig. 228)	184	257	161	253	184	314	167	253	147	320	82	163	305
" " " head (*ac*) . . . in % of the length of the body	20.7	19.9	20.8	19.7	20.1	19.6	21.5	18.9	20.6	19.6	21.1	19.9	19.5
" " " " reduced (*ad*)	15.7	14.6	15.8	14.7	15.3	14.8	16.0	14.3	15.5	14.7	15.8	14.8	14.6
Distance between the dorsal fin and the tip of the snout (*aq*)	43.5	44.0	42.7	43.2	42.8	43.6	44.0	42.6	43.5	44.3	43.6	43.0	43.8
Base of the dorsal fin (*qr*)	11.1	10.7	11.0	11.5	11.1	12.3	10.8	10.8	10.5	11.0	11.2	11.9	11.5
Height " " " (*st*)	15.5	15.4	15.7	15.8	15.1	15.8	15.0	14.7	14.7	15.4	14.7	14.5	14.8
Length of the pectoral fins (*uv*)	13.8	14.2	15.1	15.2	14.4	15.2	15.9	15.5	13.1	15.1	12.3	13.1	15.3
Preabdominal length (*aw*)	27.5	28.6	26.5	27.7	29.0	29.2	27.0	28.9	27.9	29.6	28.2	27.9	28.5
Distance between the ventral fins and the tip of the snout (*aw*)	47.9	47.1	47.1	46.9	47.8	48.7	47.1	46.9	48.2	49.1	48.1	47.7	44.4
Length of the ventral fins (*wx*)	13.8	14.3	14.6	14.6	14.1	14.3	14.1	14.1	13.3	14.3	14.4	13.1	14.2
Postabdominal length (*wy*)	25.6	26.0	24.6	25.8	24.9	26.9	24.6	25.7	24.4	26.0	23.5	24.7	25.9
Distance between the anal fin and the tip of the snout (*ay*)	71.2	71.1	70.3	71.1	71.6	73.7	71.0	70.6	71.3	73.4	70.7	71.3	72.8
Base of the anal fin (*yz*)	11.3	11.3	12.1	12.1	10.7	10.7	10.7	11.7	10.8	11.0	10.1	10.7	11.0
Height " " " (*αβ*)	9.8	10.5	10.1	10.7	9.9	10.4	10.0	10.1	8.7	10.1	7.1	8.8	10.1
Dorsal margin of the peduncle of the tail (*γδ*)	9.9	9.1	10.2	9.1	9.3	8.9	10.0	9.3	10.1	9.0	9.8	9.7	8.7
Length " " " " (*zb*)	14.1	13.5	10.6	13.7	13.2	13.3	13.3	13.3	13.3	13.2	13.0	13.1	13.5
Ventral margin " " " (*zε*)	9.2	8.9	9.5	8.9	9.3	8.6	9.7	9.4	9.6	8.5	9.3	9.6	8.7
Least depth " " " ($\zeta\eta$)	6.8	7.1	7.0	7.5	7.0	7.4	6.8	7.2	6.4	7.2	6.1	6.7	7.1
Length of the middle caudal rays (*ϑb*)	5.2	6.2	5.5	5.9	5.9	5.4	5.9	5.8	5.6	5.4	6.3	5.5	5.1
" " " longest rays in the upper caudal lobe (*ιz*)		20.3	17.5	19.8	18.9	19.2	19.3	18.5	16.1	18.1		17.5	18.3
Length of the snout (*ag*) . . . in % of the length of the head	24.3	25.1	24.8	24.9	24.8	26.0	25.1	25.0	25.5	27.3	23.8	25.7	22.8
Longitudinal diameter of the eyes (*gh*)	25.3	22.6	26.9	23.1	24.7	21.2	25.2	22.2	25.2	20.8	27.7	24.6	21.1
Vertical " " " " (*ef*)	22.3	19.4	22.6	19.9	22.7	18.2	21.3	18.6	21.3	18.1	23.6	21.2	18.5
Breadth of the snout at the rostral protuberances (o_1o_2)	16.5	16.1	17.0	16.5	14.6	16.0	15.3	15.9	16.0	15.9	14.6	16.3	16.2
Depth " " " " " (o_3o_4)	9.4	9.1	9.4	9.4	9.4	10.6	9.0	10.3	10.4	12.2	9.2	10.5	11.9
Breadth of the forehead at the middle of the eyes	28.6	30.1	27.6	31.2	28.4	30.0	28.3	30.9	27.9	29.7	27.6	29.3	30.0
Length of the maxillaries (*ai*)	25.2	27.5	28.9	27.7	28.2	27.1	27.6	29.0	29.0	27.8	28.9	27.9	27.8
" " " lower jaw (*kl*)	45.2	44.0	45.8	44.6	44.5	42.0	45.8	44.5	43.5	44.3	44.4	42.7	44.8
" " " suboperculum (*op*)	30.3	29.8	29.7	29.7	29.0	30.2	30.8	29.6	29.6	29.0	30.8	30.1	28.9
Vertical diameter of the eyes . . . in % of the length of the head reduced	30.0	26.1	29.9	26.2	29.7	24.1	28.1	24.5	28.3	24.2	31.4	28.4	24.6
Depth of the snout at the rostral protuberances	12.6	12.1	12.4	12.7	12.3	14.0	12.1	13.6	13.8	16.3	12.3	14.1	15.8
Length of the maxillaries	33.8	37.1	38.3	37.3	36.8	35.9	37.0	38.3	38.6	37.3	38.5	36.8	36.9
Breadth " " . . . in % of their length	37.9	37.0	36.4	36.5	37.0	37.3	36.9	36.2	37.7	38.6	30.9	38.3	37.7
Length " " . . . in % of the length of the lower jaw	55.7	63.0	63.9	62.2	63.7	64.7	60.3	65.2	66.9	67.4	65.1	61.5	66.7
Least depth of the peduncle of the tail	72.9	84.5	72.3	85.1	78.8	89.6	69.3	85.2	71.3	89.3	64.4	78.9	87.7
Depth of the snout at the rostral protuberances in % of its breadth at the same point	56.8	56.3	55.3	56.3	64.4	66.4	58.9	65.1	64.8	76.6	64.0	65.3	74.0
Number of gill-rakers on the first left branchial arch	35	36	35	36	29	32	31	33	25	25	23	24	25

Not even in the averages do we here find any constant difference, except in the number of the gill-rakers; and even the form difference which in the case of adult specimens is the most trustworthy distinction between *blasikar* and *fetsikar*, the different depth of the snout, proves to be a character of age. But in the last-mentioned respect, where the percentages rise with age, as well as in other characteristic features, e. g. the relative length of the lower jaw, where the percentages sink with increasing age, we find that, where a change of growth is clearly defined in tendency, the *fetsik* (*Lavaretus*), at the same size as the *blasik*, has attained a more advanced development.

The sexual differences show that in the males the length of the abdominal part is generally less than in the females, the anal fin thus beginning comparatively farther forward, and the snout broader but longer, the males being thus ranged as representatives of the earliest developmental stages of the type. In the differences of sex, which may easily be traced in the above table, the *blasikar*, however, often follow a different rule from the *fetsikar*, and consequently, when the former become manocentrous, or the latter pycnocentrous, the general rule for the sexual difference is commonly reversed, a circumstance which most readily suggests the presence of hybridism[1].

Guided by the alterations of development and the differences of sex included in the preceding table, we may easily explain the form-series, as it appears in the following table of averages:

Averages															
Number of specimens measured	7	6	17	33	4	17	15	5	21	101	11	5	18	11	6
Length of the body expressed in millimetres	120	358	192	231	182	235	285	371	297	244	349	383	371	325	321
Number of gill-rakers on the first left branchial arch	53	45	32	35	27	32	24	28	34	25	29	31	25	21	19
Length of the head ... in % of the length of the body	21.4	19.5	19.1	20.0	20.4	19.9	19.3	22.0	19.6	19.9	17.9	18.8	19.7	19.4	17.4
" " " " reduced	15.8	14.4	15.0	14.8	15.2	15.0	14.7	16.1	14.6	14.9	13.4	13.8	14.5	14.7	12.6
Distance between the dorsal fin and the tip of the snout	41.8	44.1	43.6	43.1	43.1	43.2	44.1	46.1	43.9	43.7	43.2	43.9	44.9	43.7	44.9
Base of the dorsal fin	11.7	11.7	11.0	11.1	10.8	11.2	11.3	10.9	11.4	11.1	10.9	11.6	10.8	11.7	12.7
Height " "	15.2	16.2	15.2	15.7	16.9	13.7	15.0	16.0	15.3	14.8	13.1	14.1	15.2	17.9	16.7
Length of the pectoral fins	15.0	15.4	14.2	14.7	15.0	15.3	14.7	15.7	14.6	14.3	13.3	13.9	15.2	14.7	15.4
Preabdominal length	26.7	29.3	28.0	27.9	26.0	28.6	28.6	31.5	28.9	28.5	31.1	29.6	24.9	28.7	28.4
Distance between the ventral fins and the tip of the snout	47.3	48.9	47.3	47.2	46.1	47.5	47.7	52.3	48.5	48.2	48.5	47.3	49.2	47.7	46.1
Length of the ventral fins	11.4	11.7	13.9	11.4	11.0	11.7	13.5	11.3	11.1	13.7	12.7	13.3	11.1	14.8	11.7
Postabdominal length	26.2	25.8	24.8	25.6	25.7	25.6	26.0	23.2	25.5	25.7	25.8	26.3	25.5	26.2	27.7
Distance between the anal fin and the tip of the snout	72.7	73.0	70.5	71.1	72.0	71.0	72	73.8	72.8	72.3	72.7	72.7	73.3	72.8	72.4
Base of the anal fin	10.5	12.1	11.8	11.8	11.7	11.1	11.0	10.6	11.0	10.9	10.7	11.1	10.7	11.2	11.5
Height " "	10.9	10.2	9.8	10.1	10.5	10.1	9.7	11.1	9.0	9.7	8.5	9.5	10.0	11.6	11.2
Dorsal margin of the peduncle of the tail	9.5	9.5	9.2	9.4	9.7	9.4	8.9	7.9	8.7	9.3	9.7	8.5	8.8	9.1	8.4
Length " "	13.4	13.2	13.8	13.2	14.0	13.3	13.2	12.5	13.5	13.3	13.8	13.3	12.9	13.1	12.8
Ventral margin " "	8.9	8.6	9.7	9.0	9.4	9.3	8.8	7.9	8.6	9.0	9.6	8.7	8.7	8.9	8.4
Least depth " "	7.3	7.8	6.7	7.3	7.2	7.1	7.0	7.2	7.1	6.9	6.5	7.2	7.2	8	7.8
Length of the middle caudal rays	5.2	5.2	5.3	5.8	5.6	5.8	5.2	6.1	5.4	5.6	4.7	4.9	5.4	5.4	5.6
" " " longest rays in the upper caudal lobe	17.0	18.5	18.6	19.3	19.7	19.0	18	18.8	17.9	18.1	15.6	17.7	17.7	19.7	18.1
" " " snout ... head	27.0	25.7	24.7	24.9	24.4	25.2	25.7	28.4	26.4	26.4	26.7	27.0	28.3	27.4	25.7
Longitudinal diameter of the eyes	16.2	18.4	25.5	23.6	26.7	23.4	21.2	19.4	20.0	22.2	19.0	18.3	18.2	19.6	20.5
Vertical " "	14.7	16.0	21.8	20.4	23.0	19.9	18.7	17.0	18.5	19.7	16.7	16.4	15.7	17.8	18.4
Breadth of the snout at the rostral protuberances	18.0	16.4	16.5	16.7	16.5	15.5	15.3	20.3	15.6	16.2	16.9	16.7	15.9	16.0	14.6
Depth " "	10.7	9.3	9.2	9.3	9.4	9.6	10.4	13.0	11.6	11.2	12.2	11.3	12.7	12.7	12.6
Breadth of the forehead at the middle of the eyes	27.8	30.6	30.1	30.2	31.2	29.6	29.3	30.1	29.0	29.4	31.7	31.4	29.6	32.1	31.7
Length of the maxillaries	31.7	27.8	27.9	27.6	28.1	28.1	27.7	32.3	27.8	28.1	27.6	27.1	28.6	26.7	24.2
" " " lower jaw	44.8	44.4	44.7	44.7	45.0	44.2	42.0	44.7	43.1	42.1	41.7	40.7	40.9	38.7	36.6
" " " suboperculum	29	29.5	30.1	30.0	31.8	29.0	29.7	28.0	29.1	29.7	29.7	29.4	28.6	30.7	30.5
Vertical diameter of the eyes ... in % of the length of the head reduced	19.1	21.0	28.8	27.1	30.1	26.2	24.1	23.2	24.5	26.7	22.6	22.7	21.7	21	21.8
Depth of the snout at the rostral protuberances	14.1	12.0	12.7	12.7	12.6	13.1	13.7	19.0	15.6	15.7	16.4	15.1	16.9	16.7	17.4
Length of the maxillaries	43.2	37.6	36.7	37.2	37.7	37.2	36.5	44.1	37.4	37.7	37.7	36.9	37.8	36.5	33.4
" " " lower jaw	60.7	60.4	59.1	60.0	57.7	58.5	56.1	57.1	56.5	56.6	56.7	55.6	55.2	52.7	50.4
Least depth of the peduncle of the tail	46.1	54.2	44.1	49.2	47.8	47.1	48.7	45.2	48.8	46.4	49.7	52.4	49.3	56.2	61.5
Breadth of the maxillaries ... in % of their length	35.4	37.4	35.7	36.7	35.0	36.8	36.7	37	37.2	37.4	38.8	38	39.7	40	40.7
Depth of the snout at the rostral protuberances in % of its breadth at the same point	60.1	56.7	55.7	56	57.1	63.8	69.1	68.7	75.2	70.0	72.7	67.7	79.1	79.7	87.1
" " " ... in % of the length of the maxillaries	33.8	33.7	33.7	33.7	33.4	35.7	38.4	41.6	42.2	40.1	44.7	41.8	45.2	45.7	52.7
Length of the head reduced in % of the distance between the dorsal fin and the tip of the snout	37.7	33.1	34.2	34.7	35.7	34.8	32.7	34.7	33.3	34.0	30.7	31.4	32.5	32.1	30.2

[1] SMITT, l. c., pp. 281 seqq.

The clearest expression of the evolutional course of the form-series we here find in the relation between the depth of the snout at the rostral protuberances and the length of the maxillaries: the former increases and the latter decreases, so that the averages rise with great regularity from left to right in the last line but one of the table. Yet these averages, as we have mentioned, must be considered with reference to the size of the specimen: among small specimens both of *Nilssonii* and *lavaretus* for example the manocentrous show a smaller average than the pycnocentrous; but the law of evolution tells us, according to the preceding table, that if the former had been permitted to attain a sufficient size, their percentages for this relation would undoubtedly have risen enough to fill their place in the series.

Bearing this result in mind, we can easily determine the systematic value of the peculiarities which seem to characterize the Gwyniad where it lives under exceptional conditions. In Enare Traesk for example (Finnish Lapland) it sometimes develops the *beaked* form[a] at a length of 14 or 15 cm. and with a depth of snout persistently answering to the shallow snout of the typical *blasikar*, though it is quite manocentrous, with no more gill-rakers than a *polcur*. But to coin a special name for such a form, is of questionable utility, for a similar prolongation of the snout, though not quite so great, may be observed in young *blasikar*, for example from Qvickjock, where they attain maturity at about the same size[b].

The relation between the two groups, the one[c] collected round the *blasik* type, the other[d] round the *fetsik* type, is evidently the same as that between *trutta* and *salar* among the Salmons. They come so near each other that constant characters to distinguish them cannot be adduced; the one is a more advanced development of the other, and they intermingle in their spawning operations[e]. However unlike the differentiation of form may be in localities at a distance from each other, variations as great may be observed in the same water, the extremes of the form-series appearing side by side. No wonder then that ichthyologists have failed sharply to define local varieties, though a more than adequate number of names have been proposed to this end.

The coloration of the Gwyniad is essentially the same as that of the Vendace, and is subject to the same variations of light or dark tone. The back is of a lustrous steel-blue, whence the name of *blasik*, or black, in which case the latter colour also extends to the upper part of the head and forward over the snout, or, like the top of the head, of a more greenish gray tint and more or less transparent, the transparency being most noticeable in the occiput and the snout, though the tip of the latter is commonly brownish black. The sides of the body have a silvery lustre, but often pass into a dirty gray, which colour has given rise to the name of *grasik*, and is sometimes uniformly distributed over the middle of the sides, but generally more prominent at the limits between the longitudinal rows of scales below the lateral line. The ventral side is of a purer white, at the middle milky white. The sides of the head partake in the silvery lustre of the sides of the body; but on the gill-cover this hue frequently passes into a brassy lustre; and the articular process of the operculum is of a brownish black colour, which is continued back in a longitudinal stripe. The yellowish colour often extends to the cheeks and jaws. The lower part of the head is of the same colour as the belly. No less variable is the coloration of the fins. Sometimes all of them are entirely black; but in the lighter varieties they may all be light, greenish gray or transparent. As a rule, however, they are light (gray or dashed with red) at the base, but the outer part of the fin-membrane is dark, grayish or brownish black, this being due to a rarer or denser agglomeration of brownish black pigment, which is sometimes merely besprinkled on the tips of the pectoral and ventral fins. The same pigment is frequently scattered in fine dots over the skin of the whole body[f], and usually collects on the middle or bottom of the dorsal fin, on the upper part of the head, on the inner (hind) surface of the pectoral and ventral fins, and sometimes here and there on the sides of the body,

[a] SMITT, l. c., tafl. V, fig. 89.
[b] SMITT, l. c., *tab. metr.* X, No. 169.
[c] FATIO's *Coregonus dispersus*.
[d] FATIO's *Coregonus balleus*.
[e] FATIO has recognised a blending of characters in his "species composita", *Coregonus Suidteri* (*Fne Vert. Suisse*, vol. V, p. 270).
[f] They are sometimes entirely wanting in the light varieties.

in irregular dark spots. Sometimes the pectoral fins are of a plain grayish red, while all the others are black. During the spawning-season the scales of the sides, most commonly below the lateral line, are coated with dermal tubercles, such as we have noticed in the Cyprinoids. These tubercles, of a white or reddish gray colour, form longitudinal rows (see Plate XLII, fig. 4), one to each row of scales, but they are not present on all the rows of scales, sometimes only on 5, sometimes on as many as 13, most of them below the lateral line. They are sometimes present both in males and females, sometimes only in the males; and many breeding Gwyniads, even males, in the same shoal are without them[a].

The Gwyniad, as we have already mentioned, is spread throughout Sweden; and the rule is that the *blåsikar* belong to fresh water, the *fetsikar* to the sea, the rivers flowing into the sea, and the great lakes. So in this respect too the relation between the two main groups of Gwyniad forms is fully analogous to that between *trutta* and *salar* among the Salmons. The range of the Gwyniad probably extends over all northern countries both of the Old and New Worlds[b]. Throughout Finland and Norway the species occurs; but in the latter country, according to COLLETT, its range is interrupted between Trondhjem and Tromsö, which is also the case with several other fresh-water fishes. In Denmark, where it is called *Helt* and *Snabel* (the German *Schnäpel* = Sw. *näbbsik*), it is common on the mainland, less so on the islands and round their coasts. It is also common throughout Germany north of the Alps — where it bears many names, *Maräne*, *Blaufelchen*, *Renke*, *Kilch*, etc. — and in the Baltic Provinces of Russia. But in South-eastern Europe it is wanting. In Switzerland it occurs in the numerous forms (24 sub-species) described by FATIO. In Savoy it inhabits the Lac du Bourget; and it has been introduced in recent times into Lakes Maggiore and Como on the southern slope of the Alps. In France proper, with the exception of the most eastern districts, it is wanting; but to the fish-market of Paris, where it is known by the name of *Outil*, it is supplied from Belgium and Holland, where in its *näbbsik* form, called *Houting* and *Adelvisch*, it inhabits the North Sea and the Zuider Zee and ascends the Rhine. In England it is common in Ulleswater and the other Cumbrian lakes, up to a height of 2,600 feet above the sea-level, being here known as the Schelly, in Scotland it inhabits Lake Lomond, where it is called the Powan, and in the Welsh lakes it bears the name of the Gwyniad. The Houting form has been taken on the east and south coasts of England. The North American White-fish has its true habitat in the region of the Great Lakes, but its range extends to the Arctic Ocean. But in Greenland and Iceland the species is unknown.

In this wide geographical extension there are three centres where the Gwyniad attains its most robust development: Siberia, the Baltic countries, and the basin of the Great Lakes in North America. The first home of the species lay in the north, and to the southern tracts in the interior of Europe where it now occurs, it had free access during the Glacial Period. But when the waterways became landlocked, and the extent of the seas was reduced, it was compelled to adapt itself to the various environments of its abode, and it has thus been differentiated into a number of forms which cannot, however, be distinguished by constant characters.

"The Gwyniad's habits," writes EKSTRÖM of the Baltic form, "differ little from the Salmon's. Like the latter it ascends from deep water in the spawning-season, and is said to observe a certain order in its evolutions." "The roading Gwyniads," wrote GISLER from Norrland, "gather in shoals with such consent that hardly a single fish can be found on the coast between the shoals. They mostly repair to the coast in violent gales from the south and south-east, which drive them into fjords and estuaries. As soon as the wind veers to the west, they ascend the rivers with eager haste, and are then observed to shape their course in two wings or lines converging to a point, as is related of the Salmon[c]." "In the island-belt of Mörkö," continues EKSTRÖM, "the Gwyniad ascends from deep water, where it has passed the winter, in spring-time, when the Baltic Herring spawns. It follows the

[a] According to GISLER they are wanting in the males which first reach the spawning-place.

[b] BEAN (*Cat. Coll. Fish. Exh. by U. S. Nat. Mus.*, Gt. Intern. Fish. Exhib. London 1883, p. 8) and TURNER (*Contrib. Nat. Hist. Alaska*, Arct. Ser. Publ. Sign. Serv. U. S. Army, No. II, p. 104) mention *Coregonus clupeiformis (albus)* from Alaska; and as we have stated above, we know of no specific difference between this form and our European Gwyniad.

[c] See above.

Herring-shoals, and devours their roe. Afterwards it returns to deeper water, and does not re-appear until the close of summer, at the end of September. Except during the spawning-season the Gwyniad is so cunning and cautious a fish that its sagacity has given rise to a proverbial expression, a sly person being called an *arg sik* (a thorough Gwyniad). It is also timid, and so voracious as to devour not only the roe of other fishes but also its own. It dies soon after it is taken out of the water." This greatly depends, however, on the depth at which it is caught. When drawn up from very deep water, it dies at once, the air-bladder swells, and the belly is distended, sometimes to monstrous dimensions.

The lake Gwyniads also assemble in shoals twice a year. The first period is during summer, when insect life is most thriving, gnats and dragonflies sport at the surface or drop into the water, and when the small crustaceans (*Entomostraca* and fresh-water Gammaroids) are most plentiful. Shoals of Gwyniads then seek their food at the surface and in the shallows. The other period is in autumn and winter, when the Gwyniads gather to spawn. Similar observations have been made in North America[a]. In Lake Ontario, for instance, the Gwyniad is taken early in spring far out in the lake, in about 200 feet of water. At the beginning of June it repairs in shoals to the coast in quest of food. At the beginning of August, when the heat of the upper layers of water is too oppressive, it speedily retires to the deeper and cooler parts of the lake. About the middle of October it again approaches the coast, but on this occasion in order to spawn, an operation which lasts from the middle of November to the beginning of December, and is performed in water of a temperature of about 40° Fahr. (+ $4^1/_2$ C.). But in certain lakes the summer shoals do not appear, for example in Lake Erie, according to MILNER, where the surface temperature sometimes rises to 75° FAHR. (+ 24° C.), and where the Gwyniad resorts in summer to the deepest parts of the lake. Here, however, it is by no means condemned to starvation.

The largest and most developed Gwyniad forms, with their more or less ventral mouth (situated on the under surface of the snout), are evidently in the first place bottom-feeders. They seize the larger Gammaroids and the mollusks (*Limnaea, Planorbis, Pisidium*, etc.) which live among plants and in the mud, not to mention, as we have already stated, that they are voracious roe-eaters. Small fry also enter into their diet. Young Gwyniads and the smaller forms, with their more terminal mouth (situated at the tip of the snout), are in general shore and surface fishes, and have to content themselves with smaller prey. But in many Scandinavian lakes, especially in Norrland and Lapland, small crustaceans (*Entomostraca*) and gnat-worms occur in such multitudes that even the large Gwyniads grow fat on them.

The spawning-season occurs, as we have mentioned, in autumn and winter[b], as a rule from the middle of October until after the beginning of January. The young spawn in comparatively shallow water, only 1—3 fathoms in depth, and earliest in the year; older specimens generally breed later and in the deeper parts of the lakes. The males usually come first to the spawning-place, the females following them. The breeding fishes display eager excitement, especially at night. The males even cling fast with their teeth to the females, seizing them under the gills or by the pectoral fins. Or the pair — sometimes two or more males and one female — pressed close together, run in sinuous curves towards the surface or even above it, "belly to belly, with their sides gleaming bright in the water, where they strive and wriggle until they are rid of the roe and milt, which adheres to the bottom, and on stones or nets" (GISLER). In stormy, snowy, or very cold weather the spawning is performed in the same way, but several metres below the surface. The water round about is dyed with loose scales, and after the spawning the exhausted fish seek out resting-places.

The eggs are light yellow, and their dimensions vary considerably, according to the size of the mother fish. In *blasikar* from Lake Ring the ripe eggs measure

[a] See Mr. P. KILL in BR. GOODE, *Fisher., Fisher. Industr. U. S.*, sect. I, p. 510.

[b] According to BREHM'S description of the fishery in the R. Obi, the Gwyniads ascend the river from the sea when the ice breaks up, spawn at the end of the summer, and return in August, usually at the end of the month, to the Arctic Ocean, or at least to the Gulf of Obi (*Thierleben*, Bd. VIII, p. 235). The Gwyniads brought home by THÉEL and TRYBOM from the Yenisei in 1876 also show (see SMITT, *Riksm. Salmon.*, tab. metr. XIII, No. 424, cett.) that the eggs were so large at the beginning of July that the spawning might well have been performed in the course of the summer. In some of the very deep Swiss lakes too, according to FATIO, the Gwyniad spawns in July and August.

$1^3/_4$—2 mm. in diameter, in the larger *fetsikar* as much as 3 mm. At first they are highly sensitive, especially to warmth; when the embryo is half-developed, they are easier of transportation. In water of a temperature varying from December to April between +1 and +5° C. (34 and 41° Fahr.), the fry are not hatched and capable of swimming until 5 months after the deposition of the ova. Just after their hatching Gwyniad fry are 9 mm. long, when a fortnight old, 11 or 12 mm., at the age of one month, 15 mm., and when three months old, about 30 mm. (Norbäck). In the following year the young measure about 12—17 cm. From his examination of American Gwyniads Milner[a] deduced the following results:

Weight of the mother fish	Weight of the ovaries	Number of eggs	Number of eggs per lb in the living fish
2 lbs	$5^3/_4$ oz	21,229	10,614
$2^3/_4$ „	$7^1/_2$ „	28,500	10,364
4 „	16 „	48,100	12,000
$7^1/_2$ „	25 „	66,606	8,881

In the largest Gwyniad this result pretty nearly correspond to Norbäck's calculation for Scandinavian Gwyniads, that on an average each female Gwyniad has 7,000—8,000 eggs to each Swedish pound[b] of her own weight.

The Gwyniad does not yield to the Salmon as a food-fish. In many parts of Sweden, especially in Norrland, it is more important to the fisherman. It is taken principally with net and seine, but also on long-lines, and at the spawning-places the leister is employed. The small Gwyniads of Lake Wetter that frequent the shallower parts of the lake are netted with the so-called *strönot* (= *strewing seine*, but really a net, being without pocket), which is plied in the same way as the trammel-net[c], with a beater, but without any outer net. One end is made fast by the shore or on a shoal, and the fisherman rows the other end of the net in a spiral with many curves, one within another. In the Gulf of Bothnia Gwyniads are trapped in large *ryssjor*, with mouths and hoops a fathom wide and with a land arm sometimes a thousand feet long, extending out from the shore to deep water even where the beach is shelving. On the Swedish coast these traps are called Finnish *storryssjor*, from the country where they were first used, and they are considered to be the most effective engines of all, for not only Gwyniads, but also every other kind of fish, especially Salmon — and sometimes a seal or two — enter into the catch. But their use readily becomes an abuse, if they close channels, or are set at the mouths of rivers to bar the passage of the ascending fish. In Lake Wener the long-line is also employed; it may be baited with worms, shellfish, or small Gammaroids. But in the Lake of Constance Gwyniads take a hook baited with nothing but a black horse-hair, which is bent so as to have some slight resemblance to a fly. When fishing for Gwyniad, however, the angler should be cautious, for the fish struggles violently to escape, and often tears its mouth loose from the hook.

In flavour the large *fetsik* may be mistaken for Salmon, if boiled fresh and served with suitable sauce. Smoked *fetsik* too is a dainty food. The large *blasik* is also excellent eating — the *muksun* in particular — and the Lake Ring Gwyniad, small as it is, is commended for its fine flavour; but it will not bear keeping. Salted Gwyniad is common in the markets of Norrland, and in this form or dried the Gwyniad is an important winter food among the Lapps.

The Gwyniad fisherman suffers greatly from the depredations of the seal, which appears, says Ekström, to be highly partial to the flesh of this fish. "The islander often finds his nets stripped by the seal, and considers that he has got off cheaply, if the nets are left whole. When once the seal has found a net, and been allowed to make a good meal there, it often repeats the visit, and unless the net be removed, it comes every night without fail for its share of the fisherman's take."

[a] See Brown-Goode, l. c., p. 519.
[b] A Swedish pound is about 15 oz.
[c] See above, p. 741, note *a*.

Genus ARGENTINA[a].

Jaws toothless, but the palate armed in front with a semicircular transverse row of small but pointed, recurved teeth, and the tongue furnished within its fleshy rim with a similar, but sparser row of somewhat larger teeth. Length of the maxillaries at most about 30 % (26—29½ %) of that of the head reduced, and the length of the lower jaw at most about 50 % (43—49½ %) of the same. Breadth of the snout at the articular knobs of the maxillaries perceptibly less than that of the interorbital space, which is more than ¼ (26—29 %) of the length of the head. Base of the dorsal fin less than 8 % of the length of the body[b], or than half the length of the head reduced. Pyloric appendages little or moderately developed. Scales large, for the most part curved, and armed with small spines. About 60 (58)—70 scales in the lateral line, which is complete, and the scales of which are rendered more or less heart-shaped by an indentation at the hind margin.

In the genus *Argentina* we find reminiscences both of the Smelts and the following family: a certain degree of transparency and cucumber-like smell (not quite absent, however, in the Gwyniads) and a comparatively small number of pyloric appendages point to the former; the stiff, but fragile fin-rays and the singular shape of the scales remind us of the latter. The last-mentioned peculiarity, which is also connected with the formation of the longitudinal ridges that appear on the sides of the body in *Argentina*, and are each covered by a row of curved scales indented at the hind margin (similar in this respect to those of the lateral line), ranges *Argentina* beside the extinct genus *Osmeroides* of the Cretaceous Period[c], though in other respects the latter genus, with its numerous branchiostegal rays and its strong, toothed jaw-bones, was more like the Salmons. In *Argentina* the jaws are comparatively weak, and there are no jaw-teeth, while the maxillaries are without supplementary (jugal) bones. But the most striking among the other characteristics of *Argentina* is the reduction of the rostral region proper, which both in the Salmons and the Gwyniads is sometimes so considerably elongated. Here, on the other hand, the ethmoidal region, with its lower covering-bone, the vomer, is well-developed and comparatively long; but the intermaxillaries are so greatly reduced that the head of the vomer, in almost the same manner as in the Eels, seems to form the firm anterior margin of the mouth. Lastly we will mention a characteristic which is indeed not quite absent in the Gwyniads, but is there much less developed, almost rudimentary. Outside (under) the pelvic bones and in front of the insertions of the pectoral fins, the large ventral scales form a flap, free behind, which covers a great part of the ventral fins when they are folded.

Argentina belongs to the deep-sea fishes — as the large eyes indicate — but not to their most characteristic types. The young are frequently met with in the upper marine zones, and even ascend, according to Nilsson[d], to the mouths of rivers. In the depths of the ocean the genus probably has an extensive range. It has longest been known, for a long time exclusively, from the North Atlantic and the Mediterranean; but in 1878 it was found off the coast of New Zealand, and this in a form that can hardly be distinguished from one of the Atlantic species. Such a find as this most naturally suggests the possibility of discovering the species in intermediate localities as well; but it is remarkable that New Zealand is also the only region in the Southern Hemisphere which possesses among its autochthonic fresh-water fishes a member of the Salmon family (*Retropinna Richardsonii*).

Only two species of the genus *Argentina* are known with certainty[e].

[a] Artedi, *Ichthyol.*, *Gen. Pisc.*, p. 8.

[b] In a damaged specimen Brown-Goode and Bean found the length of the base of the dorsal fin to be 8·4 % of that of the body. According to Nilsson, however, sometimes 20.

[c] Agassiz, *Rech. Poiss. Foss.* tome V, II^me^ Partie, p, 105, Pl. 60 *b*.

[d] *Observationes Ichthyologicæ*, p. 7; *Skand. Fna. Fisk.*, p. 476.

[e] Valenciennes' *Argentina leioglossa* (without teeth on the tongue) from the Mediterranean off Algiers has already been identified by Giglioli with *A. sphyræna*, and Hutton's *Argentina elongata* from New Zealand is based on a single young specimen in bad condition (see Günther, *Deep Sea Fishes*, Chall. Exped., p. 218).

THE GREATER SIIL-SMELT.

ARGENTINA SILUS.

Fig. 229.

Base of the anal fin, as well as the longitudinal diameter of the eyes, less than half the length of the head reduced. Height of the dorsal fin less than $^2/_3$ of the preabdominal length. Lower posterior margin of the operculum straight. Gill-rakers on the first branchial arch about 20. Branched rays in the pectorals 16 or 17, in the ventrals 11 or 12. Scales of a horny yellow.

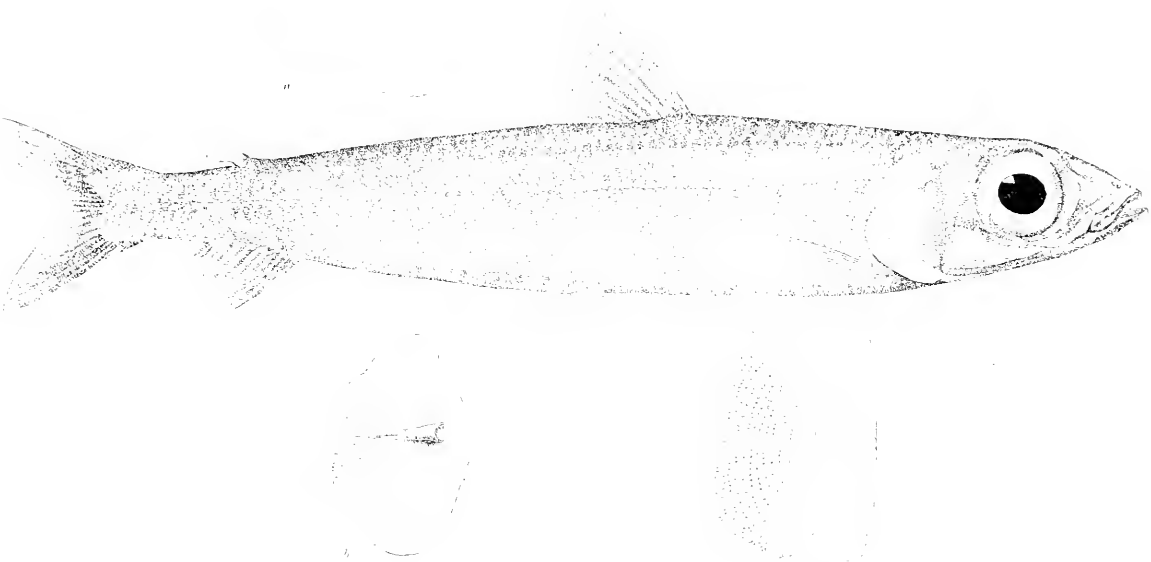


Fig. 229. *Argentina silus*, ♀, $^{11}/_{24}$ of the natural size. Taken on a Haddock-line at a depth of 50 fthms., between the Koster and Tisler Is., on the 11th Nov., 1880; C. A. HANSSON. *a*, scale from the base of the dorsal fin; *b*, scale from the lateral line; *c*, scale from the first row below the lateral line.
All the scales from the right side of the body and twice the natural size.

R. br. 6; *D.* $\frac{2}{9^a}$; *A.* $\frac{3-4}{10-12}$; *P.* $\frac{1}{16-17}$; *V.* $\frac{2}{11-12}$;
C. $x + 1 + 17 + 1 + x$; *L. lat.* 66—70. *L. tr.* $\frac{4}{3}$1. *Vert.* 65[b]—68[c].

Syn. *Salmo Silus*, ASCAN., *Icon. Rer. Nat.*, fasc. III, p. 3, tab. XXIV; CUV. (*Coregonus*), *Regn. Anim.*, ed. 2, tom. II, p. 308; NILSS., *Prodr. Ichthyol. Scand.*, p. 19. ID. (*Argentina*), *Observ. Ichthyol.*, p. 3; KRÖY. (*Acantholepis*) in GAIM., *Voy. Scand., Lap., etc., Zool.*, tab. 17; ID., *Danm. Fisk.*, vol. III, p. 98; CUV., VAL., *Hist. Nat. Poiss.*, tom. XXI, p. 421; NILSS., *Skand. Fau. Fisk.*, p. 469; GÜNTH., *Cat. Brit. Mus., Fish.*, vol. 6, p. 202. OLSSON, Lunds Univ. Årsskr., tom. VIII (1871), p. 6 (sep.); COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 173; 1879, No. 1, p. 93; N. Mag. Naturv., Bd. 29, p. 109; WINTH., Naturh. Tidskr. Kbhvn. ser. 3, vol. XII, p. 15; STORM, Vid. Selsk. Skr. Trondhj. 1883, p. 29, SM., Vet.-Akad. Handl., Bd. 21, No. 8, p. 196; PETERS., Vid. Meddel. Naturh. For. Kbhvn. 1884 (1886), p. 159. LILLJ., *Sv., Norg. Fisk.*, vol. 2, p. 679.

[a] More commonly 10, according to LILLJEBORG.
[b] According to NILSSON; 66 according to KRØYER.
[c] According to LILLJEBORG.

Salmo [illegible] (*Blankesteen*) Müll., Zool. Dan. Prodr., p. 279, vide Strøm, Skr. Naturh. Selsk., Bd. 2. H. 2 (1793), p. 12, tab. I, fig. 1.

Silus Ascanii, Reinh., Maanedskr. Literat. Kjøbvn 1833, p. 239.

Argentina syrtensium, Br. Goode, Bean, Proc. U. S. Nat. Mus., vol. I (1878), p. 261; vide Günth., *Deep Sea Fish.*, Chall. Exped., p. 217.

Obs. In the preceding pages (see above, p. 59) we have employed the name of *Blankesten*, which Strøm first applied (in *Søndmøres Beskrivelse*) to a fish of the genus *Sparus*, as a synonym of *Flackpagell* (the Common Sea-Bream), following O. F. Müller and Brünnich. But as Strøm has subsequently come to the conclusion that the former name properly belongs to the species now in point, it is best omitted in the said passage, especially as its application in Norway seems to be vague.

The Greater Siil-Smelt attains a length of nearly half a metre[a]. The body is elongated and fairly thick, the greatest depth, which occurs at the beginning of the dorsal fin, being in adult specimens about 18 % of the length, and the greatest thickness about $^2/_3$[b] of the greatest depth, or slightly greater than the postorbital length of the head. The dorsal and ventral contours form about equal curves. They meet in a point at the tip of the snout, and converge behind till, in front of the caudal fin, the least depth of the body measures about $6^1/_2$ % of its length or 1/[illegible] of the length of the head reduced. In transverse section the body forms, according to its degree of distension, a more or less regular rectangle, the back and the belly being broad, the former more so, and flatly convex or even flat, and the sides more or less compressed. A further characteristic, which we have already mentioned, are several longitudinal, low ridges. Two of these run, parallel in front, converging on the tail, on each side of the dorsal margin and on the uppermost part of the sides, the lower starting from the upper angle of the operculum; two corresponding ridges follow each side of the ventral margin and the lowest part of the sides, the upper starting from the pectoral fins, the lower from the ventrals; one ridge is formed by the lateral line; and the median line of the dorsal margin between the dorsal and adipose fins, as well as of the ventral margin between the ventral fins and the anal aperture rises in a similar ridge.

The head forms a four-sided wedge, but is so contracted below as strongly to remind us of that of the Capelin. Its upper and lower surfaces converge forwards to the shallow, but rather broad tip of the snout, which is rounded in an horizontal direction. Its sides are flat, even the upper, the interorbital part of which is depressed between the somewhat tumid supraorbital parts; and at the articulations of the lower jaw a break is formed when the mouth is closed, the upward slope of the lower jaw being somewhat sharper than the downward slope of the snout. A thick adipose membrane with numerous ducts and pores is spread from the occiput and forehead down over the operculum, the preoperculum, and the suborbital bones, and forward on the snout, surrounding the large orbits both in front and behind. The eyes occupy about $^1/_3$ (33—30 %), the postorbital part rather more than $^2/_5$ (42—46 %), and the snout about 29—30 %, of the length of the head. The nostrils lie about half-way between the tip of the snout and the eyes. The anterior is round; the posterior, which is larger and more oblong, transversely set, is entirely covered by a semicircular dermal flap from its anterior margin. The breadth of the snout at the nostrils is only slightly less than the interorbital width; but the breadth across the rostral protuberances (articular knobs of the maxillaries) is only about $^1/_2$—$^2/_3$ thereof. The rostral protuberances are indistinct. The preoperculum is distinguished by its rectangular shape and its long arm, which runs in a forward direction, coasted by the narrow interoperculum, which is of the same length. The operculum is trapezoidal, but its hind margin is sinuate. Its lower margin, which forms the fairly straight and obliquely ascending suture with the suboperculum, is almost equal in length to the diameter of the eye. The suboperculum is of uniform breadth and rounded at the lower posterior angle. The mouth is most like that of the Grayling, but the point of the lower jaw projects a little beyond the tip of the snout, and is furnished with a distinct, though small, symphyseal protuberance above and a small chin-protuberance below. The lips are not very fleshy. The curved anterior margin of the upper jaw is entirely formed, right across the mouth, by the narrow intermaxillaries, which are without nasal process, the upper jaw being thus incapable of protrusion. The maxillaries are narrow in front, so far as they are covered by the intermaxillaries, but behind

[a] Sometimes 2 Sw. ft. (59 cm.), according to Nilsson. Strøm's specimen was 43 cm. long; our largest specimen, which has lain for several years in spirits, has now shrunk to a length of about 47 cm., but measured when caught $48^1/_2$ cm. according to Mr. C. A. Hansson; and the largest specimen Collett had seen was $47^1/_2$ cm. long, in each case to the extreme tip of the caudal fin.

[b] According to Krøyer, however, sometimes but slightly more than $^1/_2$.

they expand in a downward direction so greatly that their breadth is about 28 % of their length, which measures about 20—23 % of that of the head or 28—$29\frac{1}{2}$ % of that of the head reduced. The length of the lower jaw is about $8\frac{1}{3}$—$8\frac{3}{4}$ % of that of the body, 32—34 % of that of the head, or 44—48 % of that of the head reduced. The dentition of the mouth we have already described. The most striking characteristic is that, at the extreme front of the palate, the head of the vomer and the anterior extremities of the palatine bones, which touch the head of the vomer on each side, form an arch furnished with a row of small, bent, subulate teeth of uniform size. This arch has the appearance of an inner upper jaw, compensating the lack of teeth on the upper jaw proper. In old specimens these teeth are more scattered, but longer and more villiform. The teeth on the tongue also seem to become more scattered with age: in the semi-elliptical row we have counted 10, 8, and 6. There is no palatal fold in the usual place, just behind the jaws; but behind the head of the vomer and the incurved ends of the palatine bones the skin of the palate lies in a pad-like transverse fold. The gill-rakers are set in one row, and resemble pointed, rather long, triangular disks, which are destitute of the small spines that commonly fringe them in the Gwyniads. The pharyngeals are armed with several rows of subulate teeth. The pseudobranchiae are large. The gill-openings are of considerable size, each extending from the occiput on a level with the upper orbital margin and almost in a line with the hind margin of the preoperculum down to a line with the centre of the eye. The two branchiostegal membranes are free both from each other and the isthmus. The branchiostegal rays are six in number, the last five being sabre-shaped and gradually increasing backwards both in length and breadth, the first narrow and styliform, but curved like the others.

The dorsal fin is trapezoidal, but its upper posterior margin is more or less convex. The first two rays are simple; the first branched ray is the longest, being twice as long as the first simple ray, but only slightly longer than the second. The fin begins at a distance from the tip of the snout measuring about 44 or 42 % of the length of the body, and the length of the head is about 60 or 61 % of the said distance. Its base is less in our specimens than 8 % (about $7\frac{3}{4}$ %) of the length of the body, or about 30—32 % of the length of the head. Among the preceding members of the Salmonoid family the Smelts alone have so short a dorsal fin. The greatest height of the fin is about twice the length of its base. The anal fin is also trapezoidal, but lower and at least somewhat longer than the dorsal. At its anterior margin there lie three or four simple (undivided) rays, the first quite short, about half as long as the second, the others gradually increasing in length to the hindmost, which is about equal in length to the first branched (longest) ray, or in other words to the base of the dorsal fin. The distance between the beginning of the anal fin and the tip of the snout is about 78 % of the length of the body, and the length of its base is about $\frac{1}{3}$ (33—34 %) of that of the head. The adipose fin, which resembles that of the Salmons, lies above the 4th—6th or 5th—7th branched ray in the anal. The caudal is deeply forked, the length of its middle rays being only about $\frac{1}{3}$ of that of the longest ones, or about 4 % of that of the body.

The pectoral fins resemble in shape and position those of the Gwyniads. Their length is about 14—15 % of that of the body. The first (simple) ray does not reach quite to their tip; the second or third branched ray is the longest. The blunt ventrals also remind us of the Gwyniads, but are distinguished by their numerous rays — a characteristic generally belonging to the lower (earlier) grades of differentiation among the Teleosts — and by the covering lobe, formed by large scales on the ventral side in front of their base, under which they may be concealed to a great extent. Their length is about $\frac{1}{10}$—$\frac{1}{9}$ of that of the body, or $\frac{3}{4}$ (78—74 %) of that of the pectorals. They are set halfway along the body (at a distance from the tip of the snout measuring about 49—51 % of the length of the body), exactly below the termination of the dorsal fin or a little farther back. The preabdominal length is less than in most other Salmonoids (24—26 % of the length of the body), but the postabdominal length is greater (29—27 % of the same).

The shape and texture of the scales, which are rather thick but flexible, vary according to their situation. They are densely imbricated, and inserted so far into the follicles that most often only $\frac{1}{4}$ of their surface is uncovered by the next scale in front. Their exposed part is closely set with small spines, pointing in a backward direction, which render the body as rough to the touch as in many Sharks. On the other hand, this part of the scale is without concentric striae.

or, if these are present, they are faint or at least scattered, while on the anterior (inserted) part of the scale they are all the more numerous. Radiating grooves there are none; but the anterior margin of the scale in particular is often sinuate. The nucleus of some scales, for example on the forepart of the back and of the belly, is so large as to occupy the greater part of the scale, with only a comparatively small number (20—30) of concentric striae in front of, above, and below it. But in other cases, for example in the large scales on the sides just below the lateral line (fig. 229, *c*), the nucleus is all the more reduced, so that about 80 or 90 concentric striae may be counted, about each 8th—10th one coarser than the rest, on the inserted part of the scale. Most of the scales are irregularly round, of a rounded quadrangular or broadly elliptical shape, with the longitudinal axis set vertically; and in these cases the anterior margin as well is arcuate, or elongated in an angular form at the middle. Where they cover any of the longitudinal ridges on the body, they are indented, as we have mentioned above, at the middle of the hind margin. This also applies to the scales of the lateral line (fig. 229, *b*). The large scales set in a row just below the lateral line, largest on the forepart of the body (fig. 229, *c*), are distinguished by their more rectangular shape, with straight anterior margin and with the anterior angles right angles. Along each side of the base of the dorsal fin lies a row of obliquely linguiform scales, with the exposed part obliquely triangular (fig. 229, *a*). We shall meet with similar scales in the following family, as well as a certain resemblance in the cucullate shape characteristic of the duct in the scales of the lateral line (fig. 229, *b*).

The coloration of the body is determined by the horn-yellow tint of the scales; but the inner surface of their exposed (posterior) part is lined with a thin coat of silvery lustre, which gives to the sides of the body an iridescent gleam of silvery, golden, or brassy hue. The back is darker, brownish; the belly "silvery white, with a reddish lustre" (HANSSON). The adipose membrane on the head is yellowish, but under it the cheeks and opercula gleam with a silvery lustre. The fins share in the general coloration, being of a grayish yellow or paler (whitish, according to KRØYER). The adipose fin is yellow, but at the base of the same colour as the back.

The abdominal cavity, and the pharynx forward to the root of the tongue, are black; but the black lining of the peritoneum has a silvery layer underneath. In all our specimens, however, the viscera are so greatly damaged that we cannot describe them with any minuteness.

The Greater Siil-Smelt belongs to the deep—though probably not to the deepest—parts of the North Atlantic. In company with the Norway Haddock (*Sebastes*) it lives off the Norwegian coast (ASCANIUS, STRÖM, and NILSSON) and off the east coast of North America (Sable-Island Bank off Nova Scotia, BROWN-GOODE and BEAN) at a depth of about 80—200 or 300 fathoms. The deep fjords of Norway afford it a constant abode. In the Skager Rack it is occasionally found. Like other deep-sea fishes it is sometimes suddenly carried in some way or other to depths where the pressure is inadequate to its requirements, and it is then borne helplessly to the surface, where it drifts about, unable to regain its home. Under these circumstances it has been cast ashore on the west coast of Jutland. It has most frequently been met with in the neighbourhood of Bergen; but its range extends, according to COLLETT, from the entrance of Christiania Fjord along the whole coast to Tromsö. According to STORM it is not rare in Trondhjem Fjord, and has been found, especially in late years, at several places in the fjord, to the very head thereof. In the Skager Rack, off Dynekil, between the Koster and Tisler Islands, a specimen was caught on a long-line in November, 1890, which was forwarded to the Royal Museum by Mr. C. A. HANSSON, and which is represented in our figure. From the Skaw to the extreme south of the west coast of Jutland three specimens have been found, according to WINTHER and PETERSEN, since 1871. The species consequently seems to have the southern limit of its range here in the deeper, northern part of the North Sea, for farther south it has never been met with.

Of the Greater Siil-Smelt's habits we know no more than of the life led by most deep-sea fishes. As a rule the stomach is forced into the pharynx when the fish is secured, so that nothing can be ascertained as to its food from the contents of the stomach. But to judge by its mouth, which calls to mind the Grayling, its dentition, which is somewhat more powerful than the Graylings's, and its fairly coarse gill-rakers, its predatory habits are as marked as those of the said species, and we know that it takes a hook baited with mussels (*Mytilus*, according to NILSSON) or a bit of fish (Herring, according to OLSSON). It is fat, and its flesh is said to be of good flavour. Sometimes a score or so are exposed for sale in the fish-market at Bergen; but else it is taken far too seldom to be of any economical importance to the fisherman.

THE HEBRIDAL SIIL-SMELT (SW. STRÖMSILLEN).

ARGENTINA SPHYRÆNA

Fig. 230.

Base of the anal fin perceptibly greater than the longitudinal diameter of the eyes, and more than $^1/_2$ the length of the head reduced. Height of the dorsal fin more than $^2/$[illegible] of the preabdominal length. Lower posterior margin of the operculum indented in an elongated S-form. Gill-rakers on the first branchial arch about 13 or 14. Branched rays in the pectorals 12 or 13, in the ventrals 9. Scales transparent, with a rich coat of silvery pigment on the inner surface.

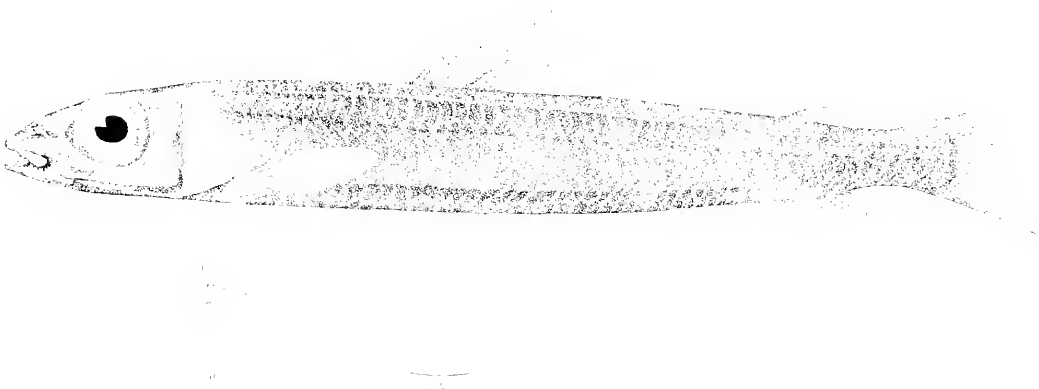


Fig. 230. *Argentina sphyræna*, ♀, natural size. Taken on a long-line off Helsö, near Strömstad, on the 12th Dec., 1879. C. A. HANSSON. *a*, one of the scales in the lateral line, magn. 2 diam.; *b*, section of the body just in front of the ventral fins, natural size.

R. br. 6; *D.* $\frac{3^a}{8}$; *A.* $\frac{5}{10}$; *P.* $\frac{1}{12-13}$; *V.* $\frac{(1)1}{9}$; *C.* $c+1+17+1+c$; *Lin. lat.* 58; *Lin. transv.* $\frac{3}{3}$ 1; *Vert.* 51[d]—52.

Syn. Sphyræna parva sive Sphyrænae secunda species, RONDEL., *De Pisc.*, lib. VIII, cap. II, p. 227. Pisciculus Romae Argentina dictus, WILLUGHB., *Hist. Pisc.*, p. 229. RAY, *Syn. Meth. Pisc.*, p. 108. *Argentina*, ART., *Ichthyol.*, *Gen. Pisc.*, p. 8; *Syn. Pisc.*, p. 17.

Argentina Sphyræna, LIN., *Syst. Nat.*, edit. X, tom. I, p. 315; BRUNN., *Ichthyol. Massil.*, p. 79. CUV., Mém. Mus., vol. I, p. 228, tab. 11, fig. sup.; RISSO, *Hist. Nat. Eur. Mér.*, tom. III, p. 462; ESM. in NILSS., *Skand. Faun. Fisk.*, p. 476; GTHR., *Cat. Brit. Mus.*, *Fish.*, vol. VI, p. 205; CANESTR., *Faun. D'Ital.*, part. III, p. 129. COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 171; 1879, No. 1, p. 92; N. Mag. Naturv. Chrnia, Bd. 29, p. 109. MALM, *Gbgs. Boh. Fn.*, p. 550; HANSSON, Öfvers. Vet.-Akad. Förh. 1880, No. 4, p. 22. MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 554; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 136, tab. CXXV; STORM, Vid. Selsk. Skr. Trondhj. 1883, p. 29; SM., Vet.-Akad. Handl., Bd. 21, No. 8, p. 196; LILLJ., *Sv.*, *Norg. Fisk.*, vol. II, p. 692.

Argentina Silus, NILSS. (p. p.), *Obs. Ichthyol.*, p. 7. EDW., Journ. Lin. Soc., Zool., vol. XV (1881), p. 334.

Osmerus Hebridicus, YARR., *Hist. Brit. Fish.*, ed. 1, Suppl. II, p. 16; NILSS. (*Argentina*), *Skand. Faun. Fisk.*, p. 474; GTHR., *Cat.*, l. c.

Argentina Cuvieri, CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 413 + *Arg. leioglossa*, p. 417, tab. 624 (vide GIGLIOLI,

[a] $\frac{1-2}{8-9}$ according to DAY.

[b] $\frac{2-3}{9-10}$ " " "

[c] 52—53, according to NILSSON and GÜNTHER.

[d] Sometimes 50, according to NILSSON.

Espos. intern. Pesca Berlin 1880, Sez. Ital., p. 102) + *Arg. quirelli*, p. 448.

Goniosoma argentinum, Costa, *Faun. Regn. Nap.*, Malacotterigii Abdominali, Genere Goniosoma, tab. XXXVI.

Argentina decagon, Clarke, Trans., Proc. N. Zeal. Inst., vol. XI (1878), p. 295, tab. XIV, fig. infer. (vide Day, l. c.).

(?) *Argentina elongata*, Hutton, Ann., Mag. Nat. Hist., ser. 5, vol. III, p. 53; Günth. *Deep Sea Fish.*, Chall. Exped., p. 218, tab. LV, fig. B.

The Hebridal Siil-Smelt attains at most about half the length of the preceding species[a]. It is besides, in most cases, of a more elongated form, the greatest depth in adult specimens — with the exception of gravid females — being about 13 % of the length of the body; but in this respect there is no constant distinction[b]. In other respects too both species are so like each other that the essential differences are but few. The Hebridal Siil-Smelt has a comparatively longer anal fin, a higher dorsal fin, smaller eyes and less developed adipose membrane on the head — it is no true deep-sea fish — fewer rays in the pectoral and ventral fins, fewer scales, vertebrae, and gill-rakers, but a somewhat longer peduncle of the tail (behind the adipose and the anal fins). To these we should add a characteristic first remarked by Lilljeborg, the faint S-shaped curvature of the lower posterior margin of the operculum in the Hebridal Siil-Smelt. But in coloration this species differs widely from the Greater Siil-Smelt, owing to its thin and more silvery scales, most of them deciduous.

The length of the head in adult specimens is somewhat less than $^1/_4$ of that of the body, the longitudinal diameter of the eyes rather more than $^1/_4$, and the postorbital length about $^2/_5$, of the length of the head. The forehead is flat, the supraorbital parts being hardly at all tumid, but their outer margins indented in a rounded manner above the middle of the eyes. The nostrils lie rather near to the orbits, and they are of fairly equal size, or the anterior is even a little larger than the posterior. They are circular, or oblong in the longitudinal direction of the body. The breadth of the snout at the nostrils is perceptibly less than the width of the interorbital space, and its length is about equal to the longitudinal diameter of the eyes. The jaws are relatively somewhat shorter than in the Greater Siil-Smelt, the length of the maxillaries being about 19 %, that of the lower jaw about $30^1/_2$ %, of the length of the head. The transverse row of palatine teeth is sharply defined at both ends, the margin of the palatine bones being indented just behind them. The gill-rakers are not only more scattered but also comparatively shorter than in the preceding species. The pseudobranchiæ are rather large here as there.

The height of the dorsal fin is about equal to the length of the head reduced, or nearly 18 % of the length of the body, and perceptibly more than twice the length of the base of the fin. Here too the anal fin begins at the termination of the third quarter of the length af the body, but the length of its base is nearly $^2/_5$ of that of the head. The adipose fin begins above the 2nd or 3rd branched ray in the anal.

The pectoral fins, the length of which is about $13^1/_2$ % of that of the body, are rather shorter, the ventrals, on the other hand, somewhat longer, than in the preceding species, the length of the latter being only about $^1/_{10}$ less than that of the former.

The form of the scales varies as in the preceding species, but their spines are less developed.

In fresh specimens, according to Edward, the body is so transparent that on holding it up to the light the vertebrae can be distinguished. The divisions of the brain are even more distinctly visible through the parietal and frontal bones than in the preceding species. The back is of an olive gray, the sides and opercula are silvery, the former, however, according to Edward, with different shades of colour between the several longitudinal ridges. The space between the two ridges nearest to the back is of a deep amber, the next strip greenish blue, the third space, just below the lateral line, silvery white with a bright metallic lustre; the lower spaces are similar to the upper, but their colours are fainter. The belly is then grayish white, with a dash of greenish blue and purple. The fins are for the most part transparent, the dorsal pale gray, the anal white, the caudal of a deeper gray, with "a dark longitudinal mark along either lobe near to its outer edge" (Day). The paired fins are pale, "of a faint rose colour" (Moreau). "A black spot on the upper edge of the orbit, and a smaller one on the snout" (Day).

[a] According to Moreau the ordinary length of this species in the Mediterranean Sea is 14—20 cm. Collett's largest specimen from Norway was 265 mm. long.

[b] Collett states as a change of growth that, in young specimens (with the length of the body to the end of the caudal lobes less than 15 cm.), the greatest depth is about $^1/_8$, in the oldest specimens (more than 21 cm. long) about $^1/_6$, of the said length of the body.

The abdominal cavity of this species too is black, but the pharyngeal cavity white with a coat of silver. The black pigment of the abdominal cavity, which here too rests on a layer of silvery colour, extends to the stomach, which bends abruptly downwards and forwards in about a line with the tips of the pectoral fins. Close up to the diaphragm the intestine bends no less abruptly downwards and backwards, to the right of the liver, which is comparatively small, and it is there furnished with rather long and thick appendages, varying, as it appears, in number. NILSSON counted 14—20 of these pyloric appendages, we have found 12, and MOREAU found 10—12: WILLUGHBY (RAY) counted 6 or 7, and DAY only 5. The intestine then runs in a straight line to the vent, just in front of the anal fin. The gall-bladder is thin-walled and oblong. The spleen is triangular and lies behind the stomach. The air-bladder is long and fusiform, pointed at both ends, and seems here, as in the preceding species, to be without connective duct with the œsophagus. It has long been remarked for the rich, highly lustrous coat of silvery pigment both without and within its thick wall.

In the North the Hebridal Siil-Smelt is best known as an inhabitant of Christiania Fjord, where it was also first observed, by ESMARK. From this fjord, says COLLETT, where it is caught in Sprat-seines and nets, sometimes in hundreds at a single haul, it is brought almost daily during autumn to the Christiania market. In winter solitary specimens are hooked on the clayey bottom. It was in this manner that the specimen represented in our figure was secured, the only authenticated instance of the occurrence of this species on the Swedish coast. The said specimen was caught on a Haddock-line off Helsö, 3 miles from Strömstad, about Christmas, 1879. Along the Norwegian coast the species has been met with at several places, though in no great number, up to Trondhjem Fjord, where it bears, according to STROM, the name of *Starsild*. *Stromsild* (*Stream Herring*), the name by which it is known in Christiania Fjord, is derived, according to NILSSON, from the circumstance that "the young at least, like young Herrings, at certain seasons enter the mouths of the rivers, and are found at the outlets of the streams." On both sides of Scotland and off the Yorkshire coast solitary specimens have been taken; but the species is most common and has longest been known in the Mediterranean, on the coasts of Italy and France. As we have already mentioned, it has also been found on the coast of Algiers; and it apparently belongs to the New Zealand fauna, far from its European home. Its bathymetric range extends to a depth of at least 200 fathoms, for MALM received three specimens which had been found in the stomach of a Ling caught at that depth on the fishing-bank of Storegg off the Norwegian coast.

In the stomach of the Hebridal Siil-Smelt EDWARD discovered small crustaceans and *Sertulariæ*, COLLETT Anneloids. But as it is also hooked on lines set for Haddock and the smaller Codfishes, it apparently feeds like them on mollusks and, probably, on small fishes. It is a sociable and lively fish, and in the seine it wriggles till the scales fall off; but after this, says COLLETT, it floats about helplessly at the surface. Of its spawning-season widely different accounts are given. According to RISSO it breeds in the Mediterranean in spring, and appears on a sandy bottom in April. YARRELL mentions a female, 8 inches in length and full of roe, that was taken on the west coast of Scotland in June. On the east coast of Scotland EDWARD caught a male fairly full of milt in October. COLLETT received from the neighbourhood of Stavanger a gravid female taken in June; but in Christiania Fjord he found the females full of roe in October. The female caught by HANSSON had extremely small eggs in December, but did not seem to have spawned in the course of the autumn, in which case the ovaries would probably have been still more shrunken[a].

In Scandinavia the Hebridal Siil-Smelt has never been put to any practical purpose, except perhaps as bait on a long-line or hand-line. Its flesh is good, according to RISSO, but its cucumber-like smell perhaps uninviting. Greater advantage has been taken of this fish in Italy. There the silvery pigment of its air-bladder and scales has long been collected to afford material, under the name of *essence d'orient*, for the manufacture of imitation pearls, as we have above described when treating of the Bleaks.

[a] Cf. SMITT, *Riksmusei's Salmonider*, tab. metr. VII.

Fam. SCOPELIDÆ.

Form of the body variable, generally Herring-like but also irregular (strongly compressed and deep). Scales, where present, thin, middle-sized or large. Sides of the body (in all the Scandinavian forms but one[a]) furnished with luminous spots. Dorsal margin of the tail furnished with an adipose fin. Margin of the upper jaw formed either by the intermaxillaries alone or partly (behind) by the maxillaries as well. No barbels. Air-bladder, where present, simple and without connexion with the cranial cavity. Branchial cavity (in all the Scandinavian forms) furnished with pseudobranchiæ. Ovaries with oviduct.

Most of the fishes belonging to this family have a common characteristic which is connected with their manner of life, and of which we have seen no instance among the preceding fishes. Nearly all the Scandinavian Scopeloids and most of the others possess organs by means of which they more or less voluntarily emit a phosphorescent light, and which are therefore known as *luminous spots*. As a physical reflex or a chemical phenomenon such phosphorescence is found in certain plants; as a real manifestation of a vital function it is not uncommon in the animal kingdom. Many — if not most — of the lower and the lowest marine animals are phosphorescent; and among the higher evertebrata the glow-worm (*Lampyris*) is familiar to us all. In the glow-worm the light extends not only to the fatty bodies in the abdomen, but also to the eggs, i. e. the fat of the yolk, and consequently this phenomenon — in the last case at least — is not unconditionally an attendant of nervous activity. Nor is this the case with the light that radiates from the dermal mucus of certain Batrachians[b], though the more copious secretion thereof produced by irritation is subject to the control of the nerves. Among fishes too, in some of the organs more highly developed for phosphorescent purposes, the light seems to be at least partially independent of the immediate action of the will. But in some fishes special nerves have been found whose extension in these organs suggests that the light radiates in the direction chosen by the fish and at the moment when the fish desires its aid.

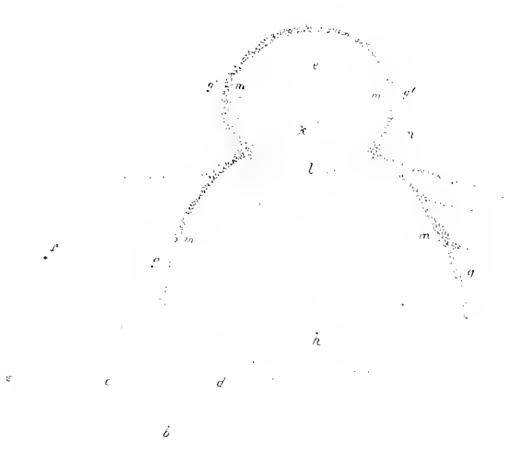
In their more developed forms the luminous spots closely resemble the so-called parietal organ of lower fishes, Batrachians, and reptiles. Together with the said organ they have been included among so-called ocellate organs; and where it has been declared with certainty that a special nerve for such an organ might be traced, their function may best be compared to that of electric or pseudoelectric organs, i. e. that, as nervous force by means of fine nerve ramifications upon a so-called electric plate excites electricity in a finely granular mass (a transformation of the sarcoplasma of a muscular cell) on each side of an elastic plate (a transformation of the rhabdia — rod-substance — of a muscular cell), so the nervous force of the luminous spots, by its action upon a strongly refractive and coagulant mucus (a transformation of cells in a slime-gland of the skin), causes this mucus to burn and shine.

In their simplest form the luminous spots are described by Lendenfeld[c] as depressions or elevations of the skin, scattered or distributed in rows on the surface of the body, the smaller (0·1—0·3 mm. in diameter) without pigment, the larger (0·3—0·5 mm. in diameter) with a layer of pigment within their base. They are then covered only by the thin epidermis, and are furnished with nerves and fine capillary vessels from the skin. Internally they are indeed hollow; but the inner surface is lined on the outer part (distally) with a layer of closely packed fusiform cells, at right angles to the skin, and on the inner part (proximally) with a layer of gland-tubes, arranged in a similar concentric manner and closely packed. These tubes are closed and rounded at the basal (proximal) end, open towards the centre of the organ, and full of gland-cells, which secrete the granular mass that fills the hollow in the centre. This mass, a strongly refractive and coagulant slime, is produced by an immediate

[a] The obscure and extremely rare *Sudis atlanticus*.
[b] Boie, Isis 1827, p. 726.
[c] Günther *Deep Sea Fish.*, Rep. Voy. Challeng., Zool., vol. XXII, App. B.

transformation and dissolution of the gland-cells, which are afterwards ejected through that end of the tube which opens into the hollow.

From this comparatively simple structure, which as yet reminds us of slime-glands of the skin, the first step to higher differentiation is that, as the sac deepens more and more, its inner (bottom) part is separated by a constriction of the wall and becomes spherical in shape, while the outer part remains more or less regularly cup-shaped, a rotation-paraboloid with circular mouth, in which case the axis is vertical to the surface of the body (fig. 231), or elliptical and more or less elongated[a], in which case the axis is obliquely set. Throughout the wall of the organ, within the layer of pigment, lies an extremely thin, but powerfully refractive membrane (*m*), which even extends over the mouth of the organ, where we also find a double membrane, consisting of an inner, cellular leaf (*d*) and an outer, structureless one (*c*) explained as a kind of lens, and situated within the thin, structureless epidermis (*b*), which has been compared to a cornea. The internal structure is otherwise essentially the same as in the simpler luminous spots — though both connective tissue and nervous elements enter more plentifully into its composition — but the shining mass (*k*) here lies as a more or less lens-shaped body in the annular constriction between the spherical (inner) and cup-shaped parts of the organ, forming a disk between these two parts but itself divided into two parts (*k* and *l*) by a thin membrane, which is distended like a diaphragm right in the constriction. To this disk run the extreme ramifications of the spinal nerve (*n*)



A

B

Fig. 231. *A:* Section of a compound luminous spot in *Astronesthes niger*, × 100. After LENDENFELD.

b, cornea-like, transparent part of skin over the organ; *c*, transparent membrane outside the lens-shaped body *d*; *e*, gland-tubes of the spherical part; *f*, pigment layers; *g* and *g'*, pigment coating of the outer and inner parts of the luminous body; *h*, gland-tubes in the outer part of the luminous body; *k*, granular mass and cells, inner part; *l*, outer part; *m*, shining membrane within the pigment layer; *n*, nervous cells.

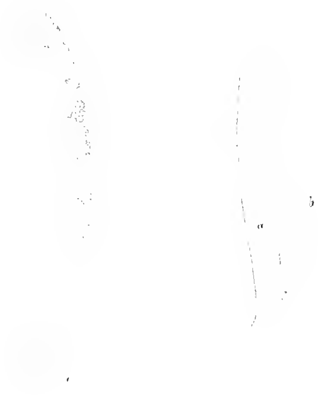
Fig 231. *B:* Diagrammatic section of the luminous spot represented in fig. *A*, showing the reflection and refraction of the rays of light in the luminous spot. After LENDENFELD.

a_1—a_4 and b_1—b_4, rays of light emitted from the central part (*k*) of the luminous spot and reflected in the lower, spherical part of the same; c_1—c_3, d_1—d_3, e_1—e_4, and f_1—f_3, rays of light from the same source, emitted in a centrifugal direction, reflected from the sides of the outer, parabolic portion of the organ, and refracted by passing through the cornea-like layer (*g*); xx_1, axis of the optical system; *g*, cornea; *h*, shining tissue of the outer, parabolic part; *i*, glands of the inner, spherical part.

[a] See for example the upper spots in our figure of *Argyropelecus Olfersii*.

that innervates the organ; and the rays of light emitted from the shining mass are reflected, as shown in fig. 231, *B*, collected in a cone and concentrated at their exit through the dermal lens.

These luminous spots[a] regularly appear, among the fishes now under consideration (see for example our figure of *Maurolicus Mülleri*), in two rows, an upper and a lower, along each side of the body. In their more highly developed form, which consists mainly in the addition of a more powerful reflecting apparatus[b], it is the rule, however, that the upper row breaks up into two or more groups of 3—6 spots gathered in a row, and more or less entirely coalescent internally (with the elsewhere spherical parts). Similarly



A *B*

Fig. 232. *A*: The confluent lower abdominal spots of *Sternoptyx diaphana*, twice the natural size, and seen from below. *a*, ventral fins. After LENDENFELD.

Fig. 232. *B*: Section of the luminous spots shown in fig. *A*. *a*, basal canal; *b*, outer parabolic cups. After LENDENFELD.

the inner parts of the luminous spots in the lower (ventral) row frequently coalesce; and this confluence may extend to still more spots, even till the spots on one side of the body coalesce with those on the other. This is the case, for example, with the luminous spots set at the very edge of the belly, in front of the ventral fins, in *Argyropelecus Olfersii*. Here the inner parts of 12 pairs of luminous spots coalesce, forming a common, longitudinal, basal canal (cf. fig. 232, *B*, *a*), while the outer (distal) parts of each spot (cf. fig. 232, *B*, *b*) remain independent on each side of the sharp median carina of the ventral margin (cf. fig. 232, *A*). Besides the above-mentioned reflecting apparatus, which lies within the pigment layer, and which here consists of a comparatively thick layer of closely packed and prismatic, calcareous spicules, LENDENFELD has described, from the outer (cup-shaped) portions of these organs, cylindrical and prismatic structures within the refracting mass (analogous in situation to the above-mentioned gland-tubes). In these structures he distinguished two kinds of radiating cells, one of them elongated and club-shaped, with an oval, highly refracting body (probably a vesicle) in the thicker, distal end; and these cells, the proximal peduncles of which he supposes to be in direct connexion with the nervous fibrils, are in his opinion "the special phosphorescent elements".

These more highly developed luminous spots appear not only on the sides of the body in longitudinal rows, but also on the halves of the lower jaw and on the branchiostegal membrane. The largest of them are isolated shining spots on the sides of the body, on the dorsal or the ventral margin of the tail, or on the head, especially below the eyes, on the snout, and on the forehead. The large suborbital spots that occur in certain species are innervated by a special branch of the fifth pair of cranial nerves. That their function is subordinated to the will of the fish, seems therefore indubitable. LENDENFELD explains their purpose as twofold: 1) the illumination of the water round the fish, whether their possessor be seeking food in the dark abysses of the ocean or at the surface in the night-time — possibly too as a signal between the sexes during the spawning-season — 2) the intimidation of a pursuing enemy, when a sudden flash of light may save the fugitive. The latter interpretation applies in particular to the luminous spots situated on the hind part of the body.

The parietal organ of Amphibians and reptiles, according to our present knowledge of its structure, seems also capable of explanation as a luminous spot. The largest luminous spots known are found in a deep-sea fish of the Scopeloid family, *Ipnops Murrayi*[c], whose

[a] Composite, ocellar, phosphorescent organs, without reflector, LENDENFELD.

[b] Composite, ocellar organs, with special reflector, LENDENFELD.

[c] GÜNTHER, *Deep Sea Fish.*, l. c., p. 190, pl. XLIX, fig. B, and MOSELEY, ibid., App. A, pl. LXVII and LXVIII.

eyes and optic nerves are entirely aborted, the fish being consequently quite blind[a]. But under the extremely thin and transparent roof of the skull (answering to the parietal and frontal bones, which are hardly distinguishable), and forward over the wide palatine arch, thus extending above nearly the whole surface of the flattened head to the posterior limit of the nasal region, there lie a pair of lamelliform luminous spots, separated from one another by a longitudinal median septum rising from the roof of the mouth. Above each of these luminous spots run both the frontorostral branch of the cephalic system of the lateral line and the nasal branch of the fifth pair of cranial nerves. The position of these luminous spots is thus, like that of the parietal organ, intracranial. With regard to their function GÜNTHER remarks: "The power of producing light, and thereby attracting other creatures, must be of great use to a fish, which, deprived of organs of sight and touch, would be unable to procure its food."

As we have mentioned above (p. 826, note *f*), GÜNTHER[b] has proposed to range the Scandinavian members of this family in two families, the *Sternoptychidæ* and *Scopelidæ*. But the difference between these two families is hardly appreciable. They occupy an intermediate position between the Salmonoid and Clupeoid families. In common with the former they possess an adipose fin behind the true dorsal fin, and their ovaries, like those of the latter, are furnished with a special oviduct. The adipose fin is often very small, but in most cases furnished with fibrillous (cartilaginous) rays. The distinction adopted by GÜNTHER consists merely in the greater or less length of the intermaxillaries, the posterior part of the margin of the upper jaw being formed in his *Sternoptychidæ* by the maxillary bones. But these bones often coalesce so closely with the intermaxillaries that the limits between them can hardly be detected. The utility of the character is thus considerably reduced. On the other hand it happens, in GÜNTHER's *Scopelidæ*, that the hind part of each intermaxillary bone is firmly applied to the outer surface of the maxillary, above the lower margin of the latter. Consequently the said margin may form part of the margin of the upper jaw in this family as well, though in such instances it is toothless. We therefore prefer the older opinion, embraced in recent times by MOREAU[c] and retain the Scopeloid family in its entirety. It then contains about eighty species of marine fishes, most of them deep-sea forms or nocturnal surface-fishes but some belonging to the littoral regions of the tropic seas. The Scopeloids belonging to the Scandinavian fauna may be distinguished as follows:

1: Snout shorter than the postorbital part of the head. Dorsal fin situated about half-way along the body.
- *A*: Abdominal part of the body exceedingly deep and compressed: its ventral margin sharp and separated by an abrupt break from the under surface of the tail. (Subfamily *Sternoptychinæ*) — *Argyropelecus Olfersii*.
- *B*: Abdominal part of the body passing uniformly (without sharp break) into the caudal part, and with more or less terete ventral margin.
  - *a*: Maxillaries furnished with teeth behind, and entering into the structure of the margin of the upper jaw. (Subfamily *Cocciinæ*) Preabdominal length greater than the postabdominal .. .. — *Maurolicus Mülleri*.
  - *b*: Maxillaries toothless, and as a rule forming no part of the margin of the upper jaw (Subfamily *Saurinæ*). Preabdominal length less than the postabdominal.
    - *α*: Length of the base of the dorsal fin more than $1/5$ of that of the body. Longitudinal diameter of the eyes less than $1/2$ of the postorbital length of the head — *Myctophum elongatum*.
    - *β*: Length of the base of the dorsal fin less than $1/6$ of that of the body. Longitudinal diameter of the eyes more than $1/2$ of the postorbital length of the head — *Myctophum glaciale*.

2: Snout longer than the postorbital part of the head. Dorsal fin situated far back (Subfamily *Paralepidinæ*). No luminous spots — *Sudis atlanticus*.

[a] Also without olfactory nerves, according to MOSELEY.
[b] *Cat. Brit. Mus., Fish.*, vol. V, pp. 384 and 393.
[c] *Hist. Nat. Poiss. Fr.*, tome III, p. 491

SUBFAMILY STERNOPTYCHINÆ.

Body of a singular irregular form, deep and compressed, especially in the abdominal part, whose sharp ventral margin is abruptly cut off by a posteriorly ascending break (postabdominal part) from the under surface of the tail. Cleft of the mouth sharply ascending. Snout shorter than the postorbital part of the head.

By its singular form of body, deep as that of the Dory or the thinnest Carangoids, but with an abrupt break in the inferior profile between the abdominal and caudal regions, this subfamily is so well distinguished from all other fishes that no detailed diagnosis can be necessary. The resemblance in the form of the body to *Zeus* (see above, p. 305, note *a*), and the similar structure of the ventral margin in *Trachichthys*, a Berycoid form (see LOWE, *Fish. Madeir.*, p. 64), have suggested that these fishes should be included among the Acanthopterygians. But merely their luminous spots and the distribution thereof ought, at the first glance, to assign them to their right place, beside the other Scopeloids. Only four species, distributed among three genera, are known with certainty. All are nocturnal surface-fishes, which by day descend to some depth below the surface, but at night ascend to higher strata. They belong to the basins both of the Atlantic and the Pacific, strictly to the warmer regions thereof; but on the Norwegian coast is occasionally found a species of the

GENUS ARGYROPELECUS[a].

Forepart of the back surmounted by an erect, thin and transparent, osseous structure, resembling a dorsal fin, and composed of the neural spines of the anterior abdominal vertebræ and their chondrified interspaces. Jaw-teeth set in one row.

Of this genus, which is known exclusively from the Atlantic and the Mediterranean, VALENCIENNES[b] has indeed adopted four species; but two of them are known only from his somewhat defective descriptions, and the other two come extremely near to each other.

[a] COCCO, Giorn. Scienc., Lett., Art. Sic., No. 77, Palermo 1829. The name signifies, according to AGASSIZ, *with silver helmet* (ἄργυρος, *silver*, and πήληξ, *helmet*). To COCCO's paper we have not been able to refer.

[b] CUV., VAL., *Hist. Nat. Poiss.*, tom. XXII, pp. 392, seqq.

ARGYROPELECUS OLFERSII

Fig. 233.

Length of the maxillaries about equal to the horizontal length of the head[a]. *Distance between the dorsal fin proper and the tip of the snout about half the length of the body, but perceptibly less than the greatest depth of the body, which is about* $^3/_5$ *of its length, and only slightly less than (at least* $^9/_{10}$ *of) the distance between the ventral fins or the anal fin and the tip of the snout. Length of the base of the dorsal fin proper about equal to the vertical diameter of the eyes*[b], *and the least depth of the tail about* $^1/_3$ *of the said diameter*[c]. *Silvery lustre of the body extending over the sides of the tail.*

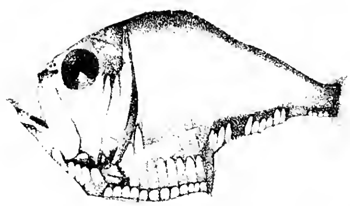


Fig. 233. *Argyropelecus Olfersii*, natural size. Taken off Hægholm, near Bergen, on the 28th Jan., 1890. Specimen in the possession of the Bergen Museum.

R. br. 9; *D.* 9; *A.* 12; *P.* 10; *V.* 6; *C.* $x+1+18^d+1+x$.

Syn. Sternoptyx Olfersii, Cuv., *Règn. Anim.*, ed. 2, tom. II, p. 316, tab. XIII, fig. 2; v. Düb., Kor., Vet.-Akad. Handl. 1844, p. 80, tab. 3, fig. 6; Lowe (*Pleurothyris*), *Fish. Madeir.*, p. 64; (*Argyropelecus*), Proc. Zool. Soc. London 1850, p. 247; Cuv., Val., *Hist. Nat. Poiss.*, vol. XXII, p. 408; Nilss. (*Sternoptyx*), *Skand. Fna. Fisk.*, p. 486; Günth. (*Argyropelecus*), *Cat. Brit. Mus., Fish.*, vol. V, p. 386; Coll., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 149; 1879, No. 1, p. 84; N. Mag. Naturv. Chrnia, Bd. 29, p. 102; Storm, Vid. Selsk. Skr. Trondhj. 1883, p. 29; Günth., *Deep Sea Fish.*, Chall. Exped., p. 167; Lilli., *Sv., Norg. Fisk.*, vol. III, p. 3.

Argyropelecus Olfersii attains, according to Collett, a length of at least 82 mm.; but most of the specimens known are of smaller size. Cuvier's specimen was 68 mm. long. The two specimens that we have been enabled to examine — kindly lent us by the Museums of Christiania and Bergen — measure, from the tip of the snout to the end of the middle caudal rays, respectively 63 and 64 mm., being thus about equal in size to the specimen described by v. Düben and Koren.

The species is one of the most singularly shaped fishes, deep and compressed as a Dory, but, like its congener, with a sharp, posteriorly ascending break in the inferior profile between the abdominal region and the tail. In the abdominal region the depth of the body is about equal to the entire length of the trunk, or about 58—62 % of the length of the body; whereas at the vent the depth is only half of the greatest depth, and about equal to the length of the tail. The least depth, in front of the supporting (spinous) caudal rays, is only about $^1/_{10}$ of the length of the body. The thickest part of the body is the head. According to v. Düben and Koren, the thickness is greatest in the inferior part of the body; but in our specimens it is fairly uniform almost throughout the sides of the head, measuring across the upper articulations of the preopercula about $^1/_5$ of the length of the body or 43—46$^1/_2$ % of the length of the head. Both the dorsal and the ventral margins are compressed and, in part, sharp, the latter, however, from different

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[a] Somewhat greater or less; in *Argyropelecus hemigymnus* only about $^3/_4$ of the said length.

[b] In *Argyropelecus hemigymnus* about $^2/_3$ thereof.

[c] " " " " $^1/_2$—$^2/_3$ "

[d] 17, according to v. Düben and Koren. In *Argyropelecus hemigymnus* we have counted 16.

causes. In front of the dorsal fin the dorsal margin rises in a transparent, cartilagino-osseous carina, resembling an anterior, posteriorly ascending dorsal fin, but formed by the produced and coalescent tips of 7 neural spines. The ventral margin, on the other hand, is sharpened at the isthmus, in the abdominal region, in the region of the anal fin, and just in front of the caudal fin, by the median carina between the rows of luminous spots situated at these points, a structure most nearly corresponding to the ventral carina of the Herrings. But between the ventral fins and the anal fin the ventral margin is channelled by a groove open below. In the rest of their extent the margins of the body are indeed thin, but blunt. The dorsal profile follows a fairly regular curve in front of the true dorsal fin, but from the beginning of this fin it slopes almost in a straight line, until, at the caudal fin, it becomes horizontal. The ventral profile is even more sharply curved in front than the dorsal; but behind the above-mentioned break it ascends at the same angle as that formed by the dorsal profile in its descent, though with a perceptible break at the end of the anal fin.

The head is deeper than long. Its singular shape is due to the short snout, the vertically ascending cleft of the mouth, and the deep, but short opercular apparatus; and to these we should add the comparatively deep isthmian region, which extends under the greater part of the length of the head. At the top the head is convex from the occiput to the snout, but flat and grooved in the middle, with a sharp, longitudinal carina on each side, and strongly constricted between the eyes. Its length in an horizontal direction from the middle of the tip of the snout measures in our specimens about 28—29 % of the length of the body. The eyes are rather large and round, the vertical diameter being only a little greater than or equal to the longitudinal, and varying in our specimens between 43 and 45 % of the length of the head, or about $^1/_8$ of that of the body. They are set high, their upper margin rising almost to the frontal plane, and so near to each other that the least interorbital width is only $^1/_4$ of their vertical diameter. The postorbital length is only about $^1/_3$ (32—34 %), and the length of the snout rather more than $^1/_4$ (27—28 %), of the length of the head; and the lower margin of the pupil lies on a level with the tip of the snout or a little higher. The suborbital ring is represented only by an extremely thin, oblong, lamelliform, and vertically set preorbital bone, which coasts the anterior margin of the eye. The nasal cavities are oblong, and lie close to the anterior upper corners of the orbits and below the knob-shaped tip of the ethmoid bone. The nostrils are divided on each side by a thin, but flat septum of skin, without any elevation of the margin.

The mouth ascends almost vertically, and the tip of the upper jaw projects slightly beyond the ethmoid (rostral) tip, but admits of hardly any protrusion. The nasal processes of the intermaxillaries are short, and the latter bones, each by means of its lateral branch, are so firmly united to and coalescent with the maxillaries that the limit between them is distinct only in front, for a distance measuring about $^1/_4$ of the diameter of the eyes. The motion of the intermaxillaries is thus reduced to a considerable extent: they can only follow the forward and backward swing of the maxillaries. How far the margin of the upper jaw is formed by the intermaxillaries, it is impossible to determine without dissection, an operation of which our materials have not permitted. But the whole margin of the upper jaw is set with a row[a] of pointed, subulate and curved teeth, rather scattered and small, but of various sizes. The last four or five teeth[b] are directed forwards, the anterior ones pointing backwards. The maxillary bone, which is extremely thin, reminds us most, both in shape and structure, of that of the Herrings. Just behind (below) the constricted articular part it is curved like a sabre at the very margin of the mouth, but from this point back it is straight and of uniform breadth, forming an oblong rectangle. The median space, however, is not ossified, but consists of a silvery skin, distended between the true maxillary bone and its supplementary (jugal) part, which coalesces behind with the maxillary, and which extends, in the form of an osseous rod, forward to the articular part. The entire length of the maxillary is somewhat more than $^1/_4$ (about 26—29 %) of the length of the body, and its breadth in the oblong part about $^1/_4$ of its own length. The lower jaw is about equal in length to the maxil-

[a] Sometimes we find in front, on the intermaxillaries, a tooth or two lying inside or outside this row.

[b] Situated on that part of the upper jaw which, when the mouth is wide open, lies outside the branch of the lower jaw, and thus below the true cleft of the gape. In *Argyropelecus hemigymnus* the length of the intermaxillaries may be traced backward to this point, which there answers to about the middle point in the length of the maxillaries.

laries. Each of its two branches resembles an acute-angled, isosceles triangle, with the short (hind) base turned downwards, where the angular part forms a projecting, spine-like angle. Within (above) and parallel to the thin lower margin runs a ridge on the outer side. The symphysis is straight, and projects downwards in a chin-protuberance, channelled behind. Most of the teeth in the lower jaw, which are also set in a single row, are about twice as large as those in the upper jaw; but one of the anterior teeth on each side is considerably larger than the rest, and at the extreme front, where the teeth are of about the same size as in the upper jaw, they are more distinctly arranged in a double row. The tongue is rudimentary, and the cartilaginous tip of the hyoid bone is smooth, without teeth. Only the upper jaw is furnished with a palatal fold, and this is not very broad. The vomer is toothless, but on the anterior part of the palatine bones, as well as on the upper pharyngeals, small teeth may be felt. The pseudobranchiæ on the inner surface of the opercular and hyomandibular bones form an oblong patch, in which about 14 filiform, transversely set lamellæ may be counted. The gill-slits are large, extending far forward in the mouth; but the upper parts of the hind branchial arches coalesce with the front side of the scapular arch, the hindmost gill-slit thus being closed above and rather short. The gill-rakers are long but scattered, numbering about 14 on the first branchial arch, besides a few small, hardly perceptible spines at the lower (anterior) end. Where the horns of the hyoid bone touch the tip of the basi-hyoid series (the lingual bone), they are furnished with an erect protuberance. The outer gill-openings are large, their upper angle lying on a level with the centre of the eyes, and the branchiostegal membranes being free from the isthmus and united to each other not quite to the full length of the first branchiostegal rays, so that the anterior angle of the openings lies in about a line with the tip of the snout. The branchiostegal rays are slender and rod-like. The first six lie rather near each other, and the first of all is set close to the corresponding ray on the other side; the last three are somewhat larger and set further apart.

The opercular apparatus, in accordance with the shape of the head, is characterized by its height. The vertical arm of the rectangular preoperculum is about three times as long as the horizontal. The preopercular angle is prolongated to a short, flat (thin), triangular spine, pointing downwards. The other opercular bones are extremely thin and flexible. The operculum is rectangular, but forms an oblique articulation above. Its surface is obliquely crossed by a ridge running from the anterior upper corner downwards and backwards. Its breadth is equal to the length of the snout. At its lower margin lies the triangular suboperculum, with a more or less deep indentation behind. Below the latter and below the preoperculum lies the interoperculum, which is divided into two parts, the anterior (below the preoperculum), elongated and united with the branchiostegal membrane only behind, the posterior quadrangular with rounded corners or circular, and entirely coalescent with the branchiostegal membrane, on which it lies like a scale.

The greater part of the head, as well as the rest of the body, is covered with a thin, silvery epidermis; but the upper temporal region, between the eyes and the occiput, is naked, the surface of the bones being finely grooved and granulated.

The fins resemble in quite essential respects those of the Hemibranchs and Lophobranchs. As in the said fishes, the soft rays, which are thin and transparent, with the tips strongly compressed in the longitudinal direction of the body, show but little developed ramification and have only scattered joints[a]. In the supporting apparatus of the paired fins too, we find points that remind us most of the Sticklebacks.

The true dorsal fin is obliquely rounded, the first rays being the shortest, but gradually increasing in length to the fifth or sixth, which is the longest in the fin. It begins at a distance from the tip of the snout measuring about half (50—51 %) of the length of the body, and the length of its base is about equal to the vertical diameter of the eye or a little greater, about $12\frac{1}{2}$—14 % of the length of the body. A little in front of this fin ends the fin-like osseous ridge formed by the projecting tips of 7[b] neural spines belonging to the abdominal vertebræ, together with the thin and transparent, feebly ossified interneural mem-

[a] We are indeed ignorant of the manner of locomotion employed by *Argyropelecus Olfersii*; but from this structure of the fin-rays we may conclude that the fins perform their function by means of vibrations. This is the case, as we have seen above, not only in the Sticklebacks and Pipefishes but also in the Dory, where the second dorsal and the anal fins are furnished with similar rays.

[b] In *Argyropelecus hemigymnus* belonging to the 3rd—9th vertebræ.

brane by which they are connected. The adipose fin behind the dorsal fin is long and low.

The anal fin, which begins just behind the vent, is longer but lower than the dorsal fin proper, and the hind part of its margin is deeply concave. The distance between it and the tip of the snout is about 61—63 % of the length of the body, and its base measures about 17—18 % of the same. In the distribution of the rays we observe that the first seven and the last four are set more or less close together at the base, but that the eighth ray is more widely separated both from the seventh and the ninth, and points straight downwards, its direction thus converging with that of the seventh ray.

The caudal fin is deeply forked. The length of the middle rays is 8 % of that of the body, and appears to be perceptibly less than half (at most about 46 %) of that of the longest rays. At the upper margin of the fin lie 9, at the lower 6, short but comparatively thick and hard supporting rays, the anterior directed outwards (respectively upwards or downwards).

In the suspensory apparatus of the pectoral fins, the uppermost bone, probably answering to the supra-clavicular bone — in which case the posttemporal bone is wanting — is bent at a right angle. Its upper, shorter, horizontal arm is straight and of uniform breadth, attached to the median line of the occiput — not at the side, where the posttemporal bone is attached in other fishes — and its lower, vertical arm, which is somewhat broader and forms a thin expansion in front, rests upon the upper part of the clavicle. The angle between the arms forms a short spine, directed backwards, and both arms are coursed on the outside by a longitudinal groove, bounded by ridges and hollowed into grooves similar to those in the upper part of the temporal region (see above). The ridges and grooves are continued on the outside of the vertical part of the clavicle in front of the pectoral fins, and below the latter the clavicle sends out, in the skin, a backward process, flat and of uniform breadth, but curved upwards like a sabre, and with similar grooves on the outer surface. The inferior part of the clavicle expands forwards and inwards to a thin, vertical blade, projecting straight downwards in a pointed spine, which marks the limit between the sloping isthmian region and the horizontal ventral margin. The pectoral fins are obliquely set; when at rest, they point upwards and backwards. They are rather long, but narrow and obliquely pointed. The third or the fourth ray is the longest, but only slightly longer than the second. The first ray, which is the only simple one, is a little shorter than the second; the last (10th) occupies about $^2/_{11}$ of the length of the fin, which measures somewhat more than $^1/_4$ (26—27 %) of that of the body.

The ventral fins are set undermost on the ascending break in the ventral margin, with their insertions close together and vertically situated, the first ray, which is simple but, like the others, compressed, being thus the lowest, and the under side of these fins in other fishes being here turned inwards[a]. In shape the ventral fins are oval, and their length is about equal to the height of the anal fin, $8^1/_2$—$9^1/_2$ % of the length of the body. The lowest point in their insertions lies at a distance from the tip of the snout measuring nearly $^2/_3$ ($62^1/_2$—65 %) of the length of the body, and the distance between this point and the foremost point in the insertions of the pectoral fins (the preabdominal length) is about 29—30 % of the same length. The postabdominal length, which ascends but breaks off at an angle, measures in a straight line about $14^1/_2$—15 % of the length of the body. The thin pelvic bones, which are vertically set, share in the structure of the septum between the luminous spots of the preabdominal margin. But at the lower posterior corner each of the pelvic bones projects in a spine, and sends out above this spine an ascending process[b] which joins the lower part of the hindmost preabdominal rib, while the lower tips of the preceding ribs touch the squamous growths that enter into the structure of the sharp ventral margin and bear its luminous spots.

The greater part of the body — except the black or grayish brown back — is covered with a thin, silvery skin; but according to v. Düben and Koren scales are also present, though these are thin and deciduous. "These scales are rather large (about $2^1/_2$ mm. long in a specimen 65 mm. in length), smooth with entire margin, and of a bright silvery lustre like their underlayer. Under the microscope they gleam with all the colours of the rainbow, but not even then does

[a] This is also the case, as we have seen above (p. 426), in *Bothina*, but is there due to an entirely different structural peculiarity.
[b] Cf. the analogous structure in the Sticklebacks, see above, p. 635, fig. 157, *A*, *es*.

their surface show any regular streaks or the like." Of the lateral line v. DÜBEN and KOREN saw only a trace, "in the form of an elevated line beginning below the origin of the true dorsal fin, and running along the middle of the body to the base of the caudal fin."

The luminous spots are distributed as follows. On the under side of the lower jaw — on the soft chin[a] — below the tip of the lingual bone, lie two rather undefined spots, which are probably luminous[b], though in this species, to the best of our knowledge, they have not yet been examined. On the ceratohyoid bones, in the skin between the bases of the first (lowest) 7 branchiostegal rays, there are 6 small luminous spots on each side of the body. Behind these each side of the isthmus is furnished with 6 larger luminous spots, gradually increasing in size as the isthmus grows deeper behind. These are succeeded, on each side of the sharp preabdominal margin of the belly, by a row containing 12 luminous spots of fairly uniform size, somewhat smaller than those on the isthmus and smallest at the beginning and end of the row. Above the rows on the isthmus and the preabdominal margin each side of the body bears a row of 10 luminous spots; but this row is interrupted and belongs partly to the head, partly to the abdominal region. One spot lies within the anterior (horizontal) arm of the preoperculum, but spreads downwards over the anterior part of the interoperculum. Another, smaller spot occupies the lower part of the suboperculum and the hind part of the interoperculum. Two large spots adjoin to the hind margin of the clavicle above the insertion of the pectoral fin, and are indeed vertical in direction, but set so that their tops form a continuation of the curve followed by the upper parts of the spots on the isthmus. The remaining six abdominal spots are about equal in breadth to the last-mentioned pair but shorter than they, and lie in a continuous, horizontal row, but lower than the last-mentioned pair. Each of them occupies the space between two ribs, and lies vertically or obliquely above one of the spots in the lower preabdominal row, the penultimate spot, however, being situated above the penultimate two in the lower row, both of which occupy the same intercostal space. The segmental arrangement of the luminous spots is thus not observed with complete uniformity. Each side of the postabdominal margin bears a continuous row of 4 luminous spots. Owing to the singular form of the body these spots are indeed set at the ventral margin, i. e. their lower parts extend thither, but also on a level with the two large spots above the insertion of the pectoral fin. In size they answer most nearly to the spots in the upper preabdominal row, which they also resemble in the circumstance that the spots on one side of the body do not coalesce internally (superiorly) with those on the other side, as is the case with the lower preabdominal row. The postabdominal spots on one side of the body are also separated inferiorly from those on the other: their defining walls do not coalesce below, like those of the preabdominal spots, into a median edge. On each side of the body the walls coalesce into a more or less high, thin rim, and together form in this manner a groove or deep channel, open below, at the hind extremity of which the vent is situated. The luminous spots on the tail form two groups, the one, along the posterior two-thirds of the base of the anal fin, being a row of 6 rather large spots, the 2nd, 3rd, and 4th smaller than the rest, the other a row of 4 smaller spots at the inferior margin of the tail, just in front of the caudal fin. All these luminous spots thus belong to the lower part of the body. Higher up we find, however, an isolated luminous spot on each side of the head, on a level with the tip of the snout. This spot is situated on the uppermost part of the preoperculum, just below its articulation.

The above description of the luminous spots in *Argyropelecus Olfersii* applies in every detail to the analogous organs in *Argyropelecus hemigymnus*, a Mediterranean and Central Atlantic form which in other respects too so closely resembles *A. Olfersii* that it evidently represents a lower stage in the same course of development.

Argyropelecus Olfersii has been named after a Prussian diplomatist who, while on a voyage to Brazil, secured an example of this species that had become entangled among weeds to a lead-line, "between the Canary Islands and Brazil." The specimen figured by CUVIER (l. c.) was found by DUSSUMIER some kilom. south-east of the Cape of Good Hope, among a floating

[a] *Mentum*, pars inter gnathidia mollis (SUNDEVALL).

[b] Cf. *Argyropelecus hemigymnus* and *Sternoptyx diaphana*, LENDENFELD in GÜNTHER, *Deep Sea Fish.*, l. c., p. 314.

mass of "zoophytes" (Hydrozoa on seaweed?). It lay on one side at the surface, but was still alive. Its colour was described as nacreous on the sides of the body, reflecting various hues, principally azure blue. The back was black, with the same play of colours; the fins were transparent; the eye was of a handsome green.

The species is thus known originally as a surface fish. By the Challenger Expedition, however, it was taken in a dredge that had been drawn at the bottom in 1,125 fathoms of water, off Cape Finisterre. In most instances, as in the case of deep-sea fishes, the specimens secured have drifted helplessly at the surface and been cast ashore by the waves. The congener of this species — if they are both entitled to an independent specific rank — was taken in 1869 by the *Porcupine* expedition, in 540 fathoms of water, between Scotland and the Faroe Islands[a], and in 1880 and 1882 by the American expeditions on the *Blake* and *Fish-Hawk*, in 225 and 245 fathoms of water, off the coast of Florida[b]. *Argyropelecus Olfersii* is also frequently found off the Norwegian coast in the stomach of Cod, a circumstance which seems to indicate that it keeps near the bottom, as is further suggested by its large eyes. But at night its congener is often met with at the surface off the coast of Sicily; and it is highly probable that *Argyropelecus Olfersii* shares this habit. To the true deep-sea fishes it cannot thus be referred; and the above-mentioned instances of its occurrence at great depths do not exclude the possibility of its having been intercepted by the dredge while the latter was being drawn up. It seems most likely that in the daytime it avoids the light by retiring to depths where the sun exercises no appreciable influence.

Its geographical range extends from the Cape of Good Hope to North Cape, but appears to be restricted between the limits of the great ocean currents. It has thus been carried by the Gulf Stream on several recorded occasions to the Norwegian coast north of Bergen, but has never been found further south in Scandinavia. COLLETT mentions 8 specimens as having been found during the last thirty years, cast ashore at different points on the Norwegian coast, or taken in the stomachs of Cod or Coalfish.

Argyropelecus Olfersii is a voracious fish-of-prey, as evidenced by its dentition. In the stomach of a specimen 82 mm. long COLLETT found a half-digested *Maurolicus Mülleri* that had probably measured 50 mm. Small fishes and crustaceans are, no doubt, its principal diet. Its spawning-season is unknown; but in a female about 8 cm. long COLLETT counted about 1,000 eggs $^1/_2$ mm. in diameter, a much greater number and relatively smaller size than we found in a female *Argyropelecus hemigymnus*, taken in February off the Sicilian coast. In the latter specimen both ovaries were rather tumid but of different lengths, the right, which was the longer, measuring hardly 6 mm. The eggs were $^1/_2$ mm. in diameter, and lay so loose in the ovaries that they were probably almost ready for deposition.

SUBFAMILY COCCIINÆ.

Body of a slightly irregular Herring-form. Ventral margin more or less terete. Cleft of the mouth more or less ascending, with the margin of the upper jaw formed in front by the intermaxillaries and behind by the maxillaries, which are here armed with teeth. Teeth in the mouth of fairly uniform size. Preabdominal length greater than the postabdominal. Pseudobranchiæ well developed. Snout shorter than the postorbital part of the head.

The known forms of this subfamily are not numerous. GÜNTHER[c] enumerates 5 species, distributed among two genera, one of which, the Mediterranean *Coccia*, containing one species with the most reduced intermaxillaries and jaw-teeth, has conferred its name on the subfamily. In form and coloration, and probably

[a] DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 48.

[b] BROWN-GOODE and BEAN, Bull. Mus. Comp. Zool., vol. X (1883), p. 250.

[c] *Cat. Brit. Mus., Fish.*, vol. V, p. 387. Whether *Diplophos* (GÜNTHER, *Mus. Godeffr.*, Heft. II, p. 101) belongs to this subfamily is uncertain, so long as we are ignorant whether it possesses or is without pseudobranchiæ. The subfamily *Chauliodontinæ*, to which, according to GÜNTHER, it should else be referred, is destitute of pseudobranchiæ, and in general has a larger mouth with a more powerful dentition.

in their habits, these fishes closely resemble the small Herrings in whose company they are frequently found; and they sometimes appear, like the latter, in shoals. All of them are small fishes. Most of them belong to the Mediterranean, only one species being known from the Atlantic; and this is so like one of the Mediterranean forms that its right to the rank of a separate species seems questionable. This same species has also been claimed, probably with justice, for the fauna of New Zealand. The subfamily has thus an extensive geographical range, and probably occurs in other intermediate regions both of the Atlantic and the Pacific. Another species, *Maurolicus tripunctulatus*, described by ESMARK from the neighbourhood of Madagascar, is stated by LÜTKEN[a] to occur in "Denmark Sound" between Iceland and Greenland (66° N. lat.; 28° W. long.). The same peculiarity, the occurrence of a species in localities so remote as, on the one hand, the North Atlantic and the Mediterranean, on the other, New Zealand, without its being known from intermediate regions, we have already observed in the case of *Argentina sphyraena*, which also associates with the Herrings. And the Herring family, as we shall soon see, contains some of the most widely diffused piscine species.

GENUS MAUROLICUS.

Snout and forehead forming an unbroken profile, slightly sloping. Tip of the lower jaw prominent. Breadth of the maxillaries less than half their length and less than the breadth of the operculum (measured in the longitudinal direction of the body). Jaw-teeth distinct, though small. Pseudobranchiae present. Air-bladder wanting.

This genus is distinguished, at the first glance, from *Coccia*[b] by the form of the snout, which in the latter genus comes nearest that of *tschir* among the Gwyniads, being short and blunt, tumid and truncate. With this is connected the form of the maxillaries. *Coccia*, whose gape is thus rendered much smaller, is also without true jaw-teeth, these being merely fine serrations of the sharp and thin edges of the jaws. In *Coccia*, on the other hand, the luminous spots are more numerous: the upper preabdominal row is continued, unbroken and dense, on the postabdominal region, the row thus containing 25 spots; and on the branchiostegal membrane, which behind coalesces so completely with the operculum as to be almost indistinguishable therefrom, *Coccia ovata* possesses 12 luminous spots. *Coccia*, with its large eyes, which almost touch at the forehead, where the interorbital width is extremely small, also seems to be a still more marked nocturnal fish.

BOREAL PEARL-SIDE.

MAUROLICUS MÜLLERI.

Plate XLIV, fig. 3.

Upper row of ventral luminous spots interrupted at the ventral fins and containing 9 or 10 spots between these fins and the pectorals. Length of the lower jaw less than 15 % of that of the body, or than 16 % of that of the body minus the caudal fin, and the postorbital length of the head more than $^{3}/_{5}$ of the length of the lower jaw.

R. br. 10[c]; *D.* $\frac{2}{8}$; *A.* $\frac{2}{22}$; *P.* $\frac{1}{(15)\ 16-18}$; *V.* $\frac{1}{6}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* 26—28; *L. tr.* 5; *Vert.* 32[f].

Syn. Salmo maxillis edentatis, inferiore longiore; ventre punctato, MÜLL., *Zool. Dan. Prodr.*, p. 49.

[a] Vid. Meddel. Naturh. For. Kbhvn 1891, p. 211.

[b] Cocco, N. Ann. Sc. Nat. (Bologna), Ann. I, tom. II (1838), p. 192 (p. 32, sep.) "segnalato col nome di un celebre letterato siciliano" (BONAP.).

[c] According to GÜNTHER.

[d] 9, according to NILSSON, *Prodr.*; 8, according to *Observ. Ichthyol.*; 8 or 9, according to GÜNTHER; 9 or 10(?), according to KRØYER.

[e] *A.* 26—33, according to DAY.

[f] According to DAY.

Sheppy Argentine, PENN., *Brit. Zool.* (ed. Warr. 1776), vol. III, p. 286, tab. LXV, No. 156.

Salmo Mulleri, GMEL., *Syst. Nat. Lin.*, ed. XIII, tom. I, p. 1378; KR. (*Maurolicus*), *Danm. Fisk.*, vol. III, p. 113.

Argentina Pennanti, WALB., *Ichthyol. Art.*, pt. III (*Gen. Pisc.*), p. 47; CUV., VAL. (*Scopelus*), *Hist. Nat. Poiss.*, vol. XXII, p. 436; YARR. (RICHARDS.), *Brit. Fish.*, ed. 3, vol. I, p. 330; DAY (*Maurolicus*), *Fish. Gt. Brit., Irel.*, vol. II, p. 49, tab. CIX, fig. 2; COLL., N. Mag. Naturv. Chrnia, Bd. 29, p. 104; PETERSEN, Vid. Meddel. Naturh. For. Kbhvn 1884 (1886), p. 158; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 10.

Scopelus borealis, NILSS., *Prodr. Ichthyol. Scand.*, p. 20; ID., *Observ. Ichthyol.*, p. 9; ID., *Skand. Fna, Fisk.*, p. 479; GTHR (*Maurolicus*), *Cat. Brit. Mus., Fish.*, vol. V, p. 389; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 150; 1879, No. 1, p. 84; MALM, *Gbgs, Boh. Fna*, p. 533; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 42; STORM, Vid. Selsk. Skr. Trondhj. 1883, p. 30; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 284.

Scopelus Humboldtii, YARR., *Brit. Fish.*, ed. 1, vol. II, p. 94; ed. 2, vol. II, p. 161 (nec RISSO, nec CUVIER); STORER, Mem. Amer. Acad. Arts. Sc., n. ser., vol. II, p. 450; vol. VI, p. 328, tab. XXV, fig. 5.

Forma mediterranea (an species distincta?), maxillis et mandibula longioribus:

Maurolicus amethystino-punctatus, COCCO, l. c.; GTHR, l. c., p. 390.

Maurolicus australis, HECTOR, Trans., Proc. N. Zeal. Inst., vol. VII, p. 250, tab. XI, fig. 90, D, vide GÜNTHER, Ann. Mag. Nat. Hist., ser. 4, vol. XVII (1876), p. 399.

Obs. In 1766 STRÖM found on the shore, at Wolden parsonage in Söndmör, a specimen of this species (see his MS, quoted by COLLETT), a drawing and description of which he sent "more than 20 years before 1791" (see Skr. Naturh. Selsk., Bd. 2, H. 2, p. 15) to O. F. MULLER, who appends to his above-mentioned diagnosis, "Cl. STRÖM misit." Afterwards STRÖM confused this species with *Myctophum glaciale*, which he distinctly figured and described in Skr. Naturh. Selsk. (l. c.) — a circumstance first pointed out by NILSSON in his *Skand. Fna*. But this cannot affect the determination of *Salmo Mulleri* in GMELIN, who merely copied MÜLLER.

The Pearl-side belongs to the small fishes. Our largest specimen from Bohuslän indeed measures 72 mm. from the tip of the lower jaw to the extreme end of the caudal fin; but the distance from the tip of the snout to the end of the middle caudal rays, the measurement termed in the present work the length of the body, is not quite 68 mm.

The body is moderately elongated, with terete back and belly, flattened, vertical and parallel sides. In the forepart of the body, in front of the dorsal and ventral fins, the ventral contour is perceptibly more curved than the dorsal; but in the hind part of the body these contours are straighter and converge with fair uniformity towards the base of the caudal fin. The greatest depth of the body, which occurs at about the middle of the preabdominal part, is about $^1/_5$ (18—21$^1/_2$ %) of the length of the same[a]; and the least depth of the tail is about $^1/_3$ of the said depth or $^1/_{15}$—$^1/_{16}$ (about 6$^1/_2$ %) of the length of the body[b]. The greatest thickness, which is fairly uniform throughout the forepart of the trunk (the preabdominal region), measures about 8—10 % of the length of the body.

The outlines of the head run in uninterrupted continuation of those of the body, its sides being also flat and parallel; but the lower jaw, which sharply ascends when the mouth is closed, renders the inferior contour of the head more curved, while the superior contour is straighter. The forehead is also grooved longitudinally, its edges rising in a ridge that runs along each side, and extends forward above the margin of the eye, at the anterior upper angle of which it divides to enclose the nasal cavity; but the middle of the forehead is coursed by a lower longitudinal ridge. The length of the head is about $^1/_4$ (26—22$^1/_2$ %) of that of the body. The eyes are round, though their longitudinal diameter is somewhat greater than the vertical, and measures about 38—35 %[c] of the length of the head. They are set high, their upper margin lying almost in the plane of the forehead, and are only very slightly and obliquely upturned. The least interorbital width is about $^2/_5$ of their longitudinal diameter, which is equal to the postorbital length of the head. The nostrils are set close together, each pair at the extreme front of the triangular nasal cavity, above the dark top of the preorbital bone and behind the articular knob — also dark-coloured — of the maxillary. The anterior nostril on each side is round, the posterior an obliquely-set, transverse slit. The suborbital ring, which forms the silvery cheek, is thin but complete along the lower half of the orbit, in front of uniform breadth, only slightly broader at the penultimate suborbital bone, the hindmost suborbital bone, on the other hand, being small and triangular. The tip of the snout is sharp (shallow) but truncate, with a slight indentation at the middle. The length of the slender intermaxillaries is equal to the vertical diameter of the eyes. The maxillaries are formed as in the preceding

[a] 20—23 % of the length of the body excluding the caudal fin.

[b] About 7 % (according to LILLJEBORG nearer 8 %) of the length of the body excluding the caudal fin.

[c] According to LILJEBORG 32 % of the length of the head from the tip of the lower jaw.

species, but are curved in a sabre-like fashion throughout their length, and their supplementary bone, which is elliptical behind, projects in front in a tip that extends to a line with the anterior part of the preorbital bone. Their median breadth is rather more than $^1/_3$ of their length, which is equal to that of the lower jaw, and less than 15 % of that of the body or than 16 % of the length to the middle of the base of the caudal fin. In this last relation we have a character, constant to the best of our knowledge, to distinguish this form from the Mediterranean *Maurolicus amethystino-punctatus*, which is otherwise deceptively like *M. Mülleri*. The branches of the lower jaw are deep, but have an arcuate upper margin; and the symphysis is shallower than in *Argyropelecus Olfersii* and has a feebly developed chin-protuberance, which however projects distinctly, when the mouth is closed, beyond the tip of the snout[a]. As in *Argyropelecus Olfersii*, a sharp ridge runs along the outside of each half of the lower jaw, parallel to the thin inferior margin. The branches of the lower jaw approach rather near to each other at the inferior margin behind; but in front (behind the symphysis) the space between them widens into a clavate mentum (chin-space). The feeble dentition of the mouth consists of small, pointed teeth, set in a single row and of uniform size, on the intermaxillaries, on the hind (free) part of the lower edge of the maxillaries, on the upper edge of the lower jaw, as far as it is free when the mouth is open, and in an arcuate transverse row on the head of the vomer. There is no tongue; but the anterior (lower) part of the basihyoid bones forms a transversely-set rim, rising within the mouth like a tongue. The upper palatal fold is extremely narrow, the lower better developed. The pseudobranchiæ are rather large, but consist of only 9 or 10 transversely-set, filamentous lamellæ. The gill-rakers are set in one row, pointed, rather long, and so dense that they number about 30 on the front of the first branchial arch. The first gill-slit is long, the others rapidly decrease in length. The outer gill-openings are large in this species too, the two branchiostegal membranes being hardly at all coalescent. Above they extend to a level with the upper margin of the eye, below to a line with the anterior extremity of the preorbital bones. The branchiostegal rays are 10, the first extremely small, the others slender, except the last (uppermost), which is broad and sabre-shaped. Among the thin bones of the opercular apparatus both the operculum and suboperculum are quadrilateral, rectangular, the former being rather more than twice as large (deep) as the latter, but with the upper posterior angle rounded. In the lower margin of the suboperculum there is a rounded indentation. The interoperculum is more oblong, growing narrower in front, and lies along the lower arm of the preoperculum. The preoperculum resembles a somewhat open (obtuse-angled) carpenter's square, with both arms of nearly equal length.

The dorsal fin is trapezoidal, with the upper posterior margin rapidly sloping. It begins at a distance from the tip of the snout measuring about 55—48 % of the length of the body. The length of its base is about 9—7$^1/_2$ %, its height in front about 10$^1/_2$—12 %, of the length of the body. The adipose fin, situated above the posterior part of the anal fin, is long and low, as in *Argyropelecus Olfersii*. The anal fin is much longer than the dorsal, but so deeply incised at the margin that its anterior part is almost similar to the latter fin, though much lower, while its posterior part is very low and of uniform height, only the last rays being slightly prolongated. Its distance from the tip of the snout is about 63—60 %, its base about 18$^1/_2$—20 %, and its greatest height about $^1/_9$, of the length of the body. The caudal fin is forked, though not so deeply as in *Argyropelecus Olfersii*; its middle rays occupy about 7—8 % of the length of the body[b]. At the upper margin we have found 8 supporting rays, at the lower 5. The pectoral fins are bluntly pointed, semioval. Their length is about 16—14 % of that of the body. The ventral fins are of almost the same shape, but much shorter, their length being about 9—10 % of that of the body, and only slightly greater than or even equal to the diameter of the eye. They are set at a distance from the tip of the snout measuring about 52$^1/_2$—50$^1/_2$ % of the length of the body, sometimes a little in front of, sometimes behind the perpendicular from the beginning of the dorsal fin. The preabdominal length is about 30 (31$^1/_2$—29$^1/_2$) %

[a] Both the maxillaries and the lower jaw are so thin and transparent that the whole of the former and the upper posterior part of the latter are invisible in v. Wright's figure.

[b] In v. Wright's figure, which evidently represents a fresh and perfect specimen, the caudal fin is much less forked than in our specimens.

the postabdominal about 10 (11—9) %, of the length of the body.

The whole body, forward to the interorbital space, is covered with extremely thin, transparent, rather large, and rounded scales, somewhat higher than long, and with scattered, concentric striae on the posterior part. There is no special lateral line, the scales of the median line being without pores.

The luminous spots are distributed in the same manner as in *Argyropelecus Olfersii*, but more regularly. A comparison with *Coccia ovata* shows most clearly of all that they lie in three rows, though the middle row should probably be regarded as a ramification of the lowest, or *vice versâ*. The uppermost row begins at the extreme front of the chin, and in *Coccia* runs back without a break along the branches of the lower jaw and on the branchiostegal membrane, one spot being situated between each pair of branchiostegal rays, till the membrane coalesces behind with the interoperculum and suboperculum so completely that the luminous spots apparently lie on the inner surface of these bones. Above the row, on the inside of the lower preopercular angle, we find one spot, suggesting an upward ramification of this row. In the Pearl-side the row is interrupted along the branches of the lower jaw, only two spots, probably answering to the second pair in *Coccia*, appearing on the soft chin-space, and further back each of the branchiostegal membranes is furnished with 6 spots, which shine through the maxillaries and the horizontal (anterior) arm of the preoperculum. On the inner surface of the opercular apparatus the remaining spots are the same as in *Coccia*[a]. The lowest row of luminous spots starts from the anterior extremity of the isthmus, in *Coccia* quite at the mental angle, where the two lateral halves of the first mentioned row meet, and follows the ventral margin, in this genus without interruption, merely forming a curve at the beginning of the anal fin, back to the lower corner of the base of the caudal fin. But in front of the base of each pectoral fin and above this row, lies one spot, suggesting an upward ramification of the row, and on a level with the last-mentioned spot runs the upper ventral row, pair by pair with the spots of the lower row, and unbroken in *Coccia* to a line with the beginning of the anal fin. In the Pearl-side the lowest row begins similarly at the anterior extremity of the isthmus; but this extremity is situated further back, hardly in front of the perpendicular from the anterior margin of the eye, and the row runs on each side of the body, in an upward curve containing 6 luminous spots, towards the base of the pectoral fin. At the ventral margin between the last pair of these spots, begins the true (lower) ventral row, which should thus be regarded here as a downward and backward ramification of the isthmian row, and runs on each side of the body to the lower corner of the base of the caudal fin. This row contains 43 spots, the pair at the base of each ventral fin (the 13th and 14th in the row) somewhat obliquely arranged, and the remaining 4 on the postabdominal region forming a slight upward curve. A slight break in the row occurs at the beginning of the anal fin (between the 18th and 19th spots), and a similar break at the end of the same fin (between the 34th and 35th spots). The upper ventral row of luminous spots, which in the Pearl-side — to judge, at least, by its direction and the form of the spots — is a more immediate continuation of the isthmian row, begins in the upper part of the axilla, and runs, containing 9 spots, to a line with the base of the ventral fin, from which point it is interrupted throughout the postabdominal region, but re-appears in a single spot above the beginning of the anal fin. The spots in the upper ventral row, those between the branchiostegal rays, and most, if not all, of the posterior spots in the isthmian row, are obliquely cut and prolongated in a downward direction (see above, p. 921, with note *a*).

The coloration of the Pearl-side is almost the same as that of the smaller Herrings, a lustrous silvery white, but dark, shading into blue on a greenish ground, on the back and the top of the head. So long as the scales adhere, they give the sides of the body a tinge of yellow. The black rims of the luminous spots stand out sharply from the pale bluish (in spirit-preserved specimens yellowish) lustre of their interior; and where these rims touch, along the base of the anal fin and the inferior margin of the tail, there appears a coal-black band. The end of the tail itself is of the same colour as the back, and outside (behind) the tail a narrow, black band crosses the base of the caudal fin.

[a] The luminous spot which MOREAU (*Hist. Nat. Poiss. Fr.*, tome 3, p. 511) observed in *Maurolicus amethystino-punctatus* on each side of the snout, near the nostrils, we have not been able to detect in our preserved specimens of the Pearl-side; but it is distinctly shown in v. WRIGHT's figure, small, but prolongated along the lower margin of the anterior part of the preorbital bone.

All the fins are light and transparent, with only the anterior margin or, in the caudal fin, the two outer margins, of the same colour as the back, or dark.

Of the internal organs we shall merely remark, after DAY, that the stomach is cæcal, the duodenum furnished with 8 rather large pyloric appendages, and the whole intestinal canal forms only two convolutions. The testes and ovaries are paired and long.

The Pearl-side is a gregarious fish, and though it is most often met with in solitary specimens among small Herrings (Sprats and Herring-fry), it also appears in shoals of its own, instances of which have been observed on the coasts both of Finmark and England. Like *Argyropelecus Olfersii*, it is a pelagic and nocturnal fish of extensive geographical distribution. It has been found on both sides of the North Atlantic, and differs but slightly, if indeed it be specifically distinct, from *Maurolicus amethystino-punctatus*, a Mediterranean species with which GÜNTHER has combined *Maurolicus australis*, a New Zealand form described by HECTOR.

Within the limits of the Scandinavian fauna the Pearl-side was first discovered by STRÖM off Söndmör, and on the Swedish coast it was first taken by NILSSON, near Gothenburg, in a seine drawn for small Herrings. It has since been found at many points, both in Bohuslän and Norway, cast ashore by the waves, or in the stomach of Cod and Herring[a]. South of Bohuslän it is unknown on the Swedish coast, and only one find has been recorded on the west coast of Denmark, consisting of a specimen lying on the shore at Hjorring in the north of Jutland. On the Norwegian coast it is much commoner, north to Hammerfest, and ascends the fjords. In the Lyng, one of the Finmark fjords, east of Tromsö, there appeared in 1866, according to COLLETT, a whole shoal of Pearl-sides. They could be scooped up in bucketfuls from the surface, and at least 50 specimens were preserved. Similar shoals have been seen on the coasts of Great Britain and Ireland, in the North Sea, the Channel, and the Irish Sea. According to EDWARD[b] the Pearl-side is a regular winter visitor off Banff, never failing to appear in the month of January; and from January to March Mr. SIM gathered in two years nearly 200 specimens on the shore near Aberdeen. It would thus seem to be most common to the north; on the English coast south of Yorkshire only solitary specimens have been found, and on the west coast of France, as well as in Holland, the species is unknown. On the east coast of North America it is stated to occur but seldom.

The small teeth and fine gill-rakers of the Pearl-side show that it lives on minute animals. These consist principally, we may assume, of the small crustaceans (Entomostraca) that are so abundant in high northern latitudes[c], and which compose the chief food of the Herring too, though the latter, as we have seen, also preys, like *Argyropelecus Olfersii*, on the Pearl-side.

During winter, when the Pearl-side appears in such numbers off the Scotch coast, DAY examined its generative organs, and found the comparatively large eggs and the milt almost ripe in February. We may hence conclude that the spawning is performed in spring.

SUBFAMILY SAURINÆ.

Body of only slightly irregular Herring-form, or more terete and elongated. Ventral margin more or less terete. Cleft of the mouth large and horizontal or only slightly ascending. Intermaxillaries extending to the termination of the margin of the upper jaw. Teeth in the mouth of fairly uniform size. Preabdominal length less than the postabdominal. Snout shorter than the postorbital part of the head.

By the more forward situation of the ventral fins and the greater elongation of the intermaxillaries this subfamily is raised to a higher rank than the two preceding ones, so far as regards the general rules for the development of the Teleosteous type in these respects. But in the first-mentioned character these fishes come

[a] TRYBOM found a Pearl-side about 7 cm. long in the stomach of a female Herring measuring 311 mm. that was taken in a drift-net off Vinga on the 8th Sept., 1885.

[b] See DAY, l. c., p. 51.

[c] COLLETT also found in the stomach of the Pearl-side *Calanus finmarchicus*.

nearer to the Herrings, and in luminousness they are generally less developed. Several of them are destitute of luminous spots, and the spots in the rows most regularly present, the ventral, are here, as a rule, smaller and simpler, whereas the spots of more irregular occurrence are sometimes highly developed. Most of these fishes have marked predatory habits, but in this respect they are surpassed by the fourth subfamily, the *Chauliodontinæ*, which are distinguished by the large canine teeth in the mouth, and which in the situation of the ventral fins more nearly approach to the preceding subfamily. The situation and development of the true dorsal fin separate this subfamily, as well as the others, from the *Paralepidinæ*, where the said fin is small and set far back, and from the *Alepisaurinæ*, where the dorsal fin extends almost throughout the dorsal margin.

The name of *Saurinæ* has been coined by GÜNTHER[a], after *Saurus*, a genus of extensive range in the Mediterranean and the tropics. The subfamily is the richest in forms among the Scopeloids, containing about 50 species, which are distributed among 12 genera, with or without luminous spots, most of them belonging to the deep-sea fauna, and some being pelagic fishes. Within the Scandinavian fauna there occur only two species of the

GENUS MYCTOPHUM.

Body Herring-shaped, laterally compressed, covered with rather large scales, and furnished with luminous spots.

As a generic name need only be a name, and according to the rules of the current nomenclature must be recognised as such, even if it must be condemned on linguistic principles, the name of *Myctophum* has the right of priority, though its formation is erroneous or the result of a misprint. *Nyctophus*[b], the name which COCCO afterwards[c] suggested as the correct one, was probably the form which RAFINESQUE[d] intended to write; but an alteration seems hardly necessary. The genus has been best known under the name of *Scopelus* (CUVIER, 1817[e]), from which the name of the whole family has been coined, though as a generic name it must be rejected.

The genus contains about twenty species of nocturnal surface-fishes from the open seas of tropical and temperate latitudes.

[a] *Cat. Brit. Mus., Fish.*, vol. V, p. 394.
[b] *Night-light*. Gr. νύξ and φῶς.
[c] N. Ann. Sc. Nat., An. 1. Tom. II (Bologna 1838), p. 180.
[d] *Ind. d'Ittiol. Sicil.*, 1810.
[e] *Règne Animal*, ed. 1, tom. II, p. 169.

THE GREATER SCOPELUS.

MYCTOPHUM ELONGATUM.

Fig. 234.

Base of the dorsal fin longer than that of the anal and more than $^1/_4$ of the length of the body. Length of the pectoral fins less than that of the ventral, than either the preabdominal length or the postabdominal, and than half the length of the maxillaries, which is about half the distance between the dorsal fin and the tip of the snout or a little greater. Longitudinal diameter of the eyes less than half ($^2/_5$?) of the postorbital length of the head, which is more than $^3/_5$ of the entire length thereof. Least depth of the tail more than 8 % of the length of the body or than $^2/_5$ of the greatest depth of the latter. Scales of the lateral line slightly, if at all, larger than those of the body in general.

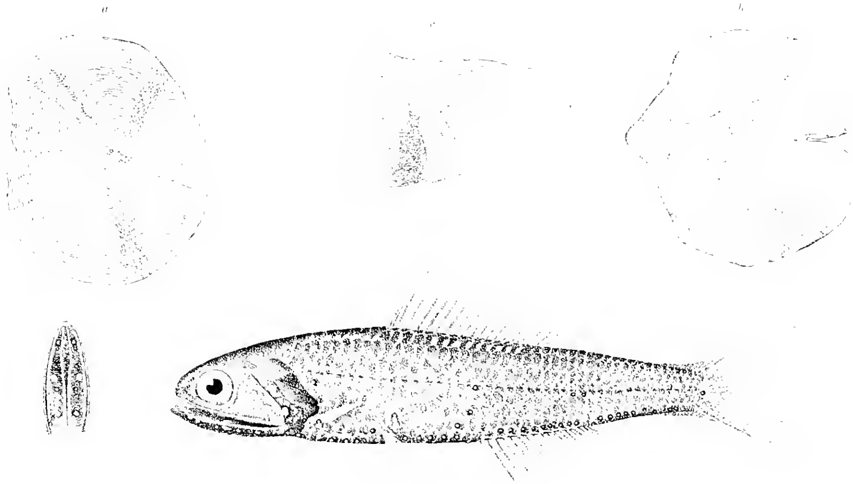

Fig. 234. *Myctophum elongatum*, together with the under side of its lower jaw. Natural size. From Trondhjem Fjord. Specimen in the possession of the Zoological Museum of Christiania University. *a, b, c*, three scales from the left side of the body. × 10. *a*, from the row next below the lateral line; *b*, from the lateral line; *c*, from the row along the base of the dorsal fin.

R.br. 8; *D.* $\frac{4}{19^a}$; *A.* $\frac{3}{16^b}$; *P.* $\frac{1}{10-11}$; *V.* $\frac{2}{7}$; *C.* $x + 2 + (15—17) + 2 + x$;

L. lat. 43[c]. *L. tr.* $\frac{3^1}{5}{}^2$ 1.

Syn. Scopelus elongatus, Costa, *Fna Regn. Nap., Pesc.*, Malacott., Scop., tab. XXXV; Steind., Stzgber. Akad. Wiss. Wien., Math. Naturw. Cl., Bd. LXXXIII, 1 (1881), p. 397; Storm, Vid. Selsk. Skr. Trondh. 1883, p. 30; Coll. (*Myctophum*), N. Mag. Naturv. Chrnia, Bd 29, p. 104; Lillj. (*Scopelus*), *Sv., Norg. Fna, Fisk.*, vol. III, p. 25.

Lampanyctus (ex Bonap.) *resplendens*, Richards., *Voy. Ereb., Terr., Ichthyol.*, p. 42, tab. XXVII, figg. 16—18; Gthr. (*Scopelus*), *Cat. Brit. Mus., Fish.*, vol. V, p. 415; Coll., Forh. Vid. Selsk. Chrnia 1880, No. 8, p. 3 cum. tab.; Storm, l. c. 1879, p. 130; 1880, p. 78.

(?) *Scopelus caudispinosus*, Johns., Proc. Zool. Soc. Lond. 1863, p. 42; Gthr. l. c., p. 416; (Adn. tamen (sec. *Johnsonum*) oculos minores (long. diam. $\frac{21 \cdot 4}{100}$ long. capitis), pinn. dors. longiorem (longit. basis $^9/_{10}$ distantiae ex apice rostri; long. capitis $= \frac{77 \cdot 7}{100}$ longit. basis illius; longit. bas. pinnae analis $^2/_3$ longit. bas. pinn. dors.; longit. postabdominalis $= ^1/_2$ longit. bas. pinn. dorsalis).

[a] 18, according to Collett.

[b] 17, according to Collett.

[c] 38(39)—50, according to Collett.

Scopelus Kroyeri, MALM, Forh. Skand. Naturf. M. Kbhvn 1860, p. 617; Vett., Vitt. Samh. Handl. Gbg., H. 8 (1863), p. 100; *Gbgs. Boh. Fna.* p. 534; SUNDSTRÖM, *Fna Sveriges Ryggradsdj.*, p. 262 (descr. erron.).

The Greater Scopelus, the larger Scandinavian species, attains a length of about 15 cm.[a] As the form of the Pearl-side reminds us of the Sprat, so the Greater Scopelus resembles an Anchovy with shortened snout. The body is rather elongated and compressed. The greatest depth, which occurs at the ventral fins, though the whole abdominal region is of fairly uniform depth, measures about $^1/_5$ (19 % in the only perfect specimen we have been able to examine) of the length of the body, and the greatest thickness is about $^3/_5$ of the greatest depth. The dorsal contour descends forward from the beginning of the dorsal fin in a gradual curve to the tip of the snout; but the ventral contour is straighter in front. The caudal contours converge at equal angles and to such an extent that the least depth of the body (in front of the caudal fin) is about $^1/_{11}$ (8·9 %) of its length, or about $^4/_9$ (46·6 %) of its greatest depth. In front the dorsal margin is convex, the ventral rather flat; behind they are both about equally compressed, neither being sharp, however, in front of the spine-like supporting rays of the caudal fin.

The head is middle-sized, its length being $^1/_4$ of that of the body; but the greatest part thereof is occupied by the temples (posterior cheeks) and opercula. The postorbital part measures about 63—66 % of the length of the head, and is of fairly uniform thickness, the sides being almost parallel, but slightly converging in a downward direction. The forehead is slightly convex, with a median carina between the anterior parts of the eyes and on the snout, the sides of which converge in front almost at a right angle. The eyes, the length of which is somewhat greater than their height, are of moderate size in proportion to the length of the body[b], but large in proportion to that of the snout, which measures at most about $^2/_3$ of their longitudinal diameter. There are, we may almost say, no true cheeks, only a thin and very low suborbital ring separating the orbit from the upper jaw; but the lower margin of this ring is sharply marked both in front and (very sharply) behind, and entirely conceals the maxillary throughout the greater part of its length, when the mouth is closed. The orbital margin is also sharply defined and especially prominent above, where it rises at the anterior angle to the frontal plane. The slightly convex interorbital space is rather broad, though it becomes narrower in front; at the middle of the eyes it is equal to, or even greater than, their longitudinal diameter. The nostrils on each side of the snout lie on a level with the centre of the eye, just in front of and below the projecting margin of the anterior frontal bone, which forms the anterior orbital margin, and are separated only by a thin dermal septum. The mouth is large, as in the Anchovy, and the horizontal cleft thereof extends throughout the greater part of the length of the head, the length of the upper jaw from the tip of the snout being 77—79 %, the length of the lower jaw 80 %, of that of the head. The margins of both jaws are straight and without lips. When the mouth is closed, only the narrow intermaxillaries are visible in front, forming the whole margin of the upper jaw, from the very tip of the snout, where their hardly perceptible nasal processes meet the rostral tip of the ethmoid bone. Above them lie the maxillaries, which are thin and show comparatively little, though gradual, expansion behind. The latter do not extend quite so far back as the intermaxillaries, a break being thus formed at the hind extremity of the upper jaw. The lower jaw, which projects as far as the upper, resembles, as a whole, a flat boat, when its two branches adjoin to each other beneath. Their lower margins are incurvated, so that they cover the isthmus underneath throughout its length, with only a narrow, longitudinal opening between them. The jaw-teeth are small, pointed, and of uniform size; they are set in a dense card, narrow but slightly broader at the anterior extremity, throughout the margins both of the upper jaw (the intermaxillaries) and the lower. They also extend over the outer surface of these margins, rendering it rough even when the mouth is closed, the inner surface, on the other hand, being smooth. Similar teeth are set on the long palatine, the entopterygoid, and the epibranchial bones, the upper and lower pharyngeals, and the whole series of the copular parts of the hyoid

[a] 16 cm., according to JOHNSON, assuming that it is this species which he has described.

[b] Their longitudinal diameter measures in adult specimens about $6^1/_2$ % of the length of the body, 23—26 % of the entire length of the head, and $37—39^1/_2$ % of the postorbital length of the head.

bone. There is no true tongue, but the cartilaginous tip of the lingual bone is rather high and prominent right in the angle between the branches of the lower jaw. Here the hyoid arch of each side is attached, and just behind it the first branchial arch, the inferior part of which is so long that it extends behind the branches of the lower jaw. The anterior gill-slits are also very large; but the last (fourth) branchial arch, with only one row of lamellæ, is united throughout the greater part of its length to the shoulder-girdle, the hindmost gill-slit thus being quite short and open only below. The gill-rakers are setiform. The outer row on the first branchial arch contains about 25 gill-rakers, 17 of them belong to the lower, front part of the arch. The pseudobranchiæ consist of a longitudinal row containing about 22 transversely set, filamentous lamellæ on the inner, upper surface of the hyomandibular bone. The opercular apparatus is considerably prolongated in a backward direction. The preoperculum, which has no lower (forward, horizontal) arm, lies, as in the Anchovy, in an oblique, backward and downward direction. Behind, this bone expands into a thin, dermatoid, membranous margin, which lies over the anterior part both of the operculum and the suboperculum, and this membranous margin is covered with scales pierced by a branch of the lateral line. The shape of the quadrangular operculum is adapted to that of the preoperculum, the former being also oblique, rhombic, and obliquely set, in the same direction as the preoperculum. The hind extremity of the opercular apparatus is formed by the upper posterior corner of the triangular suboperculum, the lower posterior side of which is indented, and at the lower angle of which lies the small, rounded, and scale-shaped interoperculum. The black branchiostegal membrane of each side is entirely separate from that of the other side, but is closely applied and united by connective tissue to the inner surface of the branch of the lower jaw, thus forming, as it were, a lining thereof, and hardly projecting beyond its margin. The eight slender branchiostegal rays increase in length backwards, but are comparatively short. On the hyoid arch lie the three luminous spots that shine through the branch of the lower jaw, the first at the base of the foremost three rays, the second on the space between the fifth and sixth rays, and the third on the membrane between the bases of the seventh and eighth rays. The gill-opening on each side extends upwards beyond the superior margin of the operculum, and the distance from the tip of the snout to the upper angle of each gill-opening is equal to the postorbital length of the head.

The true dorsal fin is rather large and of a quadrangular shape, with undulating upper posterior margin. The fin begins at a distance from the tip of the snout measuring about 38 % of the length of the body. The length of its base is about 28 %, and that of its longest ray (the fourth or fifth) about 18 %, of the length of the body. The first four rays are simple — the first ray, which is very small, also unarticulated. Among the remaining rays the anterior (13 or 14) are branched only once and at the tip, the posterior (6 or 5) twice and more deeply. The adipose fin, which is short but rather high, only slightly lower than the hindmost dorsal rays, lies about half as far from the dorsal fin as from the first upper supporting ray of the caudal. The anal fin is similar in shape and structure to the true dorsal, but much shorter, with only three simple rays at the beginning. The first ray is so small that it easily escapes attention, and the third is the longest in the whole fin, or equal in length to the first branched ray. The distance between the beginning of the anal fin and the tip of the snout is about 54 %, and the base of the fin measures about 20 %, of the length of the body, the base thus terminating a little behind the perpendicular from the adipose fin. The height of the anal fin (the length of the third or fourth ray) is about 16 % of the length of the body. The caudal fin, which is deeply forked, is remarkable in this species too for the short but strong supporting rays, true spinous rays, that arm the dorsal and ventral margins of the tail in front of the true base of the fin. In the only perfect specimen within our reach there are both above and below 10 spinous rays, gradually increasing in length behind, and 2 articulated but simple rays, the first about one-third as long as the second, which extends nearly to the tip of the fin-lobe. The remaining 16 rays are articulated and branched, the middle ones about one-third as long as the outermost, and measuring about 7 % of the length of the body; but the base of the fin is covered at the sides, at least half-way along the fin, with elongated scales, concealing the roots of the rays.

Among the paired fins the pectorals are pointed, shorter and narrower than the ventrals, which are rounded and of average size. The length of the former is about 9 %, of the latter nearly 12 %, of that of the body. The first (uppermost) ray in the pectoral fins is simple and only a little shorter than the second, which is the longest in the fin and branched like the remaining 9 or 10 rays, which rapidly and regularly decrease in length towards the bottom of the fin. In the ventral fins the first (outermost) two rays are simple, the first ray being, however, extremely small (rudimentary). The second simple ray is but slightly shorter than the third ray, which is branched and only a little shorter than the next, the length of which is equal to, or only a little less than, that of the third and fourth branched rays. The other branched rays (5th—7th) gradually decrease in length. Along the inner margin of the last ray runs a thickened growth of fin-membrane, with the appearance of a defectively developed ray. The under surface of the ventral fins seems, like the sides of the caudal fin, to be clothed with elongated scales.

The whole body is densely covered with scales, which extend forward on the head over the whole interorbital space, but are deciduous, the specimens taken being generally scaleless, or with only a part of the lateral line left. The scales (fig. 234, *a*) are thin, transparent, and flexible, rather large and of equal size, rounded or of a broad elliptical shape, set in the transverse direction of the body (with the vertical diameter greater than the horizontal); their nucleus is central; they are furnished with dense concentric striæ and a few (4—6) grooves radiating forwards and backwards. These grooves, between which the concentric striæ (thickened and elevated lines) are sharply curved, render the anterior margin of the scale sinuate, the posterior (free) margin irregularly erose. In the nucleus of the scale and the immediate neighbourhood of the nucleus, as well as in an angular patch coinciding with the margin of the dermal follicle, the concentric striæ are joined at right angles by transverse striæ, and in the hind (free) part of the scale they are irregularly broken up here and there, crossing each other in a network. The scales of the lateral line (fig. 234, *b*) have a short, pear-shaped duct at the centre of their outer surface, and are indented in a heart-shaped form, but deeply, at the hind (free) margin, by a narrow sinus, which widens, however, in front (towards the centre of the scale) in a stilliform manner. Pointed and elongated scales appear not only, as we have mentioned above, on the sides of the caudal fin and the under surface of the ventrals, but also in a row along the base of the dorsal fin, where they are more or less deformed (fig. 234, *c*), as if they were only half-scales, with laterally set nucleus and an increased number of grooves (about 9) obliquely radiating towards the anterior margin.

According to COSTA's figure the coloration of the whole dorsal side (including the upper part of the head) and the lower posterior part of the tail is brownish red, of the opercular apparatus shifting green and black, of the ventral side dark brown, of the sides of the head silvery. The few scales still adhering to the specimen kindly lent us from Christiania Museum suggest that the silvery lustre extended throughout the sides of the body; but where the scales are wanting, the skin of the sides (in spirit-preserved specimens) is also brownish red. Back from the occiput, sometimes to a line with the adipose fin (according to STORM), there run on each side one or two rows of orange spots, caused, according to COLLETT, by the fact that each scale in the two rows next above the lateral line bears a similar spot at its tip. These spots are visible, however, though faint, in the skin, after the scales have dropped off. COSTA figures some of them, along the base of the dorsal fin, as luminous spots.

The true luminous spots are here (in spirit-preserved specimens) of a greenish lustre. The largest on each side lies on the lower part of the hind preopercular margin. The three spots belonging to each hyoid arch we have already mentioned. The remaining spots are arranged, in the specimen now before us, as follows. Behind the shoulder-girdle, down to the isthmus, where the lowest spot lies just behind the posterior extremity of the lower jaw, runs a row of spots, the third from above being situated at the lower angle of the pectoral fin. In front of the ventral fins (on the preabdominal region) we find, on each side of the median line of the belly, a row of 3 luminous spots, and up the side of the body this row is continued obliquely backwards by a spot just before the outer angle of the insertion of the ventral fin and another set halfway up towards the lateral line. Behind the ventral fins (on the postabdominal region) there runs, on each side of the median line of the belly, from the hind (inner) angle of the insertion of the ventral fin to a line with the anal aperture, a row of 5 spots, and this row is continued up the side of the body by 3 spots, the uppermost of which is set on the lower portion of a scale in the lateral line. Along each side of the base of the anal fin is a row of 9 spots, and on the lower part of each scale in the lateral line above the end of this row there lie 2 spots. After a break measuring twice the distance between each pair of spots in the row at the base of the anal fin, there follows, on each side of the lower caudal margin, a row of 5 spots, both rows approaching each other behind; and after new interruptions there lie, on each side of the lower caudal margin, one spot just in front of the foremost supporting ray of the caudal fin, two at the side of the 4th—7th supporting rays, and one at the middle of the base of the lower caudal lobe".

The Greater Scopelus is a rare species, of which, wherever it has appeared, only solitary individuals have been found. It has most frequently been met with in Trondhjem Fjord, most often in two inlets, Örkedal Fjord and Gulos, that run south, with a common entrance west of Trondhjem, from the main fjord, where only one specimen has been taken, at Rissen, a little more to the west. All the five specimens secured by STORM in the winter of 1879—80 and the summer of 1881 measured $14^1/_2$ cm. in length, and were taken in Herring-nets. Further south, in the Skager Rack, two specimens have been found. EKSTRÖM received the one (MALM'S *Scopelus Kroyerii*) in April, 1856, from a fisherman who had found it in the stomach of a Cod taken on a long-line near the Skaw. The other specimen was procured at Strömstad by Baron CEDERSTRÖM in April, 1870, and forwarded by him to the Royal Museum; it had been taken in the same manner in Koster Fjord. On the Atlantic coast of Europe the Greater Scopelus has never been met with further south, though it seems to be one of the Herring's companions, and might consequently be expected to occur there as well. South of the Herring's geographical range, however, it has been found in the Mediterranean (off Sicily, from which locality it was first described, by COSTA; and off Nice, as described by STEINDACHNER), off Madeira (according to JOHNSON), and in the Gulf of Guinea (according to GÜNTHER); but as yet it must be reckoned everywhere among the rarest fishes. In its manner of life, which is otherwise unknown, it probably resembles *Maurolicus Mülleri*.

THE ARCTIC SCOPELUS.

MYCTOPHUM GLACIALE.

Fig. 235.

Base of the dorsal fin shorter than that of the anal, and less than $^1/_7$ of the length of the body. Length of the pectoral fins greater than that of the ventral, than either the preabdominal length or the postabdominal, and more than $^4/_5$ of the length of the maxillaries, which is perceptibly less than half of the distance between the dorsal fin and the tip of the snout. Longitudinal diameter of the eyes more than half ($> ^2/_3$[a]) of the postorbital length of the head, which is less than $^3/_5$ of its entire length. Least depth of the tail less than 8 % of the length of the body, or than $^2/_5$ of the greatest depth of the latter. Scales of the lateral line perceptibly larger than the others.

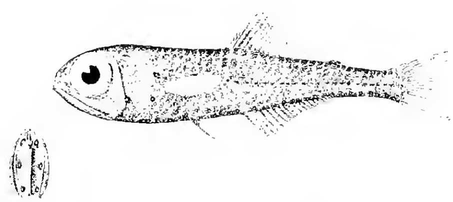

Fig. 235. *Myctophum glaciale*, together with the under surface of its lower jaw. Natural size. From Hardanger Fjord. Specimen in the possession of Bergen Museum.

R. br. 8; *D.* $\frac{3}{10-11}$; *A.*[b] $\frac{2-3}{15}$; *P.* $\frac{1}{10}$; *V.* $\frac{2}{7}$; *C.* $x + 2 + 17 + 2 + x$;
Lin. lat. 36; *Lin. tr.* $\frac{3}{4}$ 1; *Vert.* 36[c].

Syn. (?) *Labrus crolettus*, FABR., *Fn. Groenl.*, p. 166 (vide JØRGENSEN, apud KRØY.).

Scopelus glacialis, REINH., Vid. Selsk. Naturv., Math. Afh., vol. VI, p. CX; vol. VII, p. 126; KR. in GAIM., *Voy. Scand.*,

[a] Just in front of each eye, within the orbit, lies a light-coloured mass, with black limits, and similar to a luminous spot, though it is perhaps simply analogous to the growth of adipose membrane common in the Salmons and Herrings. To avoid damaging the specimen, we have refrained from examining this mass. It calls to mind, however, the large, composite luminous organ that appears on the snout of *Scopelus metopoclampus* etc.

[b] *A.* 16, according to DAY.

[c] According to KRØYER.

Lap., etc., Poiss., tab. 16, fig. 2; ID., Naturh. Tidskr. Kbhvn. ser. 2, vol. II, p. 230; NILSS., *Skand. Fna. Fisk.*, p. 483; GTHR., *Cat. Brit. Mus., Fish.*, vol. V, p. 407; ID., *Deep Sea Fish.*, Chall. Exped., p. 196; LTKN, Vid. Meddel. Naturh. For. Kbhvn 1891, p. 203[a].

Scopelus Mülleri, COLL. (nec GMEL.), Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 152; 1878, No. 4, p. 23; No. 14, p. 104; 1879, No. 1, p. 84; ID., N. Nordh. Exped., Zool., Fiske, p. 158; (?) BR.-GOODE, BEAN, Bull. Mus. Comp. Zoöl., Harv. Coll., vol. X, p. 222; BR.-GOODE, *Fisher., Fisher. Industr. U. S.*, tab. 203; DAY, Nature, vol. XXXIV, Oct. 14, 1886, p. 571; (?) A. AGASS., Bull. Mus. Comp. Zoöl., vol. XV, p. 33, fig. 219; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 20.

The Arctic Scopelus seems never to attain the size of the preceding species. KROYER had specimens from Greenland 46—96 mm. in length. The only specimen we have been able to examine, kindly lent us by the Museum of Bergen, has probably measured 77 or 78 mm., though its length cannot be stated with certainty, the caudal fin being broken off short.

The difference from the Greater Scopelus is manifested in the very form of the body. The body is deepest at the occiput or just behind this point; and the depth then decreases almost rectilineally to the base of the caudal fin, the profile of the head being arcuate both above and below, with the tip of the snout about halfway up. The body is also thickest at the occiput and shoulders, growing regularly thinner towards the base of the caudal fin. The sides of the body are flat and parallel, back from the eyes. The dorsal margin is convex, as well as the top and bottom of the head, but the under surface of the abdomen is flat. The greatest depth of the body, in proportion to its length, is only slightly greater than in the preceding species, in our specimen little more than 21 % of the length of the body excluding the caudal fin[b]; but the thickness is perceptibly greater, nearly $13^{1}/_{2}$ % of the length of the body excluding the caudal fin, so that the greatest thickness is here nearly $^{2}/_{3}$ ($63^{1}/_{2}$ %) of the greatest depth[c]. The least depth of the body, on the other hand, is less, being only slightly more than $^{1}/_{3}$ (in our specimen 35·2 %[d]) of the greatest depth.

Owing to the short form of the body, the length of the head is also relatively greater, in our specimen 29·2 % of the length of the body excluding the caudal fin[e], in spite of the fact that the postorbital length of the head is distinguished in this comparison just for its smallness, measuring only 15 % of the length of the body excluding the caudal fin[f], and but slightly more than half (in our specimen 51·5 %[g]) of the entire length of the head. The eye, on the other hand, is comparatively larger, its longitudinal and vertical diameters, which are equal to each other, measuring $^{1}/_{10}$ of the length of the body excluding the caudal fin[h]. In front, at the round slope towards the snout, the forehead is rather deeply concave, but furnished with the same sharp, longitudinal carina at the middle as in the preceding species. The gape is smaller and somewhat more ascending than in the Greater Scopelus. The difference in size is indeed hardly perceptible in proportion to the length of the body, the length both of the upper jaw and the lower being $^{1}/_{5}$ of that of the body excluding the caudal fin[i]; but in proportion to the length of the head this difference is all the greater, the jaws here extending only a little behind the perpendicular from the posterior orbital margin. The length of the snout is more than $^{1}/_{5}$ (24 %[j]) of that of the jaws. The lower jaw projects slightly beyond the tip of the snout, where its point fits, when the mouth is closed, into a cavity. The maxillary on each side extends a little further back than the intermaxillary, the narrow hind part of which lies outside and above the lower margin of the posterior extremity of the former, which here expands into a triangle, truncate behind, and thus forms the hindmost portion of the margin of the upper jaw. The branches of the lower jaw grow even further inwards than in

[a] LÜTKEN supposes with LILLJEBORG that "COLLETT has shown that STRÖM's communication to O. F. MÜLLER was based upon his (STRÖM's) drawing"; whereas it appears, from COLLETT's own quotation from STRÖM's manuscript, that the said communication must have had reference to *Maurolicus Mülleri*. STRÖM sent his figure and description (with *Maurolicus* characters) to MÜLLER "more than 20 years before 1791" (see Skrivt. Naturh. Selsk. 1793, p. 15); but did not discover his first specimen of *Myctophum glaciale* until 1774 (according to the manuscript quoted by COLLETT).

[b] Answering to $20^{1}/_{2}$ % in the preceding species.

[c] Answering to 57—58 % in the preceding species.

[d] Answering to about 46 % in the preceding species.

[e] Answering to 27—26 % in the preceding species.

[f] Answering to 18—16 % in the preceding species.

[g] Answering to 62—66 % in the preceding species.

[h] Answering to 7—6 % in the preceding species.

[i] Answering to 21—$21^{1}/_{2}$ % in the preceding species.

[j] Answering to 15—18 % in the preceding species.

the preceding species, being almost entirely contiguous when the mouth and gill-openings are closed, the only space between them then consisting of a lanceolate gap at the extreme front, just behind the symphysis.

The dentition of the mouth and pharynx is weaker than in the preceding species, otherwise of similar type. The preoperculum is vertically set, slightly curved, with the hind margin expanded but extremely thin. The operculum, which is half free at the upper margin, is quadrangular with rounded corners and smaller than the suboperculum, which lies below and inside it; but these bones, as well as the interoperculum, are so thin and so densely covered with large scales that it is difficult to determine the limits between them and their shape without damaging the solitary specimen at our disposal. The branchiostegal membranes, with their 8 rays, are united to each other below and in front, but only for a very short distance, to a line with the centre of the eyes. The pseudobranchiæ are distinct and regular. The gill-rakers resemble those of the preceding species, and number 16 or 17 in the outer row on the first branchial arch. The last branchial arch of this species too is mostly coalescent with the clavicular arch, the hindmost gill-slit being consequently very small.

In contradistinction to the preceding species, the Arctic Scopelus belongs to a subdivision of the genus, proposed by Günther, in which the dorsal fin is shorter than the anal. The former fin begins half-way along the body *minus* the caudal fin, at a distance from the tip of the snout measuring about 54 %[a] of the length of the body excluding the caudal fin. Its base measures about 15 %[b] of the same length. Its first three rays are simple; the first two unarticulated. According to Kröyer's figure the fourth or fifth ray is the longest, the posterior rays uniformly decreasing in length. The adipose fin lies about half-way between the dorsal and caudal fins, is broader (longer at the base) than in the preceding species, and is supported by fine fibrils (flexible, corneous rods) within it. The anal fin begins at a distance from the tip of the snout measuring about $54\frac{1}{2}$ %[c] of the length of the body excluding the caudal fin and its length is about 24 %[d] of the same. The first two rays are simple and unarticulated, the first ray being very small. The branched rays, accordingly to Kröyer's figure, decrease uniformly and slowly in length behind. The shape of the caudal fin cannot be ascertained from our specimen; but the fin has certainly been deeply forked, and the length of its middle rays, here as well as in the preceding species, differs but little from the interorbital width, being nearly $6\frac{1}{2}$ %[e] of the length of the body excluding the caudal fin. In our specimen we find 8 supporting (spinous) rays at the upper margin of the caudal fin and 6 at the lower. The pectoral fins, which are set obliquely and rather high, are narrow, but very long, measuring 18 %[f] of the length of the body excluding the caudal fin. The ventral fins, which lie rather near each other, the distance between them being scarcely equal to the breadth of the base of either fin[g], are shorter than in the preceding species. Their length is $\frac{1}{10}$[h] of that of the body excluding the caudal fin. Their distance from the tip of the snout, here as in the preceding species, is about $\frac{2}{5}$ of the length of the body excluding the caudal fin. The distance between them and the foremost point of the base of the pectoral fins (the preabdominal length) is $\frac{1}{9}$[i], and that between them and the beginning of the anal fin (the postabdominal length) about 15 %[j], of the length of the body excluding the caudal fin. The shortening of the body in this species, as opposed to the preceding one, thus affects in the most essential degree the abdominal region.

The scales are comparatively larger than in the preceding species, but equally thin and of essentially the same shape and texture. The greatest difference meets us in the scales of the lateral line, which are considerably higher (broader). A scale from the middle of the lateral line in our specimen is 2·1 mm. long and 5·3 mm. broad. Its anterior (inserted) margin is rather evenly rounded (not triangularly pointed at the middle, as in the preceding species), with only faint sinuses, and

[a] Answering to 41 % in the preceding species.
[b] Answering to 30 % in the preceding species.
[c] Answering to about 59 % in the preceding species.
[d] Answering to about 22 % in the preceding species.
[e] Answering to 7—8 % in the preceding species.
[f] Answering to nearly 10 % in the preceding species.
[g] In the preceding species about twice this breadth.
[h] Answering to nearly 13 % in the preceding species.
[i] Answering to about $13\frac{1}{2}$ % in the preceding species.
[j] Answering to nearly 18 % in the preceding species.

its hind margin is without the deep, narrow incision, though according to KROYER's figure of this species the incision is sometimes present in the lateral scales. On the head the scales advance over at least the greater part of the interorbital space, and large scales, as we have mentioned above, cover the whole opercular apparatus. On the posterior, expanded part of each maxillary lies an obliquely linguiform scale (triangular with rounded corners), entirely covering this part; and the bases both of the pectoral and ventral fins are covered with several scales.

The true luminous spots are comparatively small and have a yellowish lustre. The hind margin of the preoperculum, at the limit between the operculum and suboperculum, is furnished with a luminous spot, and exactly below this point, at the upper anterior angle of the interoperculum lies another. Through each branch of the lower jaw there shine three spots. On each of the clavicles there are two spots. One spot is situated at the lower angle of the insertion of each pectoral fin. From the isthmus to the ventral fins there runs on each side of the ventral margin a row of five spots. Between the insertion of the ventral fins and the beginning of the anal fin this row is continued by four spots, and along each side of the base of the anal fin by seven more. Between the anal and caudal fins, which part is damaged in our specimen, both KROYER and COLLETT found six spots in a row on each side of the ventral margin. An upper row on each side of the body, in the abdominal region and on a level with the spot at the base of the pectoral fin, contains three spots, all belonging to the row of scales next below the lateral line, the foremost of them situated at the end of the preabdominal region, the other two in the posterior part of the postabdominal region. On each side of the tail there also runs a row of three spots, but this lies higher up, each spot being situated on the lower part of a scale in the lateral line, the first spot above the space between the first pair in the row along the base of the anal fin, the second in a similar relation to the last pair in the said row, and the third at the extreme end of the peduncle of the tail. At the dorsal margin of the tail, just in front of the upper supporting rays of the caudal fin, traces appear in our specimen of a large, composite, luminous spot, LEYDIG's *Perlfleck* or *Perlgrauer Fleck*[a]. At the middle of the interorbital space lies a spot (an epiphyseal body or a parietal organ?), which in *Scopelus Rissoi*[b], a nearly related Mediterranean form, has even more of the appearance of a luminous spot.

The coloration of the body, according to KROYER, is of a brownish green or an olive hue on the back, of a brassy lustre on the sides (with a bright golden lustre, according to GRAY[c]), of a darker olive-green under the belly. The cavity of the mouth and the branchial cavity, as well as the peritoneum, are black.

The internal organs have been described by KROYER. The liver is short but thick, with three lobes, the left one being the largest: the gall-bladder is small. The œsophagus is short but wide, the stomach small but somewhat saccate. Behind the pylorus hang 8 rather large cæcal appendages. The intestine is straight but rather wide. The saccate air-bladder extends about halfway along the abdominal cavity, and is connected by its pneumatic duct with the œsophagus. The generative organs lie as usual in the posterior half of the abdominal cavity, and have complete efferent ducts.

The Arctic Scopelus has long been known in the Scandinavian fauna, but is still rarer than the preceding species. In 1774 a specimen was taken by STRÖM at Söndmör; but since that occasion only 3 specimens have been met with, to the best of our knowledge, on the coast of Norway, and not a single specimen has ever been found on the Swedish or the Danish coast. One of the said 3 specimens — the very specimen which has been kindly lent us from the Museum of Bergen — was taken by Governor CHRISTIE about 1830, probably in Hardanger Fjord; the second was sent from Haswig, near Hammerfest, to Christiania Museum by Mr. BULL; and the third was found by the Norwegian North Atlantic Expedition in June, 1876, floating at the surface on the fishing-bank of Storegg off Aalesund. The species would seem to be commoner on the coast of Greenland, from which locality the Museum of Copenhagen has received several specimens, both from the northern and the more southern colonies, and in the Arctic Ocean, where the Norwegian North Atlantic Expedition took it

[a] See *Die Augenähnliche Organe der Fische*, p. 52, and LENDENFELD, *Deep Sea Fish.*, Challeng. Exped., p. 302, The dorsal organs or "sterne-chasers" of *Scopelus*.

[b] This species is similar to *Myctophum glaciale* in most respects; but the form of the body is still more shortened, especially as regards the tail, the body thus being relatively deeper, and the head larger, while the above mentioned luminous spots belonging to the scales in the caudal part of the lateral line are wanting.

[c] See DAY, l. c.

while trawling in 1,100 fathoms of water (71° 59′ N. lat.; 11° 10′ E. long.), and Captain GRAY found it floating at the surface, but still alive (73° 12′ N. lat.; 11° 28′ W. long.). Whether it was the same species that was met with in 1880—83 by the United States' Fish Commission "off the southern shores of New England" and by the *Blake* Expedition (31°—41° N. lat.; 65°—75° W. long., see BROWN-GOODE and BEAN, l. c.), is doubtful. No description is extant of the specimens found on these occasions, and the figures show important differences from the Arctic Scopelus as described above[a].

The large eyes of the Arctic Scopelus are unmistakable tokens of a life in deep water; and most of the specimens have consisted of unlucky individuals, borne with too great rapidity to the surface of the ocean, and there left to the mercy of wind and wave. But this species is, no doubt, a nocturnal surface-fish as well, voluntarily repairing in the darkness to the upper strata of the sea, for it has frequently been found off the coast of Greenland in the stomach of seals, which cannot live in the true deep-sea regions. All that is known besides of its manner of life is that it feeds on small crustaceans, though not exclusively on the most minute kinds, for COLLETT found in its stomach fragments of an Amphipod, *Themisto libellula*, which attains a length of 20—60 mm. The remaining food, as far as could be determined, consisted of several specimens of an Ostracod, *Conchoecia borealis*, which, according to SARS, has never been found at a depth of less than 300 fathoms.

SUBFAMILY PARALEPIDINÆ.

Dorsal fin situated considerably behind the middle of the body. Snout longer than the postorbital part of the head. Pseudobranchiæ present; but air-bladder and pyloric appendages wanting, or the latter present only in a rudimentary form.

Within this subfamily GÜNTHER[b] includes two very closely related genera of *Ammodytes*-like fishes, first known from the Mediterranean, that were united into one genus by CUVIER[c], and ranged among the Acanthopterygians beside *Sphyræna*, to which they also show resemblances in form of body. The Salmon-Launces are elongated and compressed (in general a foot long or less), silvery, more or less transparent, pelagic fishes, of predatory habits, as testified by the long and pointed canines, with which their intermaxillaries, lower jaw, and palatines are generally armed. Ten species have been described or at least mentioned by name: five from the Mediterranean and the Atlantic outside, three from the North Atlantic and the Arctic Ocean, and two from the Pacific. All these species, however, may well be contained within the limits of a single genus.

GENUS SUDIS[d].

Of this genus one species is indeed known from the high North, from Greenland and Iceland, namely *Sudis (Paralepis) borealis*[e], which is described at length by KRÖYER in the "Naturhistorisk Tidskrift", 2:den Række, 2:det Bind, p. 241, and figured in GAIMARD's *Voyage en Scandinavie* etc., *Poissons*, pl. 16, B, fig. 1. But in Scandinavia this species has not yet been found. On the other hand, KRÖYER has given, in FIEDLER and FEDDERSEN's "Tidskrift for Fiskeri", 2:den Aargang (1868), p. 70, a brief account of the discovery of a

[a] Both in TODD's figure (BROWN-GOODE) and in AGASSIZ' the dorsal fin begins much further forward than in the Arctic Scopelus, and the adipose fin is high and short as in the Greater Scopelus. In TODD's figure the base of the anal fin is considerably longer, in AGASSIZ' considerably shorter, than in the Arctic Scopelus. Along the base of the anal fin TODD's figure shows a row of 15 luminous spots, AGASSIZ' only 6. The lateral line contains in TODD's figure 46 scales, in AGASSIZ' 35.

[b] *Cat. Brit. Mus., Fish.*, vol. V, p. 418.

[c] CUV., VAL., *Hist. Nat. Poiss.*, vol. III, p. 356.

[d] RAFINESQUE, *Car. Alc. N. Gen.*, p. 60. *Paralepis*, RISSO, *Hist. Nat. Eur. Mérid.* tom. III, p. 472.

[e] REINHARDT, D. Vid. Selsk. Naturh., Math. Afh., vol V, p. LXXV; vol. VII, p. 125. Probably *Clupea coerasicolus*, FABR., *Fn Groenl.*, p. 183.

SUDIS ATLANTICUS.

which was found dead in May, 1865, where it had been cast ashore near the Skaw. Two specimens are said to have been observed, after a violent storm from the west; but only one was secured, and this reached KRÖYER's hands in a greatly damaged condition. It was a large fish, half a metre long, with much deeper body than the other known species of the genus. The greatest depth was contained only 7 times in the length of the body. A manuscript published in part by LÜTKEN[a] after KRÖYER's death further contains the remarks that the length of the head was 21·7 % of that of the body, that the dentition of the mouth was comparatively feeble and uniform, that the articulation of the lower jaw lay nearer to the perpendicular from the anterior margin of the eye than in the Greenland form, *Sudis borealis*, that the ventral fins were situated below the true dorsal fin, that the adipose fin was comparatively remote from the caudal, that the pectoral fins contained 15, the anal fin 20 rays, and that the scales were small, numbering about 20 in a transverse row.

FAM. CLUPEIDÆ.

Body of the well-known Herring form, but more or less deep or elongated, more or less terete or compressed. Scales middle-sized or small, thin, and generally deciduous. No luminous spots on the sides of the body. No adipose fin. Margin of the upper jaw formed by the intermaxillaries in front and by the maxillaries behind. No barbels. Air-bladder simple or internally cellular; its communication with the cranial cavity, where such a communication exists, without mobile osseous connexion. Branchial cavity usually furnished with large pseudobranchiæ. Ovaries furnished with oviducts.

No piscine family is so important to man from an economical point of view as the Herrings; and for the systematist too this family possesses great interest. Around it are grouped a number of families, foreign to the Scandinavian fauna, that combine its characters not only with preceding types, but also with Ganoid peculiarities. Soon after MÜLLER, on the strength of VOGT's investigations, had referred the genus *Amia* to the Ganoids[b], where AGASSIZ[c] had previously ranged *Lepidosteus* and *Polypterus*, which forms as well as *Amia* CUVIER[d] included among the Herrings, STANNIUS[e] showed that the character upon which MÜLLER had laid special stress, the double row of valvules at the passage from the ventricle of the heart to the *bulbus arteriosus*, also appears in *Butirinus* (*Albula*), another of CUVIER's Herring-fishes, which is still referred by some authors to that family. GEGENBAUR[f] showed — a thought which had suggested itself to MÜLLER — that the most essential difference in this respect between the Teleosts and the Ganoids together with the true cartilaginous fishes consists in the following circumstance. In the latter the ventricle of the heart, with the transversely striped muscles of its wall, is prolongated forward to a tubular, more or less conical chamber (*conus arteriosus*), on the inner surface of which the valvules in their more or less numerous rows are situated; whereas in the Teleosts the heart is destitute of this prolongation, the beginning (base) of the branchial artery that issues from the ventricle being instead dilated into a bulb (*bulbus arteriosus*), without muscles (with only elastic wall) or with unstriped muscles alone in its wall. STÖHR[g] completed these observations by pointing out the structure and distribution of the rows of valvules in different Ganoids, Sturgeons, Chimæras, and true

[a] Vid. Meddel. Naturh. For. Kbhvn 1891, p. 231.
[b] Abh. Akad. Wiss. Berlin 1844, p. 204.
[c] *Rech. Poiss. Foss.*, tom. II, part. II, p. 1.
[d] *Regne Animal*, ed. 2, tom. II, pp. 327—329.
[e] *Bemerkungen uber das Verhaltniss der Ganoiden zu den Clupeiden*, Rostock 1846.
[f] Jen. Zeitschr., Bd. 2 (1866), p. 365.
[g] Morphol. Jahrb., Bd. 2 (1876), p. 197.

cartilaginous fishes, representing different stages of reduction. BOAS[a] followed the same method with the Teleosts, showing that in *Butirinus* there is a distinct rudiment of a *conus arteriosus*, with transversely striped muscles and two rows of valvules, and that in *Osteoglossum* — now the type of a separate family of hard-scaled fishes which in other respects come near to the Herrings — and *Notopterus* — belonging to a family also nearly related to the Herrings, but with scaly head and without oviducts — the said rudiment is considerably smaller and possesses only one row of valvules, answering to the front row in the previous fishes. In the true Herrings the rudiment has almost entirely disappeared, and is replaced merely by a layer of connective tissue, without striped muscles; and this, as we have already mentioned, is the typical condition in the Teleosts.

The essential resemblances between the skeleton of the Herrings and that of the Salmons were remarked by L. AGASSIZ. But in the former the skeleton is, as a rule, more firmly ossified, and shows some remarkable peculiarities in systematic and morphological respects.

From a comparison between the skeleton of a Vendace and that of a common Herring, it appears that the same looseness prevails in the union of the lateral parts both of the neural arches belonging to most of the anterior abdominal vertebrae and the haemal arches of the posterior abdominal vertebrae. The latter are indeed closed throughout a considerable part of the trunk, an osseous bridge joining the right shaft of the arch to the left; but lower down the shafts again separate, and the ribs are attached to each part of these divided haemal spines. The vertebrae of the Herring are further marked — as anyone who has eaten a Herring knows — by the number of scleral bones developed in the tendinous walls (aponeurotic septa) between the transverse divisions (myocommata) of the great lateral muscles. A perfect abdominal vertebra (fig. 236) has no less than three pairs of such bones, the first (*na* = epineural bones) attached to the base of the neural arch or at the limit between that arch and the body of the vertebra, the second (*pa* — epicentral bones) to the body of the vertebra, and the third (*pla* — epipleural bones) to the base of the ribs or at their insertion. In the Salmonoids we find only one or two pairs of these scleral bones, the uppermost alone or in association with the lowest. In most Clupeoid forms the lower extremities of the ribs in general are applied to the inner surface of osseous growths from the skin, to which they are, however, but loosely united. These growths belong, as we have seen above in the case of the Sternoptychoids, to the median scales of the carinated ventral margin, the so-called ventral plates, with their spiniform processes in a backward direction (*dh*).

In the Herring too a great part of the chondrocranium is continuous. The long frontal bones (fig. 237, *fr*) send out obliquely backwards and downwards, on each side behind the orbits, a large process, which runs into the squamosal bone (*squ* and *gos* in the figure, *os pteroticum*), while the frontal bone itself behind touches the parietal bone (*par*). Between the said three bones on each side of the head the cranial wall is pierced by

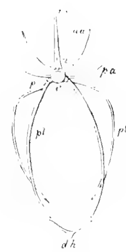

Fig. 236. Abdominal vertebra of a Herring. After BRANDT and RATZEBURG. *ns*, upper spinal process (neural spine); *n*, upper (neural) arch; *c*, corpus; *p*, transverse process; *pl*, rib; *na*, upper extracostal; *pa*, middle extracostal; *pla*, lower extracostal; *dh*, spiniferous plate at the ventral margin.

the large and oblong temporal aperture (*ap*)[b] characteristic of the Herrings. This aperture lies in front of the mastoid groove (temporal cavity), which is rather large in these fishes as well as in the Salmons and Carps, its bottom being composed of the squamosal bone, cartilage, and the mastoid bone (*mt* in the figure, *os epioticum*), while its walls belong partly to these bones, partly to the lateral portions of the squamosal part of the occipital bone (*ocs*). It is besides furnished with a roof formed by a backward process from the parietal bone (*par*), meeting a forward process from the mastoid bone (*mt*). The greater part of the roof of the cranial cavity has lost its cartilage in the Herring, only a lon-

[a] Vid. Meddel. Naturh. For. Kbhvn, 1879—80, p. 333.

[b] The temporal aperture sometimes occurs, it is true, in the Salmon (cf. BRUCH, *Osteol. Rheinlachs*, tab. IV, fig. 3, between Θ and Λ), and appears in the Smelt as a vestige of the great frontal fontanel in the cartilaginous cranium of young fishes. But it is there covered by the frontal bone.

gitudinal bridge thereof running under the frontal suture from the anterior extremity of the triangular squamosal (upper) part of the occipital bone forward to the transverse epiphyseal bridge of cartilage. In front of the latter bridge too the cartilaginous roof under the frontal bones is wanting above the olfactory lobes; but further forward, above the orbitosphenoid bone (*obsp*), begins the compact ethmoidal cartilage, extending forward to the tip of the snout. The last-mentioned cartilage, with its two terete transverse processes on each side, one in front of (*pena*) and one behind (*penp*) the nasal cavity, resembles that of the Salmons; but it rises anteriorly in a carina, and its covering bones, the true ethmoid bones, the vomer, and the lateral ethmoid bones (*etl*) are more developed. The ethmoid bones proper extend over the anterior transverse process of the cartilage (*pena*, the palatine process, on which the anterior extremities of the palatines and, partly, of the maxillaries have their articular surfaces), and each of them sends out backwards, on the upper surface of the cartilage, below and between the frontal bones, a long process, extending to about a line with the middle of the orbits. The lateral ethmoid bones (*etl*), covering the hind transverse process (*penp*) of the ethmoidal cartilage, spread like wings on either side. The vomer (*vom*) is narrow and long, being pointed behind and somewhat longer than the upper ethmoid bones. The parasphenoid bone (*psp*) is principally characterized by its complete division into two vertical plates behind the orbits, under the petrosal bone (the bone round *goa*, *os prooticum*) and the basilar part (*ocb*) of the occipital bone, and by its great elongation in a backward direction, where it projects beyond the last-mentioned bone. In the Salmons we found, it is true, that the hind orbito-muscular canal was rather large and open behind; but here the canal is still larger and entirely open, even below, its sides being formed by the vertical posterior plates of the parasphenoid bone and correspondent lamelliform processes descending from the petrosal and occipital bones, which in their turn form the roof of the canal (see fig. 237, *C*).

As the temporal aperture is a characteristic of the upper part of the cranium in the Clupeoids, so we find below a large and characteristic foramen (*fen*), covered only by the mucous membrane of the branchial cavity (upper pharynx). It occupies the point where the petrosal bone and the basilar and lateral (*ocl*) parts of the occipital bone would otherwise meet, and is separated by a special osseous septum (the bone round *gop*) from the foramen behind it (in the lateral part of the occipital bone), through which the *nervus vagus* passes out of the cerebral cavity. HASSE[a] explains this foramen (*fen*) as "the first appearance in the animal kingdom of that most important organ, the vestibular window" (*fenestra ovalis*), the communication between the vestibule and the tympanic cavity in the higher animals; and on the inner side thereof lies the *sacculus*, belonging to the nervous labyrinth, with the large otolith. The difference from the Salmonoids stands out most sharply on a comparison of this part of the Clupeoid cranium with the analogous part in the Smelt for example, where the foramen is replaced on the under side of the cranium by a large swelling, including the *sacculus*, and formed by the above-mentioned bones.

In the bones surrounding the auditory apparatus of the Herring we meet, however, with an appendage of which there is no vestige in the Salmonoids, but which is probably analogous to the several lymphatic chambers in the neighbourhood of the labyrinth that have been noticed in the skull and the front of the spinal canal of the Cyprinoids, and which there communicate with processes of the air-bladder. This appendage consists, on each side of the skull, of three osseous globules (*goa*, *gos*, and *gop*), filled with air and lined with a thin, silvery membrane. Their structure is more compact than that of the neighbouring bones, and their white colour renders them easily distinguishable. They all lie in different planes, one above another; but from the lower posterior globule (*gop*) runs an osseous duct, which ramifies and sends out a branch to each of the other two.

The foremost and largest of these globules (*goa*) lies in the petrosal bone, just behind the passage for the *nervus trigeminus* (*ftr*), in the lateral part of the cranial floor, where the said bone sends out its leaf-shaped process, down towards the parasphenoid bone, to share in the structure of the side-wall bounding the anterior part of the hind orbito-muscular canal. The outer posterior, uppermost globule (*gos*), which is skirted by the horizontal (outer), semicircular canal of the labyrinth, lies in the squamosal bone, just within the hind part of the articular cavity for the hyomandibular bone and outside the opisthotic bone (*st*, *os opisthoticum* or *intercalare*). The lower posterior globule (*gop*), the smallest and most elongated (clavate), is situated in the lateral part of the occipital bone, between the foramen of the *nervus vagus* (*fv*) and the *fenestra ovalis* (*fen*), forming the very osseous septum between these holes that has just been mentioned. The osseous shells of these globules and its cavity are indeed continuous; but whether the cavity of the membranous lining (sac) also affords at all times a free communication between them, is a question which we must leave open, for in one specimen we have succeeded in preparing the sac of the lower posterior globule whole and, as far as we could see, without any opening in front. The anterior globule (*goa*, the petrosal globule)

[a] *Anat. Stud.*, Bd. 1, p. 600.

is partly (somewhat more than half) divided within by an incomplete, horizontal septum, only the sac of the lower part being thus continuous with those of the other globules, while the upper part (the part nearest to the cranial cavity), which is pierced behind by a transversely-set, oblong aperture with a raised rim at the upper margin, is filled by an extension of the lymph-space surrounding the auditory apparatus. In the anterior part of the globule, however, this extension lies close to and above the said sac. The osseous wall of the lower posterior globule (*gop*), on the other hand, forms a tubular prolongation backwards and downwards to a line with the middle of the occipital bone, where its inner sac is continued by a duct with a more or less cartilaginous coating, that joins the anterior extremity of the air-bladder, though without free communication with the cavity thereof. All our attempts — like those of VALENCIENNES[a] — to inject liquid either from the air-bladder to the said globule or in the reverse direction, have failed; but a fine bristle may be passed with ease from the anterior osseous globule (*goa*) and through the lower posterior (*gop*) into the duct and down to the wall of the air-bladder.

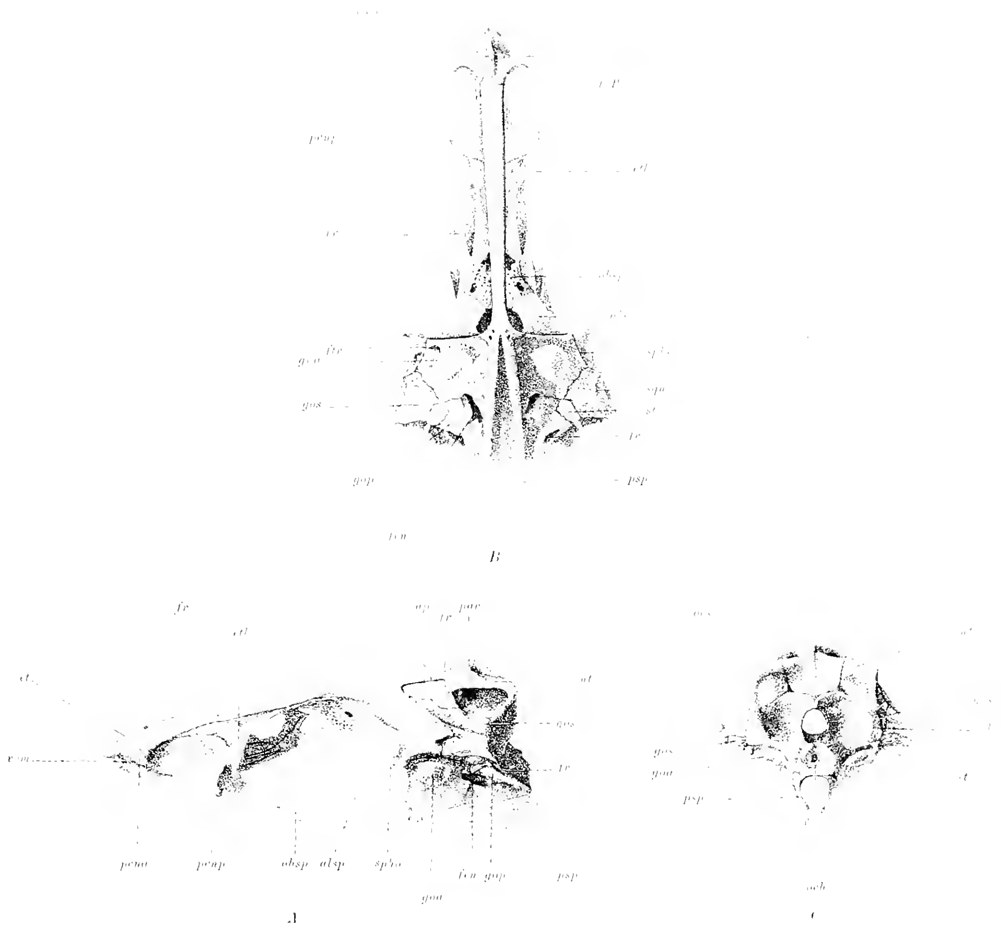

Fig. 237. Skull of a Herring × 2. *A* from the left; *B* from below; *C* from behind.

et, ethmoid bone; *rom*, vomer with its teeth; *etl*, lateral ethmoid bone; *pena*, anterior nasal process of the ethmoidal cartilage; *penp*, posterior nasal process of the same; *fr*, *fr*, frontal bone; *psp*, *psp*, parasphenoid bone; *obsp*, orbitosphenoid bone; *alsp*, alisphenoid bone; *spho*, posterior frontal bone (*os sphenoticum*); *op*, temporal aperture in front of the parietal bone; *par*, parietal bone; *mt*, mastoid or epiotic bone; *os*, squamosal part of the occipital bone; *ocl*, lateral part of the occipital bone; *ocb*, basilar part of the occipital bone; *st*, styloid, intercalary, or opisthotic bone; *fr*, foramen of the tenth cranial nerve (*nervus vagus*); *ftr*, foramen of the fifth cranial nerve (*nervus trigeminus*); *fen*, labyrinthine fenestra; *gou*, auditory globule of the petrosal bone (*globulus osseus anterior*); *gos*, auditory globule of the squamosal bone (*globulus osseus superior*); *gop*, auditory globule of the occipital bone (*globulus osseus posterior*).

[a] CUV., VAL., *Hist. Nat. Poiss.*, tome XX, p. 41.

By means of these globules and the ducts between them the wall of the air-bladder (but not its cavity, at least in full-grown Herrings[a]) is connected with the perilymphatic spaces surrounding the auditory apparatus, and variations of pressure may thus be transmitted from the former to the latter. The connexion is, however, comparatively simple, simpler at all events than in the Cyprinoids, and, as we have mentioned above (p. 826), this structure in the Clupeoids has consequently been regarded from a morphological point of view as a primitive stage of development of the corresponding apparatus in the Carp-fishes. Another characteristic of the Clupeoids is the connexion of the air-bladder not only with the stomach, into whose posterior, pointed extremity the pneumatic duct opens in the Herring, but also with the surrounding water, the hind part of the air-bladder being continued by a duct which opens on the posterior side of the triangular dermal flap forming a prolongation of the hind margin of the anal aperture[b]. The connexions of the air-bladder with the nearest environments of the labyrinth, and the large temporal aperture, which interposes only a thin and soft wall between those environments and the surrounding water, may well be the cause of the sensitiveness to noise so highly characteristic of the Clupeoids. The communication with the surrounding water, through the opening behind the vent, may help us to explain the circumstance that the air-bladder is sometimes found filled to distension with water[c].

The structure of the mouth is essentially the same as in the Gwyniads. The shape and position of the intermaxillaries in particular show striking similarities between the Herring and the Vendace. Here, however, these bones are not applied so closely to the maxillaries, which are distinguished by the accession of a further supplementary bone, situated in front of and (partly) outside the posterior one, which, as well as the maxillary itself, resembles in shape and position that of the Gwyniads.

Among the remaining peculiarities of the skeleton we will only touch upon the shoulder-girdle, which has guided PARKER[d] to some morphological conclusions highly worthy of attention. The postclavicle is not only divided, as in the Salmon, into a row of separate bones (in the Herring three, fig. 238, *B*, pcl_1, $_2$, $_3$), but also situated outside the clavicle (*cl*), an arrangement known only in the Herrings. How closely the shoulder-girdle of the Herring is connected with the dermal growths, a sign of its primitive rank from a morphological point of view (cf. above p. 635), further appears both in the thin, squamoid texture of the upper postclavicular bones at the hind margin, and in the still more squamoid,

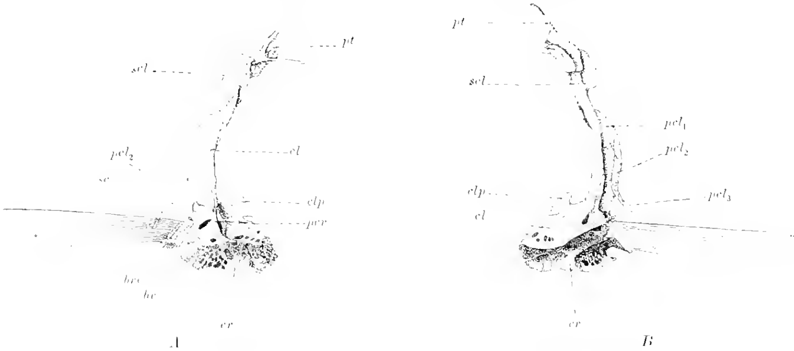

Fig. 238. Left scapular arch and pectoral fin of a Herring. Natural size. *A*, from within; *B*, from without.
pt, posttemporal bone; *scl*, supraclavicular bone; *cl*, clavicle; *clp*, ascending process from the anterior margin of the clavicle; *sc*, scapula; *cr*, coracoid bone; *pcr*, præcoracoid bone; pcl_{1-3}, the several postclavicular bones; *br*, brachial bones (inner row); *brc*, outer (distal) row of brachials.

[a] That the globules and ducts are excrescences of the air-bladder and in an embryonic state freely communicate therewith, seems more than probable; but we know of no direct observation on this head.

[b] Cf. WEBER, *De aure et auditu*, p. 73; BENNETT, Journ. Anat., Physiol., vol. XIV (1879—80), p. 405; DAY, The Zoologist, ser. 3, vol. VI (1883, Jan.), p. 24.

[c] Cf. CUV., VAL., l. c., tom. XX, p. 70.

[d] *Shoulder-Girdle and Sternum*, Roy Soc. 1868, p. 57.

leaf-shaped extension of the posterior part of the supraclavicle (*scl*), on which too the posttemporal canal of the lateral line is sometimes continued. In the apparatus of the pectoral fins we find a peculiarity otherwise unknown among the Teleosts, but characteristic of the Ganoids, namely the outer row (*bre*) of brachials (basal bones of the pectoral fins) possessed by the Herring[a].

The organs of respiration are exceedingly well developed in the Clupeoids; and they are protected as a rule by numerous and long gill-rakers. The pseudobranchiæ are large, and in many forms[b] we find on each side a separate, accessory branchial cavity, resting on the hindmost (fourth) epibranchial bone, which is flattened out into a plate for that purpose[c].

The digestive organs are as a rule comparatively simple, as in the Salmons. In all the Scandinavian Herrings the short œsophagus passes without external distinction into the stomach, which is prolonged into a sac and pointed behind; and from the anterior part of this sac issues in a forward direction the more or less muscular pyloric portion, bending back quite as sharply to pass into the intestine, which is fairly straight and runs without any convolutions to the vent. In exotic forms however — as for example in the Brazilian *Clupea anchoria* — the wall of the pyloric portion is sometimes thickened, in the same way as in the Mugiloids (see above, p. 329), into a sort of ingluvies, and the prolongated intestine forms several convolutions. Other Clupeoid forms show no backward prolongation of the stomach. The pyloric appendages are generally well developed, but quite as variable as in the Salmonoids. Even among the Scandinavian species the variations in the number of cæcal appendages behind (below) the pylorus are very great, the Sprat for example having 6—13, the common Herring 20—24, and the Shads about 80. In some exotic Clupeoids[d] the anterior portion of the intestine (the duodenum), into which the pyloric appendages open, is so greatly prolonged that bunches of these appendages occur almost throughout the length of the abdominal cavity. The mucous membrane lies, as usual, in longitudinal folds within the œsophagus and stomach; but in the intestine the folds, which are most developed, among the Scandinavian Clupeoids, in the Shads, are transverse. The liver is generally small, sometimes exceedingly small; the spleen commonly long and narrow. The saccate organs of reproduction with their complete excretory ducts are so large during the time of propagation that they fill the greater part of the abdominal cavity; but at other times, as in the generality of fishes, they are contracted, sometimes scarcely visible. The connexions of the air-bladder we have already mentioned, and we will simply add that the pneumatic duct sometimes opens into the posterior end of the stomach, sometimes further forward or into the œsophagus. In some cases too the wall of the air-bladder lies so close to the dorsal side of the stomach that the said duct is merely a very short funnel.

The scales are generally thin, deciduous, and cycloid, smooth-margined, or, not unfrequently, notched or even fringed with sharp spines at the hind margin. The head is always scaleless, as well as the fins in general; but the scales extend rather often over a great part of the caudal fin and the base of the dorsal, more rarely over that of the anal, and the axillary scales of the pectoral and ventral fins are in most cases well developed. Especially characteristic of most Herring forms are the angular, spinigerous scales at the abdominal margin, which send out lateral processes to meet the lower ends of most of the ribs (fig. 236, *dh*; fig. 240, p. 958).

The system of the lateral line shows great development, accompanied by a wide extension of the so-called adipose membrane, on the head; but the lateral line proper is wanting on the sides of the body, with the exception that in the common Herring we sometimes find the first (3—5) scales in one of the rows pierced in the ordinary manner. In certain forms, as for instance the Shads, the lateral line again crops up in some scales of singular shape, situated on the caudal fin[e].

The fins of the Clupeoids display the same wealth of variations as those of the Carp-fishes, and here too the variations principally affect the vertical (unpaired) fins. The dorsal, which is never very long, sometimes suffers reduction to the vanishing point; the anal, on the other hand, is sometimes exceedingly long, occa-

[a] Cf. Davidoff on the ventral fins of the Cyprinoids; see above p. 718. These bones appear in a cartilaginous form in several other Physostomi.

[b] See Hyrtl, *Über die accessorischen Kiemenorgane der Clupeaceen*, Denkschr. Akad. Wiss. Wien. Math. Naturw. Classe, Bd X (1885), p. 47.

[c] This spreading of the bone may be seen in the common Herring, though the accessory branchial cavity is not present.

[d] See Hyrtl, l. c., p. 51.

[e] See Heckel und Kner, *Süsswasserfische der Östreichischen Monarchie*, pp. 230, 231.

sionally so long that it joins the caudal fin, as in the Sheatfish.

The Herring family is rich in forms. Even after the sifting to which they have been subjected by VALENCIENNES[a], GÜNTHER[b], and BLEEKER[c], there remain about 200 named species, a large number of which have only a dubious claim to that rank. The family consists mainly of salt-water fishes, but many species are anadromous, and some are true fresh-water forms. It is in the temperate and frigid seas of the Northern Hemisphere that the family has attracted most attention and played the most important part in the economy of man; but gregariousness is a trait common to the whole family and shared by its members in the Southern Hemisphere. Great shoals of certain species[d] rove in the South Pacific, along the coasts of New Zealand and Australia, as the common Herring does in our latitudes. But owing to the less advanced development of industrial enterprise in those southern regions the fisheries have not yet attained such dimensions as in the earlier seats of civilization.

To the ancient Greeks and Romans the Clupeoid family was by no means unknown, though the Herring itself does not occur in the Mediterranean; and even in the time of ARISTOPHANES they had learnt to cure their take of Herrings (principally Anchovies and Sardines) by salting. *Halec* originally meant *brine*. Which species they designated by their names, it is, however, difficult to determine. Among the modern Greeks *Thrissa* is the name applied to the Mediterranean *Clupea* (*Alosa*) *aurita*. *Chalcis* (in ARISTOTLE a fish that roved in shoals) was, according to CALLIMACHUS, the same species as *Trichis*, and ARISTOTLE gives[e] *Membras*, *Trichis*[f], and *Trichias* as different ages of the same species, probably the Shad. The Anchovy was known by ARISTOTLE as *Enkraulos*, by ÆLIAN as *Engraulis*, *Enkrasicholus*, and *Lycostomus*. *Clupea* was a classical Latin name. *Alosa* (*alausa*, the Germanic *Alse*) occurs first in AUSONIUS.

Of the four subfamilies under which the Clupeoids, after the above-mentioned reductions in the number of the species, naturally fall, only two are represented in the Scandinavian fauna, by the following species of more or less common occurrence:

I: Length of the upper jaw from the tip of the snout less than $^3/_4$ of that of the head; intermaxillaries shorter than the maxillaries[g]; ventral margin carinated[h] — Subfamily *Clupeina*.
- *A*: Postorbital length of the head less than $^1/_4$ of the distance between the dorsal fin and the tip of the snout. — Subgenus *Clupea*.
  - *a*: Length of the base of the anal fin less than $^1/_4$ of the distance between the ventral fins and the tip of the snout *Clupea harengus*.
  - *b*: Length of the base of the anal fin more than $^1/_4$ of the distance between the ventral fins and the tip of the snout *Clupea sprattus*.
- *B*: Postorbital length of the head[i] more than $^1/_4$ of the distance between the dorsal fin and the tip of the snout. — Subgenus *Alosa*.
  - *a*: Least depth of the tail more than $^4/_5$ of the length of the maxillaries .... *Clupea pilchardus*.
  - *b*: Least depth of the tail less than $^4/_5$ of the length of the maxillaries .... *Clupea alosa*.
    - *α*: Gill-rakers on the first branchial arch about 40—60: var. Clupea finta.
    - *β*: Gill-rakers on the first branchial arch about 60—120: var. Clupea alosa.

II: Length of the upper jaw from the tip of the snout more than $^3/_4$ of the length of the head. — Subfamily *Engraulina* .... *Stolephorus encrasicholus*.

Several indications, as for example the more or less advanced position of the ventral fins and the gradual prolongation of the anal fin, suggest that in the Clupeoid family the course of development has been from the small-mouthed Herrings to the large-mouthed Anchovies. But our materials are not sufficient to enable us to pass a decisive opinion on this point.

[a] CUV., VAL., *Hist. Nat. Poiss.*, vol. XIX.
[b] *Cat. Brit. Mus.*, *Fish.*, vol. VII.
[c] *Atlas Ichthyologique des Indes Orientales Néerlandaises*, tome VI.
[d] *Clupea sagax*, *Clupea sundaica*, *Spratelloides delicatulus*.
[e] *De Anim. Hist.*, lib. VI, cap. 15.
[f] From θρίξ, *hair*, an allusion to the hair-like bones in the flesh.
[g] Intermaxillaries longer than the maxillaries in the subfamily *Dorosomatinæ* (*Chatoessinæ*).
[h] Ventral margin not carinated in the subfamily *Dussumieriinæ*.
[i] At all events when measured obliquely from the middle of the posterior orbital margin to the lower posterior angle of the operculum.

Genus CLUPEA.

Mouth of moderate size (in comparison with that of the Anchovies small), the length of the maxillaries being less than half (in Scandinavian forms 40—48 %) of that of the head. Tip of the lower jaw projecting to a greater or less extent beyond that of the snout. Dentition of the mouth feeble, more or less rudimentary. Anal fin not much longer (less than twice as long) or even shorter than the dorsal; its rays less than 30.

The greater number of the Clupeoids belong to the genus of the true Herrings; and the number of species[a] contained therein is great enough to have occasioned several attempts to divide it into subgenera. Valenciennes even distributed its members among several genera[b], which he based principally on the differences in the dentition. But Nilsson arrived long ago "at the conclusion[c] that the teeth are highly variable in different specimens, even of the same species, the bones which are furnished with teeth in one specimen being toothless in another". But the Shads — whose dentition is as a rule the feeblest — differ so greatly in other respects as well from the remaining Herrings that they may with reason be placed in a separate subgenus bearing the name of *Alosa*.

Subgenus CLUPEA.

Body without spots. Lower anterior portion of the outer surface of the operculum smooth (without grooves). Dorsal fin set so far back that the distance between it and the tip of the snout is more than 4 times the post-orbital length of the head. No large scales of singular form on the caudal fin.

Of this subgenus the Scandinavian fauna possesses only two species, the Herring and the Sprat, both of great economical importance, and so like each other that only a practised eye can distinguish between them, where they occur, as they often do, in company. In modern times the most painstaking student of their varieties has been the eminent German naturalist, Professor F. Heincke, who has come to the conclusion[d] that the difference between them is only gradual, in the sense that the Herring exhibits races differing from one another in the same manner as, but to a less degree than, the two species. We have above seen the same relation obtain between the Salmons and Charrs, and in the present instance too we find that the smaller species attains its place in the form-series of the genus more rapidly (at a smaller relative size) and more fully (with more prominent characters). The larger of the two species is the well-known fish,

[a] About 90 species have been described.

[b] Cuv., Val., *Hist. Nat. Poiss.*, vol. XX, pp. 14, cett.

[c] *Skand. Fau. Fisk.*, p. 489.

[d] *Die Varietäten des Herings*, II, p. 56 (VII Ber. Comm. Unters. deutsch. M.).

THE HERRING (SW. SILLEN.)

CLUPEA HARENGUS.

Plates XLIII, fig. 1 and XLIV, fig. 1.

Length of the base of the anal fin less than $\frac{1}{4}$ of the distance between the ventral fins and the tip of the snout[a]. *Number of spines at the ventral margin (between the isthmus and the vent) 36—48*[b].

R. br. 8; *D.* $\frac{3-5}{(13)14-16(17)}$ (18—20[c]); *A.* $\frac{2-3(4)}{(12)13-16(17)}$ (16—18[d]); *P.* $\frac{1}{15-17}$[e]; *V.* $\frac{1}{7-8}$[f]; *C.* $r+1+17+1+r$; *L. lat.* (56)60—66(70); *L. tr.* 15—16; *Vert.* 51—58[g].

Syn. *Harenq* (Chalcidis species) p. p., BELLON., *Nat., Divers. Poiss.*, p. 168; *Harengus*, RONDEL., *De Pisc.*, lib. VII, cap. XVI; GESN., *Hist. Anim.*, lib. IV, p. 408; SCHONEV., *Ichthyol. Slesv. Holsat.*, p. 36; NEUCRANTZ, *De Harengo*, Lübecae 1654; WILLUGHB., *Hist. Pisc.*, p. 219, tab. P. 1, fig. 2. *Clupea* maxilla inferiore longiore, maculis nigris carens, ART., *Ichthyol.*, *Gen.*, p. 7; *Syn.* p. 14; *Spec.*, p. 31; LIN., *Fna Suec.*, ed. I, pag. 120; GISSL., Vet.-Akad. Handl. 1748, p. 107. DUHAM., *Tr. Gén. Pêches*, part. II, sect. III, p. 335. *Clupea Harengus*, LIN., *Syst. Nat.*, ed. X, tom. I, p. 317; PENN., *Brit. Zool.*, tom. III, p. 294, tab. LXVIII, N:r 160 ed. London, (1776) (+ *White-bait.*, p. 325, tab. LXIX, N:r 176, quam speciem *Cyprini* generis censuit); FABR., *Fna Groenl.*, p. 182; BL., *Fisch. Deutschl.*, part. 1, p. 186, tab. XXIX, fig. 1; RETZ., *Fna Suec. Lin.*, p. 352; LACEP., *Hist. Nat. Poiss.*, tom. V, p. 427; SW., PALMSTR., *Sv. Zool.*, Bd. I, N:r 22; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 209; NILSS., *Prodr. Ichth. Scand.*, p. 23; EKSTR., Vet.-Akad. Handl. 1834, p. 20; Öfvers. Vet.-Akad. Förh. 1844, pp. 82 et 119; YARR., *Brit. Fish.*, ed. I, vol. II, p. 110 (+ *Clupea Leachii*, p. 117 + *Cl. alba*, p. 126); PARN., Mem. Wern. Soc., vol. VII, p. 315, tab. XXXV; CUV., VAL., *Hist. Nat. Poiss.*, vol. XX, p. 30, tab. 591 (+ *Clupea Leachii*, ex YARR., p. 243 + *Clupea elongata*, ex LESUEUR, p. 247 + *Clupea Pallasii*, p. 253 + *Rogenia alba*, ex YARR., p. 341); KR., *Danm. Fisk.*, vol. III, p. 138; NILSS., *Skand. Fna, Fisk.*, p. 491; SUNDEV., Stockh. L. Hush. Sällsk. Handl. 1855, pp. 81, 96, 187; MGRN, *Finl. Fiskfna*, p. 67; LINDSTR., *Gotl. Fisk.*, Gotl. L. Hush. Sällsk. Arsber. 1866, p. 19 (sep.); v. BEMM. in HERKL., *Bouwst. Fna Nederl.*, part. III, p. 380; GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 415; BOECK, *Silden, Sildef.*, I, Chrnia 1871; SARS, *Indber. Dep. Indre.* 1872, p. 5; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 185; 1879, N:r 1, p. 97; N. Mag. Naturv. Chrnia, Bd. 29 (1884), p. 111; MALM, *Gbgs Boh. Fna*, p. 570; LUNDBE., Bih. Vet.-Akad. Handl., Bd. 3, No. 4; HCKE, *Var. Her.*, Kiel. Commiss., IV—VI Jahrg., p. 37; VII Jahrg., p. 59; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 47; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 169; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 443; SMITT, Arch. Biol., vol. III (1882), p. 259, tab. XI; MELA, *Vert. Fenn.*, p. 353, tab. X; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 265 (+ *Clupea mirabilis*, ex GIR., ibid.); DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 208, tab. CXXXVIII, fig. 2; MÖB., HCKE, *Fisch. Osts.*, p. 135; BR.-GOODE, *Fisher., Fish. Industr. U. S.*, Sect. I, p. 549, tab. 204 (+ JORD., *Cl. mirabilis*, p. 568), SMITT, Bih. Vet.-Akad. Handl., Bd. 14, Afd. IV, No. 12 (1888); LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 45; LJGN, Nord. Familjebok, Bd. 14, col. 1079.

Obs. PALLAS (l. c.) united the Atlantic and Pacific forms into one species. GIRARD (Proc. Acad. Nat. Sc. Philad., 1854, p. 138) ranged the latter as a distinct species, *Clupea mirabilis*; but the characters hitherto assigned to it — at most 15 rays in the anal fin and at most 51 vertebræ — may also be found in the Atlantic Herring.

The well-known Herring comes nearest both in form and coloration to the Vendace, but its body commonly shows strong compression from the terete back downwards. But when the Herring is *full* (i. e. when the reproductive organs are ripe), the belly is also comparatively terete, though the downward compression is always marked at the head and isthmus. The fish attains a size of 43 cm. or more, but varies considerably in this respect, according to the conditions under which it lives. The greatest depth, just in front of the dorsal fin, measures on an average 18 or 19 % of the length from the tip of the lower jaw to the extreme end of the caudal fin, but sometimes rises, in gravid females, to 21 % thereof, and, on the other hand, in young Herrings, even at a length of 125 mm., measured as above, sometimes sinks to only 15 % there-

[a] Here, as in the Gwyniads, we have reckoned the tip of the snout from the articular knobs of the maxillaries.
[b] The limits of variation according to HEINCKE.
[c] In exceptional instances 17 and 21.
[d] In exceptional instances 14 and 19; 15 and 20 according to HEINCKE.
[e] In exceptional instances 14.
[f] In exceptional instances 9.
[g] According to HEINCKE.

of[a]. The least depth of the body (of the tail) measures on an average $6\frac{1}{3}$–$6\frac{1}{2}$ %[b] of the said length. According to the method of measuring the length of the body employed above, in the case of the Gwyniads, i. e. from the articular knobs of the maxillaries to the end of the middle caudal rays, the least depth of the body varies between 8 and 7 % of its length. The variations in our specimens from Bohuslän are such that the averages regularly decrease from 8·1 % to 7·3 % as the length of the body increases from 16 to 37 cm. The body as a whole is of the most beautiful fusiform shape, the dorsal and ventral contours forming regular and similar curves; but the lateral compression is so marked that the greatest thickness, which, as we have mentioned, lies nearer to the back, measures, in the line of the greatest depth, about half — in young specimens and after the spawning about $\frac{2}{3}$ — of the latter.

The length of the head varies between $22\frac{1}{2}$ and $19\frac{1}{2}$ % of that of the body[c]. It is of the well-known, three-sided, pyramidal shape that we have already seen in the Flying-fishes, but with narrower upper surface and with the snout constricted above, in front of the eyes. The most characteristic points are the prominent tip of the lower jaw and the coat of adipose membrane concealing a great portion of the eyes and extending both over the sides of the snout and the upper part of the shoulder-girdle. This membrane forms two folds in front, one composing the anterior limit of the orbit, and another the anterior eyelid, which passes above without a break into the posterior, growing narrower like the latter, but is somewhat broader below, lying in a fold outside the lower, pointed corner of the posterior eyelid, which gradually passes behind and below into the adipose membrane of the opercular apparatus and the cheeks (the suborbital ring). In this latter membrane, which is continuous both with the covering of the sides of the snout (the preorbital bones) and with the skin of the forehead and occiput, we find an abundance of the ordinary ramifications of the lateral line, which also occur on the shoulders, though everywhere less developed than we shall find them in the Shads. The top of the head, from the nostrils right to the occipital crest, as far as the frontal bones extend, is coursed on each side by a well-marked lateral ridge, bounding a depressed, lanceolate area, dotted with muciferous pores, the tip of the area lying at the occipital crest itself. But at the middle of this area runs an elevation, in front terete or even mesially depressed, behind sharper, which is formed anteriorly by the above-mentioned ridge on the ethmoidal cartilage, and disappears posteriorly, behind the interorbital space. The eyes are round, or slightly longer than high, but the part free of the eyelids is elliptical, with the upper and lower ends pointed. They are rather large, their longitudinal diameter varying on an average between $\frac{1}{4}$ and $\frac{1}{5}$ of the length of the head, and being about equal in adult specimens to the length of the snout from the middle of its tip to the anterior corner of the eye, but measuring only about half the postorbital length of the head. They are set so high that their upper margin approaches close to the frontal plane. The nostrils lie on a level with the upper margin of the pupil and about half as far from the anterior corner of the eye as from the middle of the tip of the snout. The anterior nostril of each pair is round and distinct, though comparatively small; the posterior more crack-like and usually overhung by the adipose membrane belonging to the sides of the snout. The two pairs are separated by a distance measuring on an average about $\frac{2}{5}$ of the breadth of the snout at the articulations of the maxillaries. The sharp tip of the snout is formed by the thin-lipped intermaxillaries, which strongly remind us, both in position and form, of those of the Vendace. They are flat but somewhat arched, triangular, with the posterior (outer) corner elongated to a point and armed on the inner surface of the inferior margin with a row of about 6 pointed, incurved (recurved) teeth. They are without nasal processes — the tip of the snout being consequently not protrusile — and their anterior lower corners are rounded to such a degree that they are distinctly parted from each other at the middle of the tip of the snout. But the sinus thus caused is filled by the labial skin, the tip of the snout being thus entire and truncate, without indentation or groove. In

[a] In the largest Herrings we often find retrogressions to the characters of youth. In a *full* female, with the length of the body measuring 42 cm. and with eggs 0·8—1 mm. in diameter, taken in February, 1887, off Helsö (Northern Bohuslän), the greatest depth is only 16·1 % of the said length.

[b] Varying, according to LILLJEBORG's measurements, between 5 and 7 %.

[c] According to our ordinary method of measurement.

the maxillaries we have to distinguish, as among the Vendaces, between the more terete, introrse, articular shaft, which supports the intermaxillaries on its upturned, grooved, and proximally broader, front surface, and the lateral part, set almost at right angles to the former, and indeed terete in front, but soon expanding into the flat, sabre-shaped disk that forms the externally visible maxillary. This part is obtusely rounded behind and toothed with spines at the thin lower margin, and by the addition of the supplementary bone is rendered fairly uniform in breadth throughout the greater part of its length. The posterior supplementary (jugal) bone is elliptical, and in front pointed, the anterior narrower and of uniform breadth. The length of the lateral maxillary disk, measured from the articular knob, varies on an average between 10 and $8\frac{1}{2}$ % of that of the body or between 47 and $44\frac{1}{2}$ % of that of the head, and the bone extends back to a line with the anterior margin of the pupil or even with its centre, though always so that the length of the cheek (between the maxillary and the vertical anterior margin of the preoperculum) is greater than its height exactly below the eye. The cheek is covered by the large, third suborbital bone, which also forms the greater part of the posterior limit of the orbit, the fourth (hindmost) suborbital bone being comparatively short. The lower jaw is characterized by the rather great height of the dental part — about twice the breadth of the maxillaries or $\frac{2}{5}$ of the length of the lower jaw — and by the terete ridges on the outside of this part, which diverge backwards from each side of the chin, one of them running along the upper margin, the other parallel to the lower margin. The symphysis is also fairly high, and is furnished below with a small, prominent chin-protuberance, but channelled underneath at its angle. Only at the extreme front of the upper margin do we find an arcuate row of small teeth (6 on each side of the symphysis), in well-marked, but closely approximated sockets. The length of the lower jaw varies between 13 and 12 % (in the oldest specimens 11 %) of that of the body, or 60 and 57 % (exceptionally 61 % or, in the oldest specimens 55 %) of that of the head, and it is greater, as a rule, than the length of the base of the anal fin, though in exceptional cases this relation too is reversed. On the symphysis and the sides of the lower jaw hangs a fairly broad labial fold. Internally the mouth is furnished with the ordinary transverse folds (vela), the lower being the more developed. The vomer has in front a longitudinal, lanceolate elevation, bearing a double row of small, pointed teeth, somewhat larger, however, than the jaw-teeth; and a shorter row of smaller teeth usually occupies the extreme front of each palatine. The tongue is free and fleshy, but thin-margined. On the glosso-hyoid bone is an almond-shaped card of small teeth. The gill-rakers are set in a single row on most of the branchial arches, long and setiform, with numerous small spines on their sides. On the first branchial arch there are about 70, as a rule 45—47 (exceptionally 44 or 50) on the lower part thereof, and the longest (at the middle of the arch) are about equal in length to the suboperculum at its suture with the operculum. Only on the upper part of the third arch and on the fourth arch as far as it forms the anterior margin of the short, hindmost gill-slit, do we find an inner (posterior) row of short, lamellate rakers. About 20 spines, similar in form to the latter, occupy the outside of the lower pharyngeals, which resemble branchial arches, and are furnished with only one row of small teeth, whereas the upper pharyngeals bear a triangular card of similar teeth. The outer gill-openings are large, extending above the upper margin of the operculum, from a level with the superior margin of the eye, down to a line with the anterior margin of the latter. The operculum is obliquely quadrilateral, with the upper posterior corner rounded and the lower anterior corner prolongated to an acute angle, so that the faint S-shape of the subopercular suture is directed obliquely backwards and upwards. The length of this suture varies between 23 (exceptionally $21\frac{1}{2}$) and 26 (exceptionally 27) % of that of the head. On the surface of the operculum we can distinguish three slightly convex patches, separated by two shallow grooves, one running obliquely backwards and upwards, the other obliquely backwards and downwards, from the articular head of the operculum. But these patches are smooth or marked only with faint concentric striæ, and the anterior lower patch in particular is destitute of radiating grooves or ridges. The suboperculum resembles a narrow, eccentric sector of a circle, varying in breadth; sometimes its margin shows an irregular, shallow indentation. The preoperculum is obtuse at the inner angle, but the lower posterior corner forms a rounded right angle. Its posterior disk is so broad that its length (the lower arm together with the disk) is about equal to its height (the vertical arm together with the disk). The interoperculum is triangular and equal in length to the preoperculum. Its externally visible part (below the preoperculum) is, however, sword-shaped and of uniform breadth. The hind margins of the preoperculum and interoperculum together form a slightly curved line, continued below the latter in a contour forming an obtuse angle with the inferior margin of the suboperculum. In the Herring, as in the other Clupeoids, we find a bone that seems at first sight to be a lower suboperculum, forming an angular break at the lower posterior angle of the opercular apparatus. In order that the apparatus may be more firmly closed at this angle, the anterior margin of the shoulder-girdle rises at this point in the form of an elongated, sharp-edged knob, the substratum of which consists of an upright process (*clp*, fig. 238, p. 950) from the upper margin of the horizontal arm of the clavicle. On closer examination, however, it soon appears that the apparent lower suboperculum is really the hindmost of the three broad branchiostegal rays set on the epihyoid bone. The first five rays, which are situated on the ceratohyoid bone, are subulate and more curved. The branchiostegal membranes are free both from each other and the isthmus, and overlap each other only to a very small extent in the extreme front, the left membrane lying outside the right.

The dorsal fin, which is trapezoidal in shape, begins at a distance from the tip of the snout (the articular heads of the maxillaries) measuring 47—51 % of the length of the body. The length of its base is 13—10 %, and its greatest height (the length of the first or second branched ray) 12—10 % (less frequently 9 %), of the length of the body. The anal fin is of a similar shape as the dorsal but much lower. The distance between its beginning and the tip of the snout is 71—75 %, the length of its base 11—10 % (exceptionally 12 or 9 %), and its greatest height $5^1/_2$—$4^1/_2$ % (exceptionally 6 or 4 %), of the length of the body. The caudal fin is deeply forked, the lower lobe being somewhat longer and more pointed than the upper. Its middle rays occupy about 5—4 % of the length of the body, and measure only $^1/_3$—$^1/_4$ of the length of the longest rays in the fin.

The pectoral fins are set low, as in the Salmons, and of an oval, obliquely pointed shape, the second branched (third) ray being usually the longest. Their length varies between 16[a] and 13 % of that of the body, and during youth is generally somewhat more, in old specimens perceptibly less, than half the preabdominal length, which increases even relatively with age, from 30 to 35 or nearly 36 % of the length of the body. The ventral fins are broader and shorter, but triangular. Their length varies between 10 and 8 % of that of the body. Their insertion always lies some distance, though in young specimens this is sometimes very small, behind the perpendicular from the beginning of the dorsal fin, and at a distance from the tip of the mouth measuring 54[b]—55 % of the length of the body. The postabdominal length is about $^2/_3$ of the preabdominal, and varies between about 20 and 23 % (exceptionally 24 %) of the length of the body.

The thin and deciduous scales (fig. 239) are round or quadrilateral with rounded angles. The hind (free) part is indented at the margin with small, rounded sinuses, and shows only faint traces of radiating grooves. The anterior part (covered and about twice as large) is

Fig. 239. Scale from the left side of a *Clupea harengus* 3 dm. long. × 3.

smooth-margined and marked with extremely fine and numerous, irregularly undulating and confluent, transverse striæ, without radiating grooves or with only rudiments thereof, in the form of a few streaks (5—7 upwards and downwards) obliquely crossing the others. In this striature the growth-rings of the scale also appear as concentric lines. The lateral line does not pierce any scales — only in exceptional instances are there a few perforated scales in front — but under the scales it runs straight from the upper clavicle to the middle of the base of the caudal fin. The singular marginal scales of the belly (fig. 240) are of an oblique diamond-shape, with a strengthening ridge in the median line of the belly, ending in the backward spine, and another on each side, continued by the upward process. They are remarkable in the Herring for their number, which is greater than in the following species, being as a rule, according to HEINCKE, 27—30 (excep-

[a] In young Herrings sometimes 17.

[b] In the fry sometimes $50^1/_2$.

tionally 24—32) from the isthmus to the ventral fins, and 13—15 (exceptionally 11—20) between these fins and the vent, in all 36—48. Just in front of the ventral fins lies a double plate, the upward processes being bifid, or showing indications that they were originally composed of as many as three processes. The other preabdominal plates, on the other hand, with the exception of the foremost ones, are distinguished from those of the following species by their long lateral processes.

The colour of the back is steel-blue with a lustre of green and gold; the sides are silvery. The limit between the colours of the back and belly is often marked by a tinge of lustrous green. The new-caught Herring glitters with a wealth of hues, and in the darkness it gleams with phosphorescent light. The snout and the upper parts of the head, as well as the superior part of the opercular margin, are sometimes pure black. The

Fig. 240. Spiniferous scales from the ventral margin of a *Clupea harengus* 25 cm. long. Twice the natural size.

a, the foremost spiniferous scale; *b*, the fifth, counting forward from the ventral fins; *c*, the double scale just in front of the ventral fins; *d*, the fifth scale, counting forward from the vent; *e*, the hindmost spiniferous scale.

gill-covers are of a golden lustre, more and more suffused with blood, the longer the fish has been dead. The ventral and anal fins are white but transparent, as well as the pectorals; but the upper margin of the last-mentioned fins is of a grayish or greenish black, which colour extends, in greater or less intensity, some way down the fins. The dorsal and caudal fins are darker, though the membrane is transparent, more densely speckled with grayish black, shading on the rays into green. The iris is sometimes silvery with a brassy lustre; in other cases the latter colour is predominant.

With coloration of a lighter or darker tone, and with body more or less transparent, though this transparency is always faint, the Herring varies according to the greater or less intensity of light in its surroundings.

In the temperament of the whole Herring family gregariousness and a love of migration are the most prominent traits. The common Herring, an inhabitant of the North Atlantic and probably, as we have mentioned above, of the corresponding regions in the Pacific, roves in huge shoals within the said geographical range. How far its wanderings extend, is still an undecided question, though numerous investigators, from the beginning of the last century until now, have devoted their attention to its solution. In an *Atlas maritimus commercialis*, printed in London in 1728, reference is made to the annual course of the Herring-fishery off the coasts of Great Britain and Ireland, then essentially the same as it is to the present day. The most important fishery in those waters begins in summer to the extreme north, off the Shetland Islands and then on the Scotch coast, but afterwards advances further and further south on both sides of Great Britain, to England, Ireland, and the Channel. Hence it was inferred that the Herring-shoals must come from the far North; they were supposed at first to be so large and densely packed that they had difficulty in forcing a passage "between the coasts of Greenland and North Cape"; but the Herring "army" divided as it came further south. On these assumptions the learned and clever Burgomaster of Hamburg, Johan Andersson, *d.* 1743[a], based his theory of the annual migrations of the Herring. The Herring, he opined, had its true home under the ice of the Arctic Circle. There lay its cradle, and thither it retreated year after year to escape its merciless pursuers, and to recruit its thinned numbers. But soon the home became overcrowded; large multitudes were yearly compelled to emigrate southwards, and to divide into separate armies, which marched partly to the right, to America, and partly to the left, to the west coast of Europe and into the Baltic. This theory was still accepted in the days of Pennant[b]; but Bloch[c] and Noel[d] showed it to be

[a] See his *Nachrichten von Island, Grönland und der Strasse Davis*, Hamburg 1746, pp. 51—72.
[b] *Brit. Zoology*, 1776.
[c] *Fische Deutschl.*, part. 1, p. 189.
[d] Magazin Encyclopédique, tome VI, p. 5 (Paris 1795).

untenable, the latter stating that, in his opinion, "each marine region as a rule has its native Herring, which is easily distinguished from other forms by its migrating at a different time of year, when it forsakes its first home in the depths, and approaches land to deposit its roe in more suitable localities". MAC CULLOCH[a] pursued the criticism of ANDERSSON's theory, and in direct opposition to the regularity assumed by ANDERSSON, he ranged the unaccountable variations in the Herring's approach to the coast. It was hence that YARRELL[b] drew his well-known and often misused expression, "the Herring is a most capricious fish." But MAC CULLOCH also endeavoured to find an explanation of this fickleness in the different motives that induce the Herring to migrate from deep water to the surface and the shallows. Among the causes hereof he adduces the desire of spawning, a point already touched upon by NOEL, the search for food, consisting of animals known in his time as "medusæ and other analogous marine vermes, which are produced in such abundance during the summer, in all the shallow seas," and the fear of enemies. In Sweden NILSSON has been the most eminent exponent of this theory, and he attributed thereto a great economical importance, for he based on it his assertion that a Herring-fishery may be utterly destroyed, or at all events ruined for many years, by the manner in which it is carried on. The Bohuslän fishery was in his opinion a case in point; but this conclusion has been opposed by many.

The pith of the question evidently lies in the elucidation by natural history of the varieties of the Herring, if such varieties be really in existence. NILSSON originally[c] adopted eight constant, local varieties:

1) *The Ocean Herring* (Forma *oceanica*): Rabo[d] Herring (var. *oresundica*), Kulla[e] Herring (var. *schelderensis*), Bohuslän Grass-Herring (var. *majalis*), Bohuslän Breeding-Herring or Great-Herring (var. *bahusica*), Norwegian Winter-Herring (var. *hiemalis*), Norwegian Autumn-Herring (var. *autumnalis*);
2) *The Shore Herring* (Forma *lacuensis*): Kivik[f] Herring (var. *cimbrica*), Baltic Herring or "Strömming" (var. *membras*).

Subsequently[g] he reduced the number of these varieties to six, by uniting the Rabo Herring with the Kulla Herring and the Bohuslän Grass-Herring with the Great Herring. The names given above state where the varieties were supposed to occur, and the distinctive characters were derived from the differences in the size of the head and eyes, in the depth of the body, in the position of the fins, and in the number of marginal scales on the belly. Merely a hasty observation is enough to show that these characters hold good in the main, or, to employ NILSSON's words, when the Herring appears in large numbers together. And yet they are only signs of different developmental stages. It is but natural, however, that among innumerable individuals, as when the Herring appears in multitudes sometimes so densely packed within inlets of the sea that the name of *mountains* has been conferred upon them, individual differences should be comparatively easy to trace. But if we eliminate these individual variations by calculating a sufficient number of averages from an adequate number of individuals, we can make remarkable discoveries.

Among the factors necessary to an estimation of the significance of form-characters, or to a determination of the natural relations obtaining between different varieties or species, the differences of sex and the alterations of growth occupy the foremost rank. In order to find expressions for the former, I have caused the averages to be calculated for 75 Baltic Herrings, measured by Mr. LUNDBERG, Inspector of Fisheries[h].

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[a] Quart. Journ. Sc., Lit., Arts, vol. XVI, p. 210, London 1823—24.
[b] *Hist. Brit. Fish.*, ed. 1, vol. II, p. 112.
[c] *Prodromus Ichthyologiæ Scandinavicæ*, p. 23.
[d] Råå is a large fishing-village on the Sound, south of Helsingborg.
[e] Kullen is a promontory north of Helsingborg, south of Schelder Bay.
[f] A large fishing-village near Kristianstad.
[g] *Skandinavisk Fauna. Fiskarne*, p. 493.
[h] Bih. Vet. Akad. Handl., Bd. 3, No. 4.

Averages in the Baltic Herring (*Strömming*, *Clupea harengus*, var. *membras*)			
Number of specimens measured		35	10
Length of the body from the tip of the lower jaw to the end of the caudal lobes, expressed in millimetres		212.4	219.9
Distance between the dorsal fin and the tip of the lower jaw	in % of the length of the body	44.75	44.67
" " " ventral fins	" " " " " " " "	48.71	48.79
" " " pectoral fins	" " " " " " " "	20.64	20.71
Depth of the body behind the tips of the pectoral fins	" " " " " " " "	18.27	17.93
Thickness " " " " " " " "	" " " " " " " "	9.12	8.90
Depth " " " " " " " ventral "	" " " " " " " "	15.20	15.27
Length of the head	" " " " " " " "	20.81	20.73
Horizontal diameter of the eye	" " " " " " " "	5.56	5.42
Vertical " " " "	" " " " " " " "	5.09	5.06
Interorbital width	" " " " " " " "	3.54	3.52
Length of the snout	" " " " " " " "	7.15	7.21
" " " upper jaw	" " " " " " " "	8.69	8.69
" " " lower "	" " " " " " " "	11.25	11.15
" " " base of the dorsal fin	" " " " " " " "	10.60	10.71
" " " pectoral fins	" " " " " " " "	13.02	13.03
" " " ventral "	" " " " " " " "	8.39	8.32
" " " base of the anal fin	" " " " " " " "	9.53	9.56

In vain do we seek here for any noticeable difference between the sexes. All the percentages are the same in both columns, except in two instances. The depth of the body behind the tips of the pectoral fins and its thickness at the same point are somewhat greater in the males than in the females. This difference, however insignificant it may appear, is of economical importance, and had in NILSSON's opinion a zoological importance as well. Greater depth and thickness combined involve greater fleshiness and greater value even to the epicure. The most important difference adduced by NILSSON between the Norwegian Summer (Autumn or Fat) Herring and the Norwegian Spring (Gray-boned[a]) Herring, also consisted in the relative depth and thickness. The same difference appears too between the so-called Autumn Strömming and Spring Strömming, on a calculation of the averages for these two forms, as far as they have been distinguished, in LUNDBERG's tables:

A v e r a g e s i n	Spring Strömming.	Autumn Strömming.
Number of specimens measured	23	29
Length of the body expressed in millimetres	210.9	215.5
Depth of the body behind the tips of the pectoral fins in % of its length	17.9	17.7
Thickness " " " " " " " " " " " " " " " "	9.0	8.8

The difference is indeed slight; but here as in the preceding table, its course is opposite to that of the changes of growth in the Herring, and it is therefore not without importance. The Autumn Strömming too generally finds a better market than the Spring Strömming. NILSSON remarked this difference between the *Kirik Herring* and his *Strömming*.

Exactly the same distinction may be traced, however, between different takes of the same Herring-shoal, netted at the same time, in the one instance farther from land and in deeper water, in the other nearer shore and in the shallows. This I have shown in my report to the Swedish Home Secretary on the experiments in drift-net fishing carried out under my supervision in Bohuslän during the winter of 1880—81. From the measurements taken by Mr. TRYBOM, Assistant Inspector of Fisheries, I calculated the following averages.

[a] The word in the original (*gråbenssill*) really means, according to LJUNGMAN, *grofbenssill*, i. e. coarse-boned Herring.

	Number of specimens measured	Averages: Length of the body expressed in mm	Averages: Greatest depth of the body in % of the length of the body	Averages: Greatest circumference of the body, in % of the length of the body
Drift-net take, Dec 20th, 1880, in Koster Fjord	6	314	20	46
Seine take, Dec 21st, 1880, „ „ „	5	280	17	44
Drift-net take, Jan 3rd, 1881, „ „ „	5	315	18	45
„ „ Jan. 5th, „ „ the Skager Rack, off Koster.	5	299	19	44
Seine take, „ „ „ Koster Fjord	5	259	17	39
„ „ Dec 15th, 1880, at Ottero, off Grebbestad	12	284	17	42

Here it appears distinctly that the drift-net takes (from deeper water) and the seine takes (made close in shore) differ from each other in the same way as the Fat Herring from the Gray-boned Herring and the Kivik Herring from the Strömming.

It is the difference between the Ocean Herring (*oceansillen*) and the Baltic Herring (*strömmingen*), however, that has been set forth most clearly and most reasonably, ever since LINNÆUS adopted the latter as a separate variety. The relations that obtain between these forms, I have endeavoured to deduce by another method from measurements and tables of averages[a].

Averages in Herrings from	Norway.	The Baltic	Bohuslan	Scotland	Norway		Scotland.	
Number of specimens measured	8	6	32	10	5	3	5	5
Length of the body expressed in millimetres	170.4	203.2	240.6	240.9	152.2	200.7	221	260.8
1. Length of the head in % of the length of the body	21.7	20.6	20.5	20.3	21.9	21.3	20.5	20.2
2. „ „ „ maxillaries	10.2	9.3	9.2	9.2	10.5	10.0	9.3	9.4
3. „ „ „ lower jaw	13.0	12.4	12.4	12.0	13.2	12.8	12.4	11.9
4. Height of the dorsal fin	11.0	10.3	9.9	9.9	11.5	10.4	10.4	9.7
5. Distance between the dorsal fin and the tip of the snout	48.0	48.8	48.8	49.7	48.5	49.5	48.3	51.0
6. Length of the pectoral fins	15.5	14.8	14.3	14.5	15.8	15.0	14.6	14.4
7. Preabdominal length	31.2	31.9	32.7	36.0	30.4	32.4	33.4	38.7
8. Distance between the ventral fins and the tip of the snout	52.2	52.2	52.9	53.7	51.5	53.5	53.2	54.2
9. Length of the ventral fins	9.8	9.3	9.4	8.8	9.9	9.6	8.8	8.8
10. Postabdominal length	20.8	21.9	21.9	22.7	20.6	22.0	22.0	23.3
11. Distance between the anal fin and the tip of the snout	72.4	73.6	73.7	71.5	72.4	72.9	73.7	75.2
12. Height of the anal fin	5.5	4.9	4.9	4.6	5.6	5.2	4.8	4.4
13. Length of the middle caudal rays	4.9	4.6	4.2	3.6	5.3	4.2	3.9	3.4
14. „ „ „ pectoral fins in % of the preabdominal length	50.0	46.6	44.0	42.6	51.7	47.2	43.8	41.5

Here the averages run with very great uniformity, falling or rising with age; and the form-series thus arrived at in the first four columns is controlled by the last four columns, which contain the alterations of growth in the youngest and the oldest among these races, the former consisting of Fat Herrings (*matjes*) from Stavanger, the latter of Scotch Herrings from Peterhead. Such an unbroken continuity in the form-series — if we choose to regard the Herring-races as separate forms — and such a parallelism in the alterations of growth could hardly be traced, were there no genetic affinity between all the above Herring-forms, from the Baltic and the west coast of Sweden, from Norway and Scotland. Thus, it appears, we can scarcely find any ground whatever for the assumption of a form-distinction or even of a racial difference. We see, however, that in the relations

[a] These measurements deviate in two respects from the preceding ones: the dimensions measured from the snout have been taken from the articular knobs of the maxillaries, and the length of the body has been measured to the end of the middle caudal rays. The percentages are consequently different from those already given, which can have no effect, however, upon the ultimate results.

which show the most marked alterations of growth — 7, 8, 10, and 13 in the table — the oldest Fat Herrings from Stavanger (Column 6), though smaller on an average than the Baltic Herrings (Column 2), have advanced further than the latter. Their development has proceeded more rapidly. Similarly the youngest Scotch Herrings (Column 7), though inferior in average size to the Herrings from Bohuslän (Column 3), have outstripped the latter in the alterations of growth. The more oceanic its home, the more rapid and more vigorous is the development of the Herring type. This is still more clearly shown by comparing with the last two columns Bohuslän Herrings more nearly approaching to them in age:

Averages in Herrings from	Bohuslän.	Scotland	Bohuslän	Scotland.
Number of specimens measured	11	5	8	5
Length of the body expressed in millimetres	221	221	263.1	260
Length of the head in % of the length of the body	20.5	20.3	20.3	20.2
Preabdominal length " " " " " " "	32.7	33.1	33.1	33.8
Distance between the anal fin and the tip of the snout " " " " " " "	72.8	73.7	74.3	75.2

The same results may be deduced from LUNDBERG's tables by thence selecting for comparison Baltic and Ocean Herrings with the organs of generation equally, or at all events not too unequally developed:

Averages in Herrings from	The Baltic				Bohuslän.
Number of specimens measured	11	12	19	6	7
Length of the body to the end of the caudal lobes, expressed in mm	186.1	205.6	223.3	294.2	247.9
" " " head in % of the above length of the body	21.4	20.9	20.8	20.3	18.6
Number of specimens measured	11	13	—	6	7
Length of the body to the end of the caudal lobes, expressed in mm	186.1	201.8	—	294.2	247.9
Vertical diameter of the eyes in % of the above length of the body	5.5	5.2	—	4.7	4.5

The Baltic form (the Strömming) thus fails, even at its most advanced age, to attain averages equal to those shown by the much smaller Herrings from Bohuslän in the last column. The Strömmings, as NILSSON has pointed out, have on an average a larger head and larger eyes; but this is only a general rule, for exceptions are not uncommon.

Between the Strömming and the Herring, however, the averages obtainable from LUNDBERG's tables show another distinction, the significance of which is all the greater, since it indicates a different direction of development or at least a divergent tendency, and seems most naturally to admit of explanation, as we have above stated of the analogous relations in the Salmonoids, on the assumption either that the forms are still in process of differentiation from each other, or that one of them is undergoing a degeneration expressed by reversions to the earlier stages of development. A rule of general validity, which I stated in 1882[a] in a description of an hermaphroditic example of this species, tells us that, after the dorsal fin has passed through the forward removal which, as SUNDEVALL[b] first showed, attends the development of the Herring from the larval stage, there ensues, during the subsequent growth, a backward removal of this fin. In a preceding table (p. 961) we have also seen that the percentages for the distance between the dorsal fin and the tip of the snout (relation no. 5) increase with age. The ventral fins share in this backward motion (relation no. 8). Let us now examine these relations in the Strömming, according to LUNDBERG's tables. For this purpose we divide the specimens measured by him into four groups,

[a] Arch. Biol., vol. III, p. 269. It should, however, be remarked that I was prevented from reading the proofs of this paper, which was printed at Brussels, and that a number of misprints, especially in the numerals, have consequently been overlooked.

[b] *Om fiskyngels utveckling*, Vet.-Akad. Handl. 1855, p. 20.

the first measuring 67—111 mm. in length of body, the second 136—201 mm., the third 203—240 mm., and the fourth containing all the large specimens, between 242 and 345 mm. in length. The first three groups roughly answer, according to other calculations of mine, to the age-classes of the first three years.

Averages in Strömmings					
Number of specimens measured		12	47	47	20
Length of the body to the end of the caudal lobes, expressed in millimetres		86	178.9	218.5	253.5
Distance between the dorsal fin and the tip of the lower jaw	in % of the length of the body	43.8	44.75	44.67	44.32
„ „ „ ventral fins „ „ „ „ „ „ „	„ „ „ „ „ „ „ „ „	47.1	48.93	48.58	48.39

After the second year there thus appears, on an average, by no means a backward removal, but a regular advancement both of the dorsal and the ventral fins. The normal development of the Strömming, in accordance with the rules for the Herring-type, terminates in general at the end of the second year. And it then shows, as we have seen above (the table on p. 961, relation no. 8), at an average length of 203 mm., the same position of the ventral fins as the Norwegian Herring does at a length of 170 mm. As regards the position of the dorsal fin (relation no. 5), the same rule applies to the Bohuslän Herrings.

That a racial difference exists here, seems, in a certain sense, undeniable. But this difference evidently agrees, as PETERSEN[a] has stated, with the geographical separation, and WINTHER's[b] observations go to show that this separation is sometimes evanescent. "The entire alteration in the Herring inhabiting the Sound", he writes, "may be summed up as follows. The little Baltic Herring (Kivik Herring, NILSS.), which flocks together at the beginning of autumn at the south end of the Sound, advanced in 1867 right to the middle of the strait, north of the Flint Channel, where it found the great basin known as the "*Hulkene*" untenanted by the *Bottom Herring*[c], which had already departed. After the spawning it followed the northward current out of the Sound into the south of the Cattegat, whence it returned year after year to its old spawning-place, constantly increasing, under the favourable influence of more congenial environments (the greater saltness of the water?), in size and fecundity. It continued to "improve" in this manner until 1873, when its development had advanced so far that it could no longer content itself within the confined limits of the Sound, but as it gradually attained the size and form of the "*Kulla Herring*", began to repair to the spawning-places of the latter variety. Only few returned in 1875 to the old spawning-places in the Sound, where a new stock of Baltic Herring this year (1875) replaced the old one in the Hulkene, north of the Flint Channel". The Strömming can thus become Kulla Herring, an alteration which, as we have seen, involves nothing more than a higher degree of the typical development of the species. But it by no means follows that all Strömmings become Herrings, nor does it seem possible for anyone to show that all young Bohuslän Herrings, *loddsillar* as they are called, in course of time become Ocean Herrings.

That a particular stage of development under permanent circumstances may become fixed as the termination of the development of a species under those circumstances, is nothing unusual, and the characters of youth, especially in fishes that breed before they have attained their full specific size and development, may become hereditary and, under certain conditions, remain unaltered. This is, no doubt, the explanation both of the actual difference between the average Strömming and the average Herring, and of the fact that the young of the so-called Spring Herring and Coast Herring differ from the fry of the Autumn Herring and Ocean Herring[d]. But the difference appears, to the best of our knowledge, only in the averages and, probably, only

[a] *Krotik* etc., Vid. Meddel. Naturh. For. Kbhvn, 1888, p. 1.

[b] Nord. Tidskr. Fisk., Aarg. 3 (1876), p. 12.

[c] The name given by the fishermen to the shoals of larger Herring in the Sound.

[d] "Il faut nécessairement admettre la résidence de ces poissons sur des fonds différents, ou la diversité de la grandeur et de la grosseur constitue autant de variétés ou de races qui se perpétuent par voie de génération"; CUV., VAL., l. c., XX, p. 49.

so long as the geographical separation is maintained. The three Herring varieties adopted by HEINCKE (l. c.), which he called *A*, *B*, and *C*, are also distinct expressions of different ages. The development has started from *C*, the characters of which, as HEINCKE says, are a blending of those of *A* and *B*; and the last-mentioned variety represents that stage of development in which the dorsal and ventral fins have moved furthest forward, again to recede, in accordance with the above-mentioned rule for the development, to the position which they occupy in HEINCKE's variety *A*.

Such is the manner in which the distinctions adduced between different kinds of Herring may be explained away. Practically expressed, the result is that no constant character has been discovered for the assumed varieties or races. It must, therefore, be assumed that the geographical separation is not marked enough to effect a complete severance of variety or race. The Herring is a migratory fish, no more restricted to fixed localities within its range than other such fishes. On endeavouring to find a centre for that range in the basin of the Atlantic, we arrive at a conclusion which in a certain degree recalls ANDERSSON's antiquated theory. A line including the White Sea, the extreme north of Norway, Iceland, Southern Greenland, Newfoundland, the west coast of Canada and of the Northern States, and further south on the European side meeting the Bay of Biscay, forms the approximate limit of the Herring's extension in the Atlantic. That the Herring besides is really an oceanic fish, is clearly shown by the fact that it attains its maximum size and its highest development of form in the ocean. The largest Herrings in the market come from Iceland, Norwegian Nordland, and Norwegian Finmark. Their average size (to the end of the caudal lobes) is 33—37 cm. Exceptionally large specimens are indeed known from other localities. From England we are told of Herrings 39 and 43 cm. long; but the most trustworthy and the latest accounts in DAY (l. c.) give 32 cm. as the maximum length. The Bohuslän Herring of the present day is also in general of the same size, though exceptions are not unknown. We have mentioned above a Herring from Helsö (Northern Bohuslän) which, though shrunk by the spirit in which it is preserved, measures 42 cm. to the end of the caudal lobes. It is not absolutely impossible that such Herrings may be native to our waters; but exceptions make no rule, and it must be regarded as most probable that the Herring attains its highest development, and has the centre of its range, in more northern regions, in the North Atlantic between Iceland and Norway. It is, beyond doubt, from this source that the Herring-fisheries of the North Sea and Norway, as well as of Bohuslän, derive their fluctuating supply[a].

The experience of many years teaches that the Herring comes to Southern Norway from the north-west. The Scotch Herring-fishery also begins yearly off the Shetland Islands and gradually extends further and further south. The Herring thus makes from the north an annual ascent of the plateau, offering a depth of at most 100 fathoms, on which Great Britain and Ireland are situated. If this plateau (see the map) were raised to the surface of the ocean, it would form an unbroken stretch of dry land between the said islands and the Continent from the Skaw south to about the middle of the Bay of Biscay. The west coast of the territory thus produced would coincide to the south with the present limit of the Herring's range in this part of the Atlantic. Between this plateau and Norway, along the west coast of Southern Norway, runs the deep, so-called Norwegian Channel into the Skager Rack, its depth falling short of 200 fathoms from the neighbourhood of Bergen south to Lindesnäs, i. e. outside the region where the Norwegian fishery for Spring Herring is carried on. The channel is rather narrow off Lindesnäs, but widens and grows deeper in the Skager Rack, so that between Arendal and the Skaw, somewhat nearer to Norway than to Denmark, there

[a] This opinion I advanced in 1878, as an explanation of the revival that had just begun in the Bohuslän Herring-fishery and of the prospects for its continuance, of which the authorities were then very dubious. About 1870 the fishery for Spring Herrings on the south coast of Norway had begun to decline. In 1872 the Royal Museum had obtained quite typical Spring Herrings from Strömstad. During the first years of the decade the Museum received from Bohuslän several pelagic species, Bonitos and other rovers of the open Atlantic, notorious as pursuers of the Herring. In 1856 too A. V. MALM had taken off Kalfsund Herring-fry 46—49 mm. long, which, as was then assumed, could not possibly be the young of the *Grass Herring* (a smaller kind, spawning in spring) that is always to be found on the coast of Bohuslän. It therefore seemed beyond dispute that the Great Herring had been present for several years in the North Cattegat and the Skager Rack, without being directly observed in those waters, until a part of the Herring army penetrated, after they had spawned, into the island-belt. I found every reason to believe, as has since been confirmed, that a new so-called Herring-period had set in on the coast of Bohuslän, i. e. that the Herring had made its way from the North Sea into the Skager Rack, deserting for this locality its spawning-places off the south-west of Norway.

are nearly 400 fathoms of water. The continuation of the channel, up to the 10-fathoms line, follows the west coast of Sweden south to about the latitude of Kongsbacka, i. e. as far as the true coast fishery for Great Herring has ever extended to the south in Sweden.

To trace the Herring to its ocean home is a hopeless task. Conjecture must still play a prominent part in all opinions of its life in the depths. But so much is apparently clear, that its wanderings follow the depressions and steeps of the bottom. How deep it can descend, we know not; but the advanced development that it can descend to considerable depths, of some hundred fathoms at least, though probably not to the deepest parts of the Atlantic.

As Mac Culloch has remarked, the rovings of the Herring have three motive causes, the quest of a spawning-place, the chase of food, and the dread of its pursuing enemies.

The spawning-season of the Herring lasts all the year round; but only a part of the wandering multitudes, in general those of the same age, are in breeding condition at the same time. Different spawning-seasons may hence characterize different localities, and

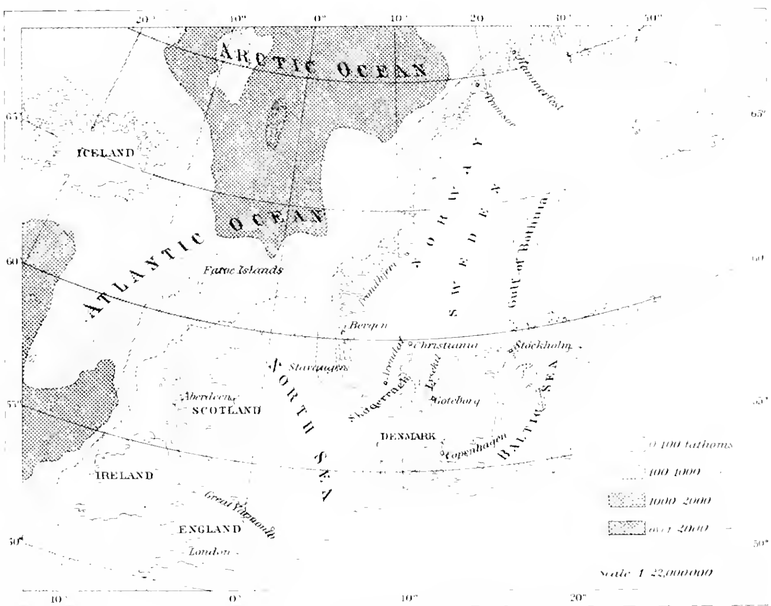

Fig. 241. The North-eastern Atlantic together with the North Sea and the Baltic. After O. Torell.

of the adipose membrane covering the head ranges it nearer than the Mackerel to the true deep-sea fishes. The pressure need not greatly distress the Herring, for only few fishes can so easily adapt the distension of the air-bladder to varying degrees of pressure. The lower temperature of the depths need not deter it, for fishes with so extensive a geographical range must by nature be accustomed to widely different temperatures, though the Herring seems sensitive to sudden variations. The same may be said of the greater or less salinity of different layers of water. All that we know of the Herring's nature well admits of the assumption in the same locality it is not uncommon to find two separate spawnings every year. In the Atlantic the two spawnings, where they occur, take place before and after the winter, in the Baltic before and after the summer. This applies to the main body of the shoals; but during the intervening periods isolated instances of breeding fish may be observed almost everywhere. As a rule the oldest Herrings spawn first, in the autumn, the younger ones later, when the spring has set in or in the summer. From the Gulf of Bothnia Gisler adduces the *Spring* or *Ice Strömming*, which spawns within the island-belt when the ice breaks up, the *Net Ström-*

ming, which spawns outside the island-belt from the middle of May to the end of June, and the *Autumn Strömming*, which spawns within the island-belt at the end of August and beginning of September[a]. In the island-belts of Stockholm and Mörkö[b] the true spring spawning occurs at the end of May and beginning of June, the autumn spawning at the end of August and beginning of September. In the south-east of the Baltic, near Dantzic and Königsberg each of the two spawning-seasons (varying from March—June and August—September) is of about the same importance to the fishery. Off Rügen and on the coast of Scania the autumn spawning is the more important; in the extreme west of the Baltic, off Trave and Schleswig, the spring spawning takes the upper hand. "The further south we advance along the Scanian coast", writes LUNDBERG[c], "the more seldom do we meet with spring-spawning Herring. The fishermen state, one and all, that several years may elapse without a single one being seen .... The spring-spawning Herring of the Sound, considered by G. WINTHER to be a distinct race, peculiar to the Sound, would also appear to consist of small specimens of the common Herring. Our Swedish fishermen there do not know of any *spring-spawning* Herring in the Sound, nor is there any regular fishery for Spring Herring on the Swedish side. A little Herring is indeed taken all the year round, mainly to serve as bait. But the Herring-fishery proper of the *Sound* and Cattegat does not commence until the middle or end of August or the beginning of September, and lasts till the middle or end of October. Most of the Herrings taken, however, are not in full breeding condition, i. e. though they are full of roe and milt, it is not quite ripe or running. At Kullen I was assured that Herrings in this last condition or spawning Herrings are very seldom caught during the true season for the Herring-fishery; but that, after the Herring-fishery proper is over, later in the autumn, at the beginning of November or end of October, shoals of spawning Herrings seek shelter, when the wind is in the north, under the lee of Kullaberg, and are then taken close in shore." In the Cattegat the true spawning-season begins in the middle of September. The Herrings taken in drift-nets off the coast of Bohuslän during the latter half of August, 1882, were for the most part not yet in breeding condition; but on the 26th of September I found spawning Herrings among the takes made 3—5 miles off Marstrand. That was the first time, during the present Bohuslän fishery for Great Herring, when it was conclusively shown that the Herring spawns, at least towards the end of September, off the said coast, and that a very profitable fishery with drift-nets might be carried on for at least a month before. That, later in the year, it continues its spawning within the island-belt as well, was proved by Mr. C. A. HANSSON, who found Herring-roe ready for hatching in Strömstad Fjord on the 5th of March, 1885. More recently (in 1888) TRYBOM observed the September spawning of the Herring in the North Cattegat off Fladen, Groves-Flak, Lilla Middelgrund, and the shelving banks north of Anholt, and outside the Cattegat at the edge of the shallows west of the Skaw[d]. Farther out in the Skager Rack, between Hanstholm (Jutland) and Christiansand (Norway), somewhat nearer to Denmark than to Norway, HEINCKE met with "spawning Bohuslän Herring" in the middle of September, 1889[e]. The younger Herring, the Grass Herring of the Bohuslän island-belt, spawns in spring, during March, April and May.

The Herring, like most fishes, chooses its spawning-places in water shallower than its ordinary home, and during youth at least, it also seeks for this purpose water of less salinity[f]. The large Herring can spawn in 60—100 fathoms of water[g], though it usually comes nearer to the coast; the smaller Herrings ascend into water sometimes no more than a fathom deep. In the neighbourhood of Stockholm the spawning is performed, according to SUNDEVALL, outside the island-belt or in the larger fjords, on rises of the bottom or reefs with 5—10 fathoms of water, close to land sometimes in only 3 fathoms. In the Baltic fishery the rule applies, that the males are the earlier, both in age and season, to attain breeding condition — during the spawning-fishery the males are usually taken first. But BOECK

[a] He further adduces from these regions *sill*, large males, with soft and running milt at midsummer or earlier, *Seine Stromming*, shotten Spring Strömming which is resting during the early summer and is then taken within the island-belt, and *Red-bellied Stromming*, answering to the Fat Herring of the Atlantic, with sexual organs not yet tumid.

[b] Cf. SUNDEVALL and EKSTRÖM.

[c] Meddelanden rörande Sveriges Fiskerier, Haft. 1, p. 40.

[d] *Sillundersokningar vid Sveriges vestkust hosten 1888*, Kongl. Civildepartementet, III, p. 16.

[e] Mitth. Sect. Küsten-, Hochs. Fischerei, Deutsch. Fisch. Ver., Jan.—Febr. 1890, p. 23.

[f] MEYER, Jahrber. Comm. Unters. Deutsch. M., Kiel, 1874—76, p. 232.

[g] BOECK, Nord. Tidskr. Fiskeri, Kbhvn, Aarg. 2, 1875, p. 263.

states quite the opposite of Norway[a]. When the spawning begins, however, the sexes mingle promiscuously, and the operation is performed much in the same way as we have above described when treating of the Gwyniads. GISLER tells in animated language how the Baltic Herring then approaches land in large and densely packed shoals, often extending more than three-quarters of a mile along the coast, and always containing many times more females than males. The fish tumble about, and lash with their tails so violently that the scales drop off and float to the surface, in company with small air-bubbles which the Herrings emit. The sea is dyed gray, and a powerful and rank smell, appreciable at a great distance, fills the air. The spawning multitude does not shun the net, but rather presses willingly into its meshes. The operation does not last long, however, at the same spot, "probably no more than five or six hours", according to SUNDEVALL, when the shoal withdraws. Out at sea the spawning presents a similar sight: in a confused mass, gleaming with phosphorescent light, the fish toss about, near the surface when the night is dark and the weather mild; deeper in the water when there is moonlight and in frosty weather[b]. The impregnated eggs sink to the bottom, and attach themselves to seaweed, stones, shells, and other firm objects, or sometimes cake together on the gravel or sand, or even on a clayey bottom.

The number and size of the eggs vary, as usual, according to the size of the mother fish and their own degree of ripeness. Their number may be estimated at about 20,000—40,000 in different females; their size, when they are ripe and ready to be deposited, varies in the Baltic Herring[c], generally speaking, between 0·92 (exceptionally 0·85) and 1 mm., in the North-Sea Herring between 1 and 1·3 mm.[d] Of the development we learn from SUNDEVALL's notes[e] that, "after the embryo had been formed, it was seen (in August) to turn in the egg seven or eight times a minute, subsequently more seldom, and latterly only once every two or three minutes. The hatching generally takes place in a fortnight or a little more, but in water of a higher temperature, over + 20° C. (+ 68° Fahr.) for example, only three days are required[f]. As long as the fry retain the yolk (fig. 242), they move in a peculiar manner. By violently bending or tossing the body, an operation repeated every second, or at somewhat greater or less intervals, they work their way upwards, to the surface (at least when they are confined in vessels 3—6 dm. deep), and as soon as they have touched the surface, they keep still and sink again to the bottom, where they lie for a while, and then resume this upward motion. — As soon as the yolk is absorbed, which takes a week's time, they commence swimming in dense shoals, with a serpentine movement. The fins and the general shape of the body seemed to have attained their full development in the course of two or three months, when the fish is about 36 mm. long." These remarks apply to the Spring Strömming. But so great may be

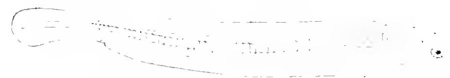

Fig. 242. Newly hatched Baltic Herring, 7 mm. long, taken on the 12th of May, 1854. C. J. SUNDEVALL.

the difference between the summer and winter growth that the Autumn Strömming, which develops during the colder months, requires in the Baltic, according to MÖBIUS and HEINCKE, 7—9 months to attain the said degree of development[g], and has then grown to a length of more than 60 mm. The ventral fins are developed in the Spring Herring of the Baltic, according to HEINCKE[h], when the fish is only $25\frac{1}{2}$ mm. long; but in the Autumn Herring they do not appear until the fish measures $33\frac{1}{2}$ mm. The following comparison has been drawn by MEYER between the growth of the Spring Herring in the Baltic and that of young Trout:

[a] l. c., p. 26.

[b] For a description of the noisy spawning at sea, and how the Herring immediately after the operation quits the spawning-place, see CUV., VAL., l. c., XX, p. 87.

[c] KUPFFER, Jahresb. Comm. Unt. D. Meere, Kiel 1874—76, p. 177.

[d] According to BOECK, l. c., 1·1 mm.

[e] *Om Fiskyngels utveckling*, Vet.-Akad. Handl., Bd. I (1855), p. 17.

[f] The hatching takes place, according to KUPFFER (l. c., p. 29), in water of a temperature between + 14° and + 19° C. within 6—8 days; according to MÖBIUS and HEINCKE (*Fisch Osts.*, p. 137), at a temperature of + 10° or + 11° C. in 11 days and at a temperature of + 7° or + 8° C. in 15 days.

[g] According to MEYER (Comm. Deutsch. Meer. 1874—76, p. 248), however, small Autumn Herrings 45—60 mm. long and of almost perfect shape are found in February.

[h] Comm., l. c., p. 128.

	Length immediately after exclusion, mm	Length 1 month afterwards, mm	Length 3 months afterwards, mm	Length 6 months afterwards, mm	Length 12 months afterwards, mm.
Herring	5—8	17—18	45—50	75—80	130—140
Trout	15	20	30	61	125

When it leaves the egg, the young Trout is thus about twice as large as the young Herring; but three months afterwards it has been outstripped by the latter.

The larvæ of the Herring are distinguished by an elongated (Eel-shaped), somewhat terete, and highly transparent body, with the vent situated far back, especially during the earlier stages, with the dorsal fin behind the middle of the body, but with the ventral fins set farther forward. The paired fins are lobate (with brachiate base), the pectorals appearing before the ventrals. In the Spring Herring of the Baltic the scales are developed at a length of only 41 mm.

When two years old, the Baltic Herring is about 20—21 cm. long; when three years old, 22—23 cm.; when four years old, 24—25 cm. In Norway the Spring Herring, it is assumed, requires 7 or 8 years to reach its full size. The males attain maturity at a length of 16—20 cm., the females at a length of about 21 cm.

After passing through the larval stage, the Herrings gather in shoals and commence their rovings along the coast, often ascending into a foot of water, and pursued by Garpike and other predatory fishes. On the shelving beach near Halmstad, though the Herring is else a stranger to Laholm Bay, the shoals of young Herrings were so dense in my childhood that during summer we boys used to catch numbers by wading out and netting them in our handkerchiefs. In July, 1834, about five miles west of the Skaw, within the innermost sand-bar, KRØYER[a] observed a shoal of Herring-fry that were about 5 cm. long. The shoal extended for a distance of about 200 yards and was more than 20 yards broad. It was so dense that the water seemed quite black. Herring-fry one year old are of rarer occurrence in the open sea[b]; but on the 12th and 13th of August, 1889, HEINCKE[c] found several specimens 15—20 cm. long among larger Herrings in the Skager Rack, on the seaward side of the Jutland Bank, where the depth was about 100 m. The Herring can thus endure the hardships of a life in the troubled ocean, and accompany its elders on their wanderings, at an early age.

The Herrings seem to seek strength, or at least to find a sense of security[d], in the close companionship of numbers, however little this avails. Out at sea they probably swim in more open order and mingle indiscriminately. The drift-net fishermen of Northern Scotland, who sometimes sail 80 miles from land, take full Herrings and shotten Herrings, ripe Herrings and maiden Herrings (matjes), in the same haul. But the nearer the Herring-shoal approaches to the shore, at different seasons of the year, the denser and the more exclusively do the different sorts congregate, in summer those which are most eager in the pursuit of food, in autumn those with the ripest organs of reproduction. Large shoals of maiden Herrings (fat Herrings) — with a thick coat of fat round the intestine, but with small, filamentous or ribbon-like organs of generation — repair in summer to the west coast of Norway north of Stavanger, and feast on their favourite food, the so-called *Aat*. The spawning Herrings, on the other hand, resort in still greater multitudes during autumn and winter, alternately, as it appears, for a series of years to the southern part of the west coast of Norway, and for another, shorter period to the Skager Rack and the Northern Cattegat as well as to the fjords of Norwegian Nordland. In the last-mentioned region the Herring sometimes advances within the island-belt before the spawning, but goes out again to breed. To the south of Norway and off the coast of Bohuslän the greater part of the Herring-shoal spawns before its appearance within the island-belt, at least in the beginning of the said period. In the Baltic the Herring goes out to sea after spawning; but on the west coast of Scandinavia it makes its way into the island-belt and the fjords, and rests there for a while, before withdrawing to the open sea. At these times it even enters fresh water. MOREAU states that it ascends the mouth of the Seine up to Quillebeuf[e]. After resting it again begins to feed, puts on flesh, and becomes what is known in Norway as *slosill* (with thread-like organs of generation). But the Herrings of the shoal are not all in the same condition, although most of them are ready to spawn. The main

[a] *Danm. Fiske*, vol. III, p. 159, note.

[b] BOECK, l. c., p. 18.

[c] Mitth. Sect. Küst., Hochseef. (Deutsch. Fisch. Ver.) 1890, p. 17.

[d] Cf. the above-mentioned observations of the Three-spined Stickleback (p. 657).

[e] Cf. also CUV., VAL., l. c., p. 66.

body sweeps along, and in the press swim Herrings small (so-called *lottsillar*), middle-sized, and large — shotten Herrings, spawning Herrings, and Herrings not yet in breeding condition.

The Herring is, no doubt, impelled, like other migratory fishes, by a well-known instinct, to retrace its way to the waters which first afforded it a home; and when the spawning Herring has found a locality where the circumstances are congenial to reproduction, it returns there, as a rule, during the following years, so long as these circumstances continue. On the coast of Bohuslän it has been observed, both in former times[a] and recent years, that during the commencement of a so-called Herring-fishery period the fish as a rule come earlier year by year, but afterwards later and later, until, tired of the place, they neither return in such numbers, nor approach so near to the coast. They have found more favourable circumstances in another locality or farther out to sea — a more tranquil spawning-place, a more plentiful supply of food, and greater security both for themselves and their offspring. The Scotch fishermen too have learnt that they may sometimes shoot their drift-nets for Herring quite close in shore, but in other years must sail far out into the North Sea throughout the fishing-season. These variations, which have been called Herring-fishery periods, cannot be determined beforehand. Our historical knowledge thereof, defective as it is, by no means points to definite periods in fixed succession. That they may depend on meteorological and hydrographic, not to say cosmic, alterations, we cannot positively deny; but the periodicity of these alterations is as yet unknown[b]. Century after century, ever since the eleventh, we have at least indications that the Herring has "come in" on the coast of Bohuslän. From the end of the twelfth century, at least down to 1537, the Herring-fishery of the Sound, with Skanör and Falsterbo as its headquarters, was far famed; but Lundberg has shown[c] that this was probably due, less to the greater abundance of the fish then, as compared with the present time, than to the commercial relations then obtaining, to the part taken in the fishery by the powerful Hanse Towns, and to the business-like manner in which they turned its resources to account. The Baltic Herring (Strömming) never appears in such vast numbers, and in this respect, as well as in its moderate size, more closely resembles the Shore Herring of Bohuslän. But Herring-fishery periods of abundance and scarcity occur in the Baltic too, as Sundevall has shown of the island-belt of Stockholm[d]. He adduces the instances that the seine-fishery for Strömming was

	at Nynäs	Årsta	Forsvik
successful .	up to 1825 incl.	. . . 1828,	. . . 1834.
unsuccessful .	. 1826 1839,	1829 1841,	1835—1843.
successful . .	. 1840 1849,	1842 1851,	1844 1851.
unsuccessful .	. 1850 et seqq.,	1852	1852 . . .

"so that each new period of plenty or scarcity sets in some years later, the farther the locality is situated within the island-belt."

Ekström gives the following description of the Baltic Herring's life in the island-belt of Mörkö: "In spring, as soon as the ice has broken up, and cleared away in some degree, the Strömming ascends from the depths where it has wintered. It rises so near the surface as to be carried along by any storm or gale. When it has come so near the coast that it does not wish to advance any further, a halt is made, the whole shoal turning round with military precision, and facing the wind. Thus it remains, almost motionless, until the wind changes and blows from the coast. It now turns again and faces the wind and the shore, but draws nearer the land to seek suitable stations. If it has drifted to a strange coast, it roves along the shore until it comes to places that seem convenient for the spawning and as a home during the summer. It now stays in their neighbourhood, roving about, now farther from land, now closer in shore, according to the direction of the wind, for on its wanderings from place to place it invariably swims against the wind or current, except, as mentioned above, when it drifts in spring to the coast. This migration, which depends on the direction of the wind and the set of the current when the fish ascends from the depths, renders the fishery more or less productive on different coasts . . . . Among these islands at any rate, such has always been the case. The experience of many years has taught the fisherman that, if the ice breaks up during a south-westerly gale, which is usually of long duration at this time of year, and which sets into

[a] See Fagelius, *Trangrumsacten* (1784), p. 129.

[b] "Brückner assumes a periodic variation in the heat radiated by the sun, and thus explains the variations of temperature, of atmospheric pressure, and of the rainfall. The thirty-five years' period has nothing to do with the number of sunspots." Kremser, Meteorologische Zeitschrift (Wien), 1891, p. 228.

[c] *Det stora sillfisket i Skåne under medeltiden och nyare tidens början*. Antiqv. Tidskr. f. Sverige, Del. 11, No. 2.

[d] Stockholms Läns Kongl. Hushållningssällskaps Handlingar, 6:te Häftet (1855), p. 187.

the island-belt, he may expect a successful fishing-season. But if the wind is north-east at the beginning of the spring, the fishery is always a failure. These migrations extend, however, over no great distance, being restricted to limits of some few leagues. The islander has a rough knowledge of the coast-line to a distance of at least some leagues from his home, and consequently can tell against which promontories or into which inlets the Strömming is driven by the wind prevailing for the time. So the islanders of Mörkö say, "If this wind holds, they will have Herring in the islands of Öster Gothland;" "With this wind the Herring will come to the island-belt of Stockholm;" etc. The places most affected by the Strömming are shallows with a level bottom in the large fjords, or the shores that abut on deep water, but do not fall sheer into the depths, having a fairly level bottom between the outer edge and the land. Such shores are generally to be found in these islands off promontories. They are all the better if there is a current. The bottom should be sandy or stony, and overgrown, at least in patches, with weeds. About midsummer, at the middle or end of June, the spawning is over, and the Strömming retires to deeper water. Towards autumn, in August, it again ascends, but never visits at this season the places where it has passed the spring or spawned, repairing instead to much deeper spots. In December or even earlier the greater number withdraw to their winter-quarters, which they choose in some deeper part of the sea. These places are not the same year after year, for, when the Strömming is taken in winter with the ice-seine, it is found standing now at one spot, now at another; but it keeps, generally speaking, to the same neighbourhood. The islanders of Mörkö have certain *strömmingsvarp*, i. e. certain sheets of water where Strömming may be taken with the ice-seine, but only the tract is known, not the exact spot."

The gregariousness of the Herring is bound up with its timidity. That it is easily alarmed by noise, we have already remarked, and EKSTRÖM adduces evidence to prove that the passing of steamers may frighten it away from the navigable channels of the island-belt, and also that the mere setting of gill-nets is sometimes enough to disturb its spawning and drive it away from a fishing-station of ascertained value. In Bohuslän too the firing of guns is now prohibited during the fishing-season. The Herring is not tenacious of life. The rapidity of its death is notorious, and has given rise in many places to the proverbial expression, "*as dead as a Herring*." But, according to EKSTRÖM[a], "the information we possess on this head is exaggerated. It is generally believed that the fish dies the very moment it is lifted above the surface of the water. I have personally made numbers of experiments to test this statement, and have found that the time varies with the temperature of the atmosphere. In spring, at the end of April, when the air is still cool and usually cold, the Strömming lives 18—20 minutes after it has been taken out of the water. If caught late in the evening or at night, it sustains life for fully half an hour. But it must be handled carefully and not exposed to any external violence. As the summer approaches, at the middle of May for example, it never lives more than 6—10 minutes, and at midsummer, when the air is quite warm, the duration of its life out of the water seldom exceeds 4 minutes. It should be remarked, however, that the individuals on which I made the above experiments had not been entangled in the meshes of a net, but were taken, quite uninjured, in a vessel out of the water and deposited on the beach or in the boat. If the Strömming has been caught in the seine, it dies almost at the moment it leaves the water, and those taken with gill-nets are dead before they are drawn up."

In spite of its feeble dentition the Herring ranks among the predatory fishes, though its victims are usually of small size. In its earliest youth it lives on the most minute marine animals. At a length of 11 mm. a Herring larva had begun to feed on the larvæ of worms (LINDSTRÖM), and a young Herring 17 mm. long had its intestine "full of food, amongst which small species of *Cyclopidæ* might easily be recognised" (SUNDEVALL). In its later youth and during the rest of its life the Herring, no doubt, lives principally on Entomostraca, Schizopods, and Pteropods. Certain parts of the North Atlantic teem with these animals, which are so plentiful as to afford a sufficiency of food to the very largest whales. The Norwegian fishermen class the Herring's ordinary food (*Aaten*) under three heads, which they call *Rødaat*, *Gulaat*, and *Svartaat* or *Krutaat*. The first consists chiefly of Copepods, either extremely small or (e. g. *Calanus finmarchicus*) as much as 8 mm. long. "It seems incredible," writes BOECK, "that creatures so small can play so important a part in the economy of a whole country; but the Mackerel and the Autumn Herring owe their fatness almost entirely to these ani-

[a] Cf. also CUV., VAL., l. c., p. 63.

mals, and under the microscope we may see the layers of fat between the muscles and viscera within the frail shell of these minute organisms." The *Gulaat* is made up principally of Annelid larvæ, the *Svartaat* of small mollusks, the larvæ of larger mollusks, and Pteropods. When the Herring has gorged itself with this food, and not had time for digestion or to excrete the remains, it is worthless as an article of trade. The fish decomposes rapidly, will not absorb the salt, and emits a disgusting stench. In Norway it has therefore been prescribed that such fish must be left three days in the seine before being drawn up and salted. The *Svartaat* is the worst, and almost hopelessly spoils the fish. But animals of a relatively small size are not the Herring's only food: it can also devour fishes of comparatively great dimensions. In the stomach of a large Baltic Herring EKSTRÖM found three good-sized specimens of *Gobius minutus*; and the stomach of a female Herring 3 dm. long, which was caught in the island-belt of Stockholm in January, 1893, and in which the ovaries were swollen to about a third of their full size, contained portions of five Herring-fry that had been almost equal in size, and the largest of which had measured $6^1/_2$ cm. We have remarked above that the Doubly-spotted Goby (p. 251) and *Crystallogobius Nilssonii* (p. 271) enter into the diet of the Herring; and it is no doubt partial to all other kinds of small fishes.

The Herring has enemies in numbers. Among fishes its most destructive foes are the Cod, the Coalfish, the Hake, large Scombroids, the Salmon, and Sharks. Among whales the lesser rorqual (*Balænoptera rostrata*), the great northern rorqual (*Balænopt. laticeps*) and the fin-whale (*Balænopt. musculus*) feed on Herrings. The porpoises are also Herring eaters; and among the most troublesome of all are the seals, which often leave nothing in the net but the heads of the fish. Numerous birds (gulls, terns, the gannet, etc.) swell the tale of its persecutors. But in the war of extermination against the Herring the most prominent part is taken by man.

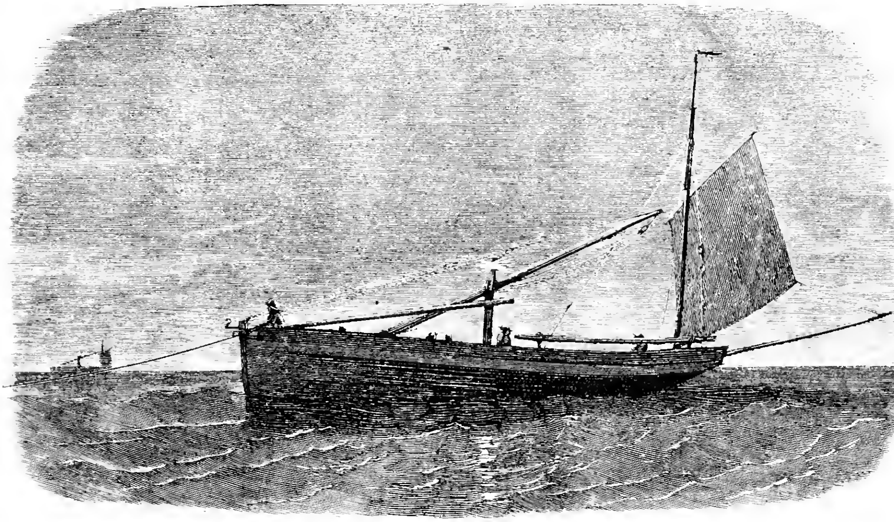

Fig. 243. A Yarmouth drift boat out fishing. After HOLDSWORTH.

In the open sea and in the great arms of the sea the Herring is taken in drift-nets, gill-nets, and purse-seines. Nearer land the gill-net and purse-seine are also used, but most commonly the seine (Sw. *vad*[a]) or, as in Denmark, the *bund-garn*, a sort of stake-net.

The *drift-net* is a continuous train of nets (Sw. *länk*) seized to a stout rope or warp (Sw. *drift-rep*), to which large floats (clumps of wood — Sw. *klabbar*, *kobbar* — or kegs — Sw. *dunkar*, *brillar* — or bags of skin, usually dogskin — Sw. *säckbojar*) are attached with stronger seizings, so as to keep the whole 'drift' afloat

[a] The word *vad* is difficult of explanation. Some write *vadа*, and derive it from the verb *vada* (to wade). The Danes write *vod*, and it is a question whether the word is not the same as that we find in *kladningsvad* (a breadth of cloth) etc.

in a vertical position"[a]. In the North-Sea fisheries one of these 'fleets' of nets frequently extends to a length of a mile and a quarter or more. The net is shot in the evening and hauled up in the morning. During the night it is allowed to drift with the boat, the warp being made fast in the bows. Drift-nets may also be used as *gill-nets*, the two ends being anchored; but the common gill-net, called *sköte* in the Baltic, *näring* in Halland, is of simpler construction and resembles the net used in fresh-water fishing. In recent times the North American[b] *purse-seine* has been introduced into Europe and employed in the Bohuslän fishery. It is a deep seine, with stout and closely corked head-rope but, strictly speaking, without foot-line, which is replaced by a purse-line running free through rings. The seine is shot in a circle round a shoal of fish swimming at the surface; and when the circle is complete, and the

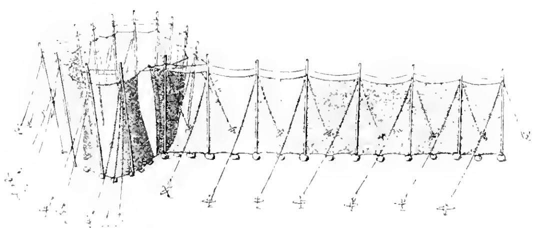

Fig. 244. Stake-net from the Sound.

net walls in the shoal, the purse-line is hauled in, till the seine assumes the shape of a bag. The *land-seine* is an engine as common and well-known as any kind of net; but in the Herring-fishery it attains its maximum dimensions, being so long and deep that whole arms of the sea or great portions thereof may be enclosed so as to bar the Herring's retreat. The fish are then secured in smaller seines. The construction of the *stake-net* (*bundgarn*, fig. 244) we have described above (p. 352).

The voracity of the Herring is such that it may also be taken with hook and line, and sometimes no bait is necessary, the mere glitter of the dancing hook being sufficient to entice the fish.

The annual take of Herrings can hardly be estimated; it must amount to thousands of millions. In the Baltic and the Sound more than 200,000 barrels of Strömmings and Herrings, valued at about £166,600, are taken yearly by Swedish fishermen. A barrel of Strömmings contains on an average more than 2,200 fish. It is estimated that 1,900—2,000 Scanian Herrings go to the barrel. According to these estimates the average annual catch of the Swedish fishermen alone exceeds four hundred million Strömmings and Herrings, and we may surely assume that the Finnish, Russian, German, and Danish fishermen together take at least three times as many. To judge from Dr. A. H. Malm's latest reports on the Bohuslän fishery, the average annual take of Herrings for the fishing-seasons 1888—92 was about five or six hundred millions, a hectolitre containing at least 300 Herrings. The average annual value of this fishery for the said four seasons was about £100,000, but in 1891—92 the value rose to £130,000.

The several takes are given in the following extracts from Dr. A. H. Malm's "Reports on the Sea-fisheries of the Province of Gothenburg and Bohus"[c]:

	Herring-fishery with					
	seines		gill-nets		drift-nets	
	Hectolitres	Value	Hectolitres	Value	No. of fish	Value
1891—92	1,403,438	£59,493	228,708	£65,153	5,254,560	£5,373
1890—91	1,094,185	£65,115	196,821	£49,288	9,651,360	£5,676
1889—90	1,538,046	£30,331	223,102	£39,391		£7,706
1888—89	1,443,390	£28,535	279,089	£24,380	——	£4,788

The value of the Halland Herring-fishery for the year 1890 is estimated by Mr. Trybom, Assistant Inspector of Fisheries, at £3,272, and for the year 1891 at £3,660. The Herring-fishery of Denmark yielded in

[a] For a more minute description of the drift-net see Holdsworth, *Deep-Sea Fishing and Fishing Boats*, p. 100; Lundberg, Meddel. rörande Sveriges Fiskerier, Häft. 1, p. 33, with illustr.

[b] At the Fisheries Exhibition (London, 1883) a net of this kind, coming from Cornwall, was catalogued as original.

[c] These reports do not take into account that portion of the fishery which falls to the share of fishermen from Halland.

1890 nearly £45,000 (£3,457 from Liim Fjord[1]). Norway's income from this source[2] in 1894 was £360,600[3]. The results of the Herring-fisheries of Great Britain and Ireland were in 1887 and 1888[4]:

	1887		1888	
	Cwts	£	Cwts	£
England and Wales	1,605,140	112,288	1,729,611	185,806
Scotland	3,217,361	611,572	2,816,796	614,858
Ireland	–		75,548	30,728

The Herring-fishery of Holland yielded in 1880 about 227,000,000 Herrings and in 1881 about 197,500,000, with a market value of between three and four million guldens (£250,000—£333,000). The French fishermen of the North Sea and the Channel took in 1884[5] 39,000,000 kilo. of Herrings, valued at about 9,000,000 francs (£360,000). The Iceland Herring-fishery of 1882[6] yielded 50,000 barrels of a total value of £72,000.

On the European side of the Atlantic the annual take of Herrings thus amounts to between 500,000,000 and 600,000,000 kilo., and commands a market price of about £2,700,000. On the east coast of North America, according to HIND[8], Herrings were taken in 1874 to a weight of about 91,000,000 kilo. No great accuracy can be expected of all these calculations and estimates, but they give at least a notion of the value represented by the Herring, for all its cheapness. The welfare of nations has depended on the Herring-fishery; and none need be surprised that this fishery has always been an apple of discord.

Many are the culinary forms in which the Herring appears. In order to fit this cheap article of food for transportation from the place of its catch to the world's emporia, it has been the custom from time immemorial to dry, smoke, and salt the Herring; and the kitchen has taken measures accordingly. The Herring-fishery became an El Dorado to the Dutch when they learnt to gut the fish[9] — to remove the gill-arches and intestine — before salting. But the Herring, like other fishes, is best and cheapest when fresh; and with the speedy means of transit and improved methods of preservation — borate or, still better, ice — now available, it may be conveyed to a considerable distance, and kept fresh for at least a fortnight or three weeks. In this condition it is excellent either boiled or fried. The English *whitebait*, the principal course at the fashionable dinners at Greenwich or Blackwall on the Thames, has a world-wide reputation. Whitebait consist chiefly of Herring-fry about two or three inches long, but also of Sprats, Sticklebacks, Gobies, and other small fishes. They are taken at flood-tide in spring and summer with a special kind of net, which is dipped a few feet below the surface from a boat anchored in 30—40 feet of water. They should, above all, be procured quite fresh and fried as soon as possible. They answer to the *fiskakaga* (fish-cake) of Scania and Halland, only that the latter is made into a cake by the addition of a greater quantity of butter or lard. In France Whitebait are known as *blanches* (*blaquets*) or *menis* (*menusses*).

Herrings and Herring-fry are also much used as bait for other fishes.

The numerous names by which the Herring is known in trade, and the details of the numerous methods employed in curing it for the market, cannot be given here. The reader who is interested in these questions will find an able treatment of them in LJUNGMAN, l. c.

[1] DRECHSEL, according to the "Dansk Fiskeriforenings Medlemsblad" 1892, pp. 74 and 75.

[2] For the Norwegian Herring-fisheries and their fluctuations see H. BAARS, *De Fischereiindustrie Norwegens*, Bergen 1873, p. 36.

[3] The Central Bureau of Statistics at Christiania, according to the "Dansk Fiskeriforenings Medlemsblad" 1892, p. 490.

[4] Fish Trades Gazette 1889, Jan. 12th and 26th.

[5] According to an official statement, in the Catal. Gt. Intern. Fish. Exhib. London 1883, 1st ed., p. 422.

[6] ibid., p. 384.

[7] ibid., p. 382.

[8] BR.-GOODE, Fisher., Fisher. Industr. U. S., sect. I, p. 549.

[9] The discovery is ascribed by tradition to WILLEM BEUKELZOON, a skipper from Biervliet in Flanders, *d.* 1387.

THE SPRAT (SW. SKARPSILLEN OR HVASSBUKEN).

CLUPEA SPRATTUS.

Plate XLIV, fig. 2

Length of the base of the anal fin more than $^1/_4$ of the distance between the ventral fins and the tip of the snout. Number of spines at the ventral margin 32—35[a].

R. br. 6—7[b]; *D.* $\frac{4-5}{12-14}$(17—19); *A.* $\frac{3-5}{15-17}$(18—20); *P.* $\frac{1}{15-16}$; *V.* $\frac{(1)1}{6^c}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* 47—50; *L. tr.* 11—13; *Vert.* 46—49.

Syn. *Sprattus* l. *Sparlingus* (Harengorum foetura), WILLUGHB., *Hist. Pisc.*, p. 221; RAY, *Syn. Pisc.*, p. 105; *Latulus*, SCHONEV., *Ichthyol. Slesv. Holsat.*, p. 41. *Clupea* quadriuncialis, maxilla inferiore longiore, ventre acutissimo (*Spratt* Anglis, *Hvassbuk* Suecis), ART. *Icht.*, *Gen.*, p. 7; *Syn.*, p. 17; *Spec.*, p. 33; LIN., *Fna Suec.*, ed. 1, p. 120. *Brisling*, STRÖM, *Sondm. Beskr.*, p. 271.

Clupea Sprattus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 318; PENN., *Brit. Zool.* (ed. Warrington, 1776), vol. III, p. 303; RETZ., *Fna Suec. Lin.*, p. 353; SWARTZ, *Svensk Zoologi*, vol. I, No. 28; NILSS., *Prodr. Ichthyol. Scand.*, p. 22; YARR., *Brit. Fish.*, ed. I, vol. II, p. 121; PARN., Mem. Wern. Nat. Hist. Soc., vol. VII, p. 322, tab. XXXV; KR., *Voy. Scandin., Lappon.*, (GAIM.), Zool., Poiss., tab. 18; *Danm. Fisk.*, vol. III, p. 177; CUV., VAL. (*Harengula*), *Hist. Nat. Poiss.*, vol. XX, p. 285; SUNDEV. (*Clupea*), Stockh. L. Hush. Sälls. Handl. 1855, pp. 81, 108, 185; NILSS., *Skand. Fna, Fisk.*, p. 516; MGRN, *Finl. Fiskfna*, p. 69; LINDSTR., *Gotl. Fisk.*, Gotl. L. Hush. Sälls. Årsber. 1866, p. 20 (sep.); v. BEMM. (*Harengula*) in HERKL., *Bouwst. Fna Nederl.*, part. III, p. 381; GTHR (*Clupea*), *Cat. Brit. Mus., Fish.*, vol. VII, p. 419; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 193; 1879, No. 1, p. 98; N. Mag. Naturv. Chrnia, Bd. 29 (1884), p. 112; SEIDL., *Fna Balt.*, p. 98; MALM, *Gbgs*, *Boh. Fna*, p. 582; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 48; MOR. (*Meletta*), *Hist. Nat. Poiss.*, *Fr.*, tom. III, p. 447; BNCKE (*Clupea*), *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 172; HCKE, *Var. Her.*, VII Ber. Comm. Deutsch. M., pp. 45 et 60; MELA, *Vert. Fenn.*, p. 354, tab. X; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 231, tab. CXXXIX, fig. 2; MOR., HCKE, *Fisch. Osts.*, p. 139; LILLJ., *Sv.*, *Norg. Fisk.*, vol. III, p. 97.

Clupea Schoneveldii, KR., *Voy.* GAIM., l. c., *Danm. Fiske*, vol. III, p. 193.

Spratella pumila, CUV., VAL., l. c., p. 357 + *Meletta vulgaris*, p. 366; tabb. 600 et 603.

The Sprat is in most respects so like the Herring that a detailed description is unnecessary. It is, however, a much smaller fish, measuring at most about 17 cm. to the tips of the caudal lobes; but at this smaller size it has undergone changes of growth in many respects more complete: it is, in a word, a more fully developed Herring form. This appears, for instance, in the length of the lower jaw, a measurement which we have never found to exceed 53 % of the length of the head, whereas in the Herring it has never proved less than 55 % of the same. In this character the alterations of growth run in decreasing percentages from the young to the older specimens.

In Swedish the Sprat has been distinguished from the preceding species by the name of *skarpsill* (Sharp Herring), a reference to its most palpable characteristic in most cases, the sharper ventral margin, with more prominent spines on the ventral plates; but this character is often illusory. A more trustworthy distinction is the difference in the number of the ventral plates, which in the Sprat does not exceed 35, 20—24 (commonly 22—23) in front of the ventral fins and 9—13 (commonly 11) behind them.

The form of the body is the same and shows the same variations as in the Herring, being deeper or shallower, but in the deeper form of Sprat (*Clupea Schoneveldii*) the ventral profile is still more curved in comparison with the dorsal. During the growth of the body from a length of 66 mm. to one of 104 mm.[d] (from the tip of the snout to the end of the middle caudal rays), the least depth of the body has proved to be on an average 7·1 % of the length thereof; and during growth from 108—147 mm.[e] we have found this average to be 8·1.

The head shows the peculiarity that the eyes are generally somewhat larger than in the Herring. During growth from a length of 73 mm. to one of 147 mm.

[a] According to HEINCKE.

[b] Sometimes 8, according to KROYER.

[c] Sometimes 7, according to HEINCKE.

[d] With 88 mm. as the average length.

[e] With 120 mm. as the average length.

the longitudinal diameter of the eye has proved to vary between 31 and 26 % of the length of the head. The branchiostegal membrane does not form so distinct an angle with the inferior margin of the suboperculum; this angle is sometimes almost imperceptible, the posterior (upper) branchiostegal rays extending further back than the interoperculum, and the last of them being obliquely truncate at the extremity or produced upwards to a blunt point, which is applied to the lower margin of the suboperculum. The number of gill-rakers on the first branchial arch we have found to vary between 46 and 51, thus fewer than in the Herring. The dentition resembles that of the Herring, but is feebler, the teeth being often imperceptible, and usually wanting on the palatines and vomer, but often present on the entopterygoid and ectopterygoid bones. The most important difference from the head of the Herring consists, however, in the comparatively short lower jaw, which is always shorter than the base of the anal fin, and the length of which varies between about 47 and $52\frac{1}{2}$ % of that of the head. The length of the maxillaries too varies in the Sprat between 89 and 84 %, in the Herring between 75 % (in exceptional cases 73 %) and 79 % (in exceptional cases 81 %), of that of the lower jaw, which is besides perceptibly shorter in the Sprat than the distance between its hind extremity and the upper angle of the base of the pectoral fin, in the Herring equal to this distance or a little longer.

The dorsal fin is of the same form and occupies the same position as in the most developed Herrings. At a length of body averaging 88 mm. the average distance between the dorsal fin and the tip of the snout proved to be 49·9 % of the length of the body, and in specimens averaging 120 mm. in length the corresponding percentage was 50·7. The distance between the anal fin and the tip of the snout is somewhat less than in the Herring, and varies between about 65 and 71 % of the length of the body; but the base of the fin is longer, its length varying between 13 and 15 % of that of the body. The caudal fin is usually not quite so deeply forked as in the Herring. The length of its middle rays is about $6\frac{1}{2}$ % of that of the body and rather more than $\frac{1}{3}$—$\frac{2}{5}$ of that of the longest rays in the inferior caudal lobe.

The pectoral fins resemble those of the Herring in their length as well as in other respects. The ventral fins are in general shorter and have fewer rays than in the Herring. Their length varies between $9\frac{1}{3}$ and $7\frac{1}{2}$ % of that of the body. Their position affords one of the most important characters of the Sprat, the distance from the tip of the snout to the anterior (upper) angle of the base of these fins extremely seldom — and then only slightly — exceeding $\frac{1}{2}$ the length of the body, and being less on an average than that between the tip of the snout and the beginning of the dorsal fin, rarely, and then but slightly, greater than the latter distance. It is consequently the rule that the ventral fins are inserted vertically below the beginning of the dorsal fin or further forward. The preabdominal length varies between 28 and $30\frac{1}{2}$ %, the postabdominal between about 17 and 22 %, of the length of the body.

The scales are exactly similar to those of the Herring, and the most essential difference in the abdominal plates has been remarked above.

The coloration too is so like that of the Herring that no constant difference can be adduced. The line of lustrous green between the dorsal and ventral colours is sometimes ribbon-shaped, rather sharply defined. According to VALENCIENNES[b] this line is sometimes a golden band; and COLLETT mentions[c] "a half-grown specimen" that had lost its scales, but was marked along this part of the sides with two, almost black stripes.

The geographical range of the Sprat does not extend so far north as that of the Herring, but else coincides therewith in the East Atlantic. On the American side the Sprat has never been found; and FABER's statement[d] that it occurs off the coast of Iceland is not convincing, for he describes its operculum as striated, in distinction from the smooth operculum of the Herring. But on GÜNTHER's authority[e] the Sprat has been included, together with several other European fishes[f], in the fauna of Tasmania.

[a] 48·3—50·4 %, according to our measurements.

[b] l. c., p. 288.

[c] 1879, l. c.

[d] *Fische Islands*, p. 178.

[e] Proc. Zool. Soc. Lond. 1871, p. 672.

[f] *Sciaena aquila*, *Zeus faber*, *Caranx trachurus*, *Stolephorus encrasicholus*, *Conger vulgaris*, *Orthagoriscus mola*, *Rhina squatina*, *Galeus canis*, *Squalus (Acanthias) Blainvillei*, etc.

In the Mediterranean the Sprat is replaced by a very closely allied species, the *Melette* of the French, *Clupea phalerica*[a]. Judging from a specimen 90 mm. long, taken off Genoa, and sent to us by Professor GIGLIOLI, the Melette is distinguished from the Sprat by the greater depth of the tail, the more advanced position of the dorsal fin, and the somewhat greater size of the head. Its relations to the Sprat in these respects are most readily indicated by the following table of percentages:

		Averages in *Clupea sprattus.*		One specimen of *Clupea phalerica*
Length of the body from the articular knobs of the maxillaries to the end of the middle caudal rays, mm		87.7	120	90
Length of the head	in % of the length of the body	21.2 [b]	20.8	22.2
Distance between the dorsal fin and the articular knobs of the maxillaries	" " " " " " " "	49.9 [c]	50.7	47.8
Least depth of the tail	" " " " " " " "	7.1	8.1 [d]	8.8
Length of the head	in % of the distance between the dorsal fin and the articular knobs of the maxillaries	42.5 [e]	41.0	46.5
Least depth of the tail	" " " " " " " " " " " " "	14.3	16.0 [f]	18.4

The Sprat is common from Trondhjem Fjord (COLLETT) to La Rochelle (VALENCIENNES). It is said to occur, though scantily, northwards to the Lofoden Islands, as G. O. SARS was informed by the fishermen, and southwards in the Bay of Biscay beyond the Gironde (MOREAU). In Scandinavia it is most common off the south-west of Norway and the coast of Bohuslän; but it is taken in numbers within the Baltic, and is common, according to MELA, throughout the Gulf of Finland, as well as in the Gulf of Bothnia up to lat. 64° N., rarer to lat. 65°. On the Baltic coast of Russia, according to SEIDLITZ (l. c.), only solitary specimens are met with that have attained full growth and sexual maturity, though the young are plentiful. Off Memel and Dantzic spawning Sprats are common in May and September; and in Putzinger Wiek (the eastern part of the Gulf of Dantzic), says BENECKE, countless spent Sprats may be seen in the May spawning-season floating dead at the surface. In Kiel Bay the Sprat is also common. On all the coasts of Denmark the Sprat occurs, though only at a few points in any great number (WINTHER). In the Zuyder Zee and all round Great Britain it is as plentiful as anywhere in Scandinavian waters.

The Sprat-shoals live and feed in the same manner as the Herring-shoals, and often intermingle with the latter. It is, we may say, a rare occurrence to take any quantity of Strömmings or small Herrings without finding a number of Sprats in the catch; and in the same way small Herrings are found interspersed among a haul of Sprats. The Sprat-fishery cannot indeed be so productive in most cases as the Herring-fishery, the Sprat being a much smaller fish; but considering the size of the fish the Sprat-shoals are hardly inferior in point of numbers or density to the Herring-shoals. The same gregariousness, the same manner of life, and the same diet conjoin the two species with each other. They are also so similar in appearance that only a practised eye can distinguish between them, unless the observer has experience enough to feel the difference in the sharpness of the ventral margin.

The spawning-season of the Sprat occurs within the island-belt of Stockholm, according to the joint observations of SUNDEVALL and CEDERSTRÖM, in June. In the west of the Baltic, according to HEINCKE, the Sprat spawns both in spring and autumn. He observed in Kiel Bay during the months of July and August Sprat-fry 25—35 mm. long, which he assumed to date from the spawning in April and May, and during the latter part of October and till December other specimens 23½—33½ mm. long, which could consequently not have been spawned, in all probability, earlier than in July. MALM found in July and August at Strömstad and off Gasö (Bohuslän) young Sprats 20—57 mm. long, which would thus seem to be the offspring of a

[a] *Melettes*, BELON, p. 208. *Aphya phalerica*, ROND., p. 212. *Clupanodon phalerica*, RISSO, *Eur. Mér.*, tom. III. p. 452; MOR. (*Clupea*), III. p. 445. *Meletta mediterranea*, CUV., VAL., XX, p. 369. *Alosa papalina*, CANESTR., *Fna D'Ital.*, *Pesc.*, p. 135.

[b] Maximum in the specimens measured by us 21·9.

[c] Minimum " " " " " " 48·6.

[d] Maximum " " " " " " 8·4.

[e] " " " " " " " 43·6.

[f] " " " " " " " 16·6.

later or earlier spring-spawning, perhaps even of a winter-spawning, the same year. From the South of England we are told by HOLDSWORTH[a] that the true spawning-month of the Sprat in the neighbouring waters is January, but that this fish also spawns during the summer; and he assumes, with reference both to the Sprat and the Pilchard, that the winter-spawning is performed near land, the summer-spawning at the surface in deeper water. But off the coast of Bohuslän the Sprat seems to be in a breeding condition in July or August as well, for at Strömstad MALM took "females almost ready to spawn", on the 15th of July, 1865.

Of the hatching of the Sprat's eggs we are ignorant; we do not even know whether the ova float at the surface, or sink, like those of the Herring, to the bottom. But the fry have been described both by MALM and HEINCKE, and differ, according to the latter, from Herring-fry of the same size in the orange tone of their coloration, the greater depth and thickness of the body, the earlier development of the ventral fins, the earlier prolongation of the air-bladder, and the smaller number of the vertebræ.

After spawning the Sprat makes its way into the island-belt, where it soon recruits its strength and puts on flesh, in this respect easily surpassing the young Herrings. In the inner island-belt of Stockholm the mass of Sprats begin to appear in August. "Till October Sprats are occasionally taken, after which time they again disappear. When they come, they are rather lean; but towards autumn they grow fatter" (SUNDEVALL). During the same season, however, Sprats are caught in the outer shallows and in the outer fringe of the island-belt. Even in winter, as at the time of writing (March, 1893), Sprats are plentiful among the consignments of Strömming exposed for sale in Stockholm. A successful Sprat-fishery is also carried on among the Småland Islands off Krakvik[c], but we have no information of any such fishery farther south on the east coast of Sweden. The chief Sprat-fishery of this country belongs to Bohuslän, especially to the neighbourhood of Fjellbacka. "Here the Sprat puts in an appearance at Michaelmas, and remains until some time after Twelfth Day. Up to Twelfth Day, or at least during the weeks just before Twelfth Day, it swims in shoals by itself; but afterwards it is accompanied by young Herrings, generally two years old" (A. W. MALM). It is said to come in both north and south of the Weather Islands, straight from the sea (the Skager Rack). But shoals of Sprats sometimes arrive later in the winter, as in 1892, when this fish was taken on the south coast of Bohuslän during February and March (A. H. MALM). In England too the main body of the Sprat army lies nearer land during winter.

The Sprat-fishery has much in common with the Herring-fishery, and is carried on both with *skötar* (fine-meshed nets) and seines. In Bohuslän the annual take was officially stated during recent years as follows:

1888	1,900 hectolitres,	valued at	£1,373.
1889	4,270	„	„ „ £2,176.
1890	2,550	„	„ „ £2,077.
1891	3,803	„	„ „ £4,062.

From these Sprats, which they can procure fresh, the inhabitants of Bohuslän prepare the best quality of their *Anchovies*, a kind of Pickled Herring, not to be confounded with the true Anchovy, which is a rare fish in Sweden. But a considerable proportion of the Sprats thus preserved in Bohuslän comes salted from Norway, where the annual take, according to COLLETT, sometimes exceeds 100,000 hectolitres. In Norway and England too Sprats are prepared for food in the same way; and according to DAY, three million tins of Sprats, pickled in a similar manner as the anchovies of the west coast of France, are annually imported into England. In Germany and in certain parts of Scotland the Sprat is smoked. This is the method employed in curing the well-known *Kieler-Sprotten*. Mild smoked Sprats in oil are not inferior to Sardines.

The Sprat suffers chiefly from the ravages of the same enemies as the Herring. But its eyes are attacked by a parasitic crustacean, *Lernæonema monillaris*. This Penellid shines at night, and to this origin DAY ascribes a supposition common among English fishermen, that the Sprat-shoal is often guided and lighted on its way by "lanthorn Sprats".

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[a] *Deep Sea Fishing and Fishing-Boats*, pp. 133–135.
[b] Gt. Intern. Fish. Exhib. London 1883, Sweden, Spec. Catal., p. 170.
[c] Intern. Fischerei-Ausst. Berlin 1880, Schwed. Catal., Spec. Th., p. 25

Subgenus ALOSA.

Sides of the body marked, at least in front, with dark spots. Lower anterior surface of the operculum coursed by more or less distinct grooves and ridges. Dorsal fin set so far forward that the distance between it and the tip of the snout is less than four times the postorbital length of the head. Inner part of the caudal lobes furnished with foliate scales, larger than the others.

Now that all attempts to employ the dentition as a means of defining subgenera within the genus *Clupea* have proved futile, no better prospect of attaining this object is offered, it appears, than by the different development and position of the fins. But the subgenus *Alosa*, which is further distinguished by the extremely feeble dentition of the mouth, is so well defined within the Scandinavian fauna that no difficulties meet us here in its characterization. In exotic forms, however, as

Fig. 245. Scales from the left side of a Pilchard 20 cm. long (*a*) and from a Shad 30 cm. in length (*b*). × 3.

for instance in the Japanese *Clupea zunasi*, the striation of the opercula is hardly perceptible, and the lateral markings of the body are confined to a single small spot on the adipose membrane of the upper scapular region; and in the Mediterranean *Clupea aurita*, where the dark markings are also restricted to the upper part of the tract round the gill-openings, the said striation consists merely of a ridge crossing the anterior part of the operculum in an obliquely downward direction. But the other characters given in the above diagnosis range these forms beside our Shads, which may be regarded as the type of the subgenus, and which are usually to be recognised at the first glance by the striation of the opercula and the spots on the sides of the body, though the latter vary both in size and distinctness, being in some individuals wanting.

The scales of this subgenus are more strongly developed at the basal angles of the fins and their bases than is the case in the preceding members of the genus. The caudal fin is covered to a great extent with scales, and bears on each side two patches of these, one on the upper and one on the lower lobe, among which the hindmost is the largest, and is also venous. Sometimes, however, these patches of scales are so thin and transparent that they easily escape observation. At the base of the dorsal fin, the upper angle of the pectoral fin, and the outer angle of the ventral fin, we find pointed scales, which partially conceal these fins; and rounded scales overlap the lower margin of the pectoral fins, covering the lowest rays, while the base of the anal fins is also scale-clad. In texture too the scales of this subgenus differ from those of the preceding one, the radiating grooves, which are there extremely faint streaks (see above, p. 957), being here far more sharply defined (fig. 245).

Both the anal and the dorsal fins show a more pointed prolongation of the outer posterior corner than in the preceding subgenus.

The most constant character, however, is the forward position of the dorsal fin, a character which is expressed in the above diagnosis of the subgenus by a comparison with the postorbital length of the head. This last measurement is relatively greater in the Shads than in the true Herrings, the validity of the character being thus unimpaired even when the trunk is shortened, as in the American Menhaden, which would else be referred by the position of the dorsal fin to the preceding subgenus.

THE PILCHARD OR SARDINE.

CLUPEA PILCHARDUS.

Fig. 246.

Length of the maxillaries at most about 40 % of that of the head. Longitudinal diameter of the eyes at least about 60 %, least depth of the tail at least about 80 %, length of the suboperculum at the suture with the operculum at least about 55 %, of the length of the maxillaries. Scales comparatively large, their number in a longitudinal row on the sides of the body at most about 30.

Fig. 246. *Clupea pilchardus* from Bohuslän. S. LOVÉN, 1861. $^1/_3$ of the natural size.

R. br. 7[a]; *D.* $\frac{2-3}{14-15}$(17—18); *A.* $\frac{2-3}{14-16}$(17—18[b]); *P.* $\frac{1}{15-16}$; *V.* $\frac{1}{7}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 28—30; *L. tr.* 8—10; *Vert.* 50—53.

Syn. *Sardines* ou *Celerus*, BELON, *Nat., Div. Poiss.*, p. 167.
Harengus minor sive *Pilchardus*, WILLUGHB., *Hist. Pisc.*, p. 223, tab. P, 1, fig. 1.
Clupea Pilchardus, WALB., *Ichthyol. Art.*, pt. III (*Gen. Pisc.*), p. 38 (varietatem *Clupeæ harengi* dixit); BL., *Naturg. Ausl. Fisch.*, pt. IX, p. 40, tab. CCCCVI; YARR., *Hist. Brit. Fish.*, ed. 1, vol. II, p. 96; CUV., VAL. (*Alausa*), *Hist. Nat. Poiss.*, vol. XX, p. 445, tab. 605; NILSS. (*Clupea*), *Skand. Fna, Fisk.*, p. 522; KR., Tidskr. Fisk. Kbhvn, Aarg. 2 (1868), p. 71; STEIND., Stzber. Akad. Wiss. Wien, LVII, I (1868), p. 738; GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 439; COLL., Forh. Vid. Sels. Chrnia 1874, Tillægsh., p. 194; CEDERSTR., Öfvers. Vet. Akad. Förh. 1876, No. 4, p. 66; 1879, No. 2, p. 62; MALM, *Gbgs, Boh. Fna*, p. 585; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 224, tab. CXXXIX, fig. 1; BACKE (*Alosa*), *Handb. Fischz., Fischer.* (M. V. D. BORNE), p. 170; LILLJ. (*Clupea*), *Sv., Norg. Fisk.*, vol. III, p. 106.
Clupea sprattus, BRUNN., *Ichthyol. Massil.*, p. 82.
Clupea sardina, CUV., *Règne Anim.*, ed. 2, tom. II, p. 319 (+ *Cl. pilchardus*, ibid.); MOR. (*Alosa*), *Hist. Nat. Poiss. Fr.*, tom. III, p. 458.

The Pilchard is a more terete fish than the Herring, but is otherwise similar in form. It is inferior to the Herring in size; but in this respect a distinction has long been maintained between two forms, the Mediterranean, which is the smaller, being about as large as the *lott-sill* (small Herring) of Bohuslän or the common Stockholm Strömming, and which is known by preference as the Sardine, and the Atlantic Pilchard, which attains, according to CORNISH[c], a length of at least 3 dm., according to DUNN[d], of $3^1/_2$ dm., including the whole caudal fin. In Sweden only adult specimens have been met with, the largest measuring 285 mm. in length (MALM), the smallest 218 mm.

[a] 6—8, according to DAY.
[b] 19—21, according to GÜNTHER; 21, according to LILLJEBORG.
[c] Zoologist, 1879, p. 62.
[d] In DAY, l. c., p. 230.

The greatest depth varies between about 19 and 22 % of the length of the body to the end of the middle caudal rays; and the greatest thickness between about 45 % (in small specimens) and 59 % of the greatest depth.

The length of the head (measured as above, in the Gwyniads and Herring, from the articular knobs of the maxillaries) varies between about $22^1/_2$ and $21^1/_2$ % of that of the body. The diameter of the eyes, which are circular, measures (in Pilchards 81—211 mm. long) between 30 and 23 %, and the interorbital width (at the middle of the eyes) 20—24 %, of the length of the head. The length of the snout is equal in small Pilchards to the diameter of the eyes; in adult specimens it shows individual variations between about 26 and 30 % of the length of the head. The nostrils — the anterior in each pair is merely a narrow slit — lie nearer to the tip of the snout than to the eyes. The

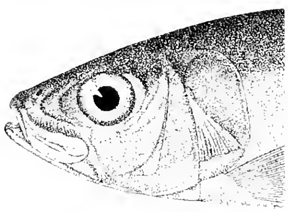

Fig. 247. Head of a Pilchard, with feebly developed covering of adipose membrane. Natural size.

tip of the mouth, which is formed by the margins of the intermaxillaries, is incised at an oblique angle, owing to the position occupied by these bones with respect to each other. The length of the maxillaries, which extend back to about a line with the anterior margins of the pupils, decreases in the above-mentioned specimens from about $39^1/_2$ to $37^1/_2$ % of that of the head, and their breadth varies between about 36 and 32 % of their length. The length of the cheek (from the hind extremity of the maxillary to the posterior margin of the preoperculum) is much greater, as in the Herring, than its height below the eyes. The length of the lower jaw, the symphysis of which shows hardly any thickening, decreases in Pilchards of the above lengths from about 55 to 48 % of that of the head. The cheeks and opercula vary in appearance according to the density of the adipose membrane on the head. When this membrane is thin (shrunken, fig. 247) the striation both of the lower anterior part of the operculum and of the preoperculum and suborbital bones consists of distinct ridges and grooves. But in other instances, when the adipose membrane is thicker (fig. 246), its ducts with their numerous ramifications occupy the grooves, and render these as well as the ridges less distinct. The upper part of the scapular region is entirely covered with this growth of adipose membrane, the elevated pores granulating the upper surface of the head. Measured in an horizontal direction the postorbital length of the head (from the apparent hind margin of the eye to the middle of the posterior opercular margin) increases with age from about 41—46 % of the entire length of the same; measured in an oblique direction (from the middle of the hind margin of the eye to the lower posterior angle of the operculum) it varies between about 47 and 53 % of the latter length, and is somewhat more, even in young specimens, than one-fourth of the distance between the dorsal fin and the articular knobs of the maxillaries. The operculum forms an almost rectangular parallelogram, with the upper posterior angle rounded, the posterior side rather convex, and the inferior side straight. The last-mentioned side (the subopercular suture) measures about 22 or $21^1/_2$ % of the length of the head. The form of the suboperculum varies, its breadth (height) being about one-third of its length in young specimens, about one-half of the same in adult Pilchards. The preoperculum is broad, with rounded, rectangular corner. The interoperculum is narrow, and has the same relation to the posterior branchiostegal rays as in the Herring, these rays forming a rectangular sinus with the inferior margin of the suboperculum. On opening the operculum we find that the black posterior limit of the pharynx and the branchial cavity is rectangular[a], corresponding to the form of the operculum itself, so that the posterior margin of the latter coincides with the vertical arm of the clavicular angle, and its inferior margin as well as the suboperculum with the horizontal arm, the margin of which consists of the above-mentioned process (answering to *clp* in fig. 238, p. 950). The gill-rakers are long and fine, with dense and regular lateral spines of small size. On the first branchial arch we have counted 110 gill-rakers, 67 on the lower (horizontal) part of the arch, and 43 on the upper. The dentition of the mouth is extremely feeble, being usually confined to a few teeth at the tip of the lower jaw and a crenelation of the

[a] Cf. Moreau's definition of the genus *Sardinella* (l. c., p. 450): "Ceinture scapulaire à bord anterieur vertical".

maxillaries at the posterior part of their under margin. The palate and tongue are almost toothless[a].

The dorsal fin begins at a distance from the tip of the snout (the articular knobs of the maxillaries) measuring in small specimens (Sardines) about $11\frac{1}{2}$ %, in large (Pilchards) about 10 %, of the length of the body, and apparently not exceeding 90 % (84—$87\frac{1}{2}$ % according to our measurements) of the distance between the ventral fins and the same point. Its base, which is about equal to its height, measures about $12\frac{1}{3}$—$11\frac{1}{3}$ % of the length of the body. The distance between the anal fin and the tip of the snout is about 66—70 % of the length of the body. Its outer margin, like that of the dorsal fin, is somewhat concave. Its base occupies about 14—16 % of the length of the body, and is four to three times its height. The caudal fin was damaged in all our specimens; but, to judge by the remnants, it seemed to be deeply forked, the length of the middle rays being about $\frac{1}{4}$ of that of the longest ones, which was about 17 % of that of the body.

The pectoral fins are rather more pointed than in the Herring. Their length is about 15—14 %, that of the ventral fins about $8\frac{1}{2}$—$8\frac{1}{3}$ %, of the length of the body. The preabdominal length is somewhat greater than the postabdominal, but both are contained about four times in the length of the body.

The size and texture of the scales we have mentioned above. At the ventral margin we have counted 20 spinigerous scales in front of and 16 behind the ventral fins. These spines are set in a groove, which is almost entirely concealed by the lowest scales on the ventral sides.

The coloration of a new-caught specimen is thus described by Malm: "Back above bluish green, sides and belly silvery white, with a dash of yellowish green towards the tail. The whole opercular apparatus, and especially the upper scapular region, as well as the anterior part of the iris and a portion of the maxillaries, of a light, lustrous yellow, like that of sulphur-pyrites, which extends some way over the shoulder-girdle. On the shoulder-girdle, but somewhat above the middle of the side, a light blood-red spot. Central part of the operculum also blood-red. The whole gill-cover iridescent, resembling the most beautiful mother of pearl. Pupil rounded. Iris nacreous, tinged with orange behind, of a greenish gold above, with a whitish ground; finely punctated with black. Lower jaw yellowish at the tip. Tip of the snout blackish. Orbit of an emerald ground-colour in front of the eye. Below the lateral line a row of six small, blackish spots, the first situated in the red colour of the operculum, the second on the upper part of the shoulder-girdle, the third in front of the tip of the pectoral fin, separated therefrom by a distance equal to about half the diameter of the pupil. Distance between the third spot and the last one equal to the length of the pectoral fin. Diameter of these spots half that of the pupil. Fins greenish gray; anal lighter; ventrals colourless. Tongue so densely punctated with dark dots that it is almost blackish".

The Pilchard is of the same importance in Mediterranean countries and, to a considerable extent, in the west of France and south of England as the Herring in the North-Atlantic fishery. Boiled and preserved in oil, it is known all the world over; but its geographical range is not so wide as the Herring's, and it can hardly vie in numbers with the latter. To the south it is known off Madeira and the Canary Islands[b]. To the north it is a stranger[c] even in the North Sea above Yarmouth, still more so in Scandinavian waters, though it has been found as far north as Bergen, whence Lilljeborg brought home to Upsala Museum two Pilchards in 1858. Malm mentions three specimens from Bohuslän, one of them taken at Kalfsund on the 15th of May, 1855, the other two at Strömstad, respectively on the 11th of August, 1865, and the 15th of July, 1869. The Royal Museum has received from Bohuslän two specimens 23 cm. long, the first obtained by Prof. S. Lovén in 1861, the second taken in Koster Fjord by Mr. C. A. Hansson on the 25th of July, 1877. According to Nilsson a female about 25 cm. in length and with ripe roe was caught among common Herrings off Kullen on the 25th of September, 1849. Kröyer mentions a specimen taken in a stake-net (*bundgarn*) in Kærteminde Fjord (Fünen) during October, 1867.

The true Atlantic home of the Pilchard thus lies south of England, where it appears on the coasts of

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[a] "After the tongue has dried, a thin carina may be traced along it, with some extremely fine teeth, visible beneath the magnifying-glass, and set in a single row, on the inner part." Nilsson, l. c., p. 524.

[b] Lowe, Trans. Zool. Soc. London, vol. II, p. 189; Steind., l. c.

[c] In modern times at least. On the east coast of Scotland, according to Parnell, the case was formerly different; — see Mem. Wern. Nat. Hist. Soc., vol. VII, p. 321.

the Spanish Peninsula and France and off the south coast of England, in the same manner as the Herring further north. In the southern part of its range, northwards along the coast of the Spanish Peninsula and in the Mediterranean, it is said to be met with near land all the year round. But where the deep water, bounded by the 100-fathoms line, lies farther from shore, between the south of the Bay of Biscay and the British plateau, the influence of which on the Herring's geographical range has been noticed above, the Pilchard, a fish that rests and winters in the depths of the ocean, approaches land in an order the reverse of that observed by the Herring. The Herring comes, as we have seen, from the north, and spreads round the coasts of Great Britain. The Pilchard appears earliest in the year off the south coast of France, and the fishery commences later and later to the north[a]. In deep water, however, the Pilchard occurs all the year round off the coasts of Cornwall and Devon, being often found, according to DAY, in the stomach of fish taken on long-lines in January; but the Pilchard-fishery with drift-nets does not begin until July, and with the seine not until August.

The Pilchard's habits are the same as the Herring's. It is extremely timid and gregarious, but greedily feeds on minute animals or even on the spores of seaweed and on *Diatomaceæ*, its sound appetite gaining it the fatness for which it is famed. The most important Pilchard-fishery on the French coast depends on this voracity. Fish-roe is imported from Norway—principally Lofoden Cod-roe, which costs the French fisherman 80—100 francs or more a barrel — and this expensive bait, sometimes mixed for the sake of economy with sand or chopped meat and pounded crustaceans, is strewn on one side of the net floating at the surface behind the boat, when the Pilchard is seen on the other side of the net. When the net is as full of Pilchards as the fisherman thinks proper—which he sees by the sinking of the cork-line—a fresh net is shot, so long as the store lasts, and the fishing goes well. The bait is costly, but justifies the outlay; and *in good years* the French fishermen take one or two milliards of Pilchards, worth fifteen to twenty million francs. Of the Cornish Pilchard-fishery FOX[b] states that the export of salted Pilchards from Penzance and Falmouth to Genoa, Leghorn, Naples and Venice amounted in 1879 to 11,938 hogsheads or about 35—36 million fish; and according to COUCH[c] the English export of these *fumadoes* has averaged for many years 30,000 hogsheads, sometimes amounting to 60,000.

In 1879 the purse-seine was first used in the French Pilchard-fishery, but it has not yet come into favour. In the Cornish fishery this engine has been employed longer, even previous to its introduction into the American Mackerel fishery.

The Pilchard-fishery is subject to the same fluctuations as the Herring-fishery, being still more dependent on the temperature of the water, but naturally too on the supply of food. According to DUNN[d] it has more than once happened during very severe winters that the English Channel proved too shallow to afford the Pilchard protection from the cold. On these occasions he saw "countless millions" of Pilchards perishing or floating dead at the surface. In quest of food the Pilchard army roves westwards from the Channel out into the Atlantic; but DUNN adduces instances to show that this fish sometimes stays off the Cornish coast, feeding on the multitudes of crustacean larvæ in the Zoëa-stage. With the same object it also makes its way up the Irish Channel; but it seldom extends its wanderings to the North Sea. In the migrations of the Pilchard and its approach to the coast so-called semi-secular periods may be observed[e], as in the case of the Herring-fishery.

The spawning of the Pilchard is probably performed in the open sea. Late in May and in June DUNN met with great numbers of ripe Pilchards 25—30 miles south of the Lizard; but the species breeds, it is stated, in winter as well, and, according to YARRELL, as early as in October. "I have reason to suppose," says COUCH, "that the spawn is shed at the surface, and mingled with it a large quantity of tenacious mucus, in which it is kept floating while it is obtaining the vivifying influence of the light and warmth of the sun," an assumption that has been corroborated by the observations of DUNN and CUNNINGHAM[f]. According to DAY the female Pilchard lays about 60,000 eggs; and it has

[a] See VAILLANT and HENNEGUY, Rapp. Gen. sur la pêche de la Sardine (GERVILLE-RÉACHE), Paris 1888, p. 28.
[b] In BUCKLAND, *Nat. Hist. Brit. Fish.*, p. 165.
[c] *Fish. Brit. Isl.*, vol. IV, p. 93.
[d] Fish. Trades Gazette, No. 485 (3rd Sept., 1892), p. 9.
[e] See COUCH, l. c., p. 85.
[f] Mith. Sect. Küst., Hochs. Fischer., Deutsch. Fisch. Ver., 1892, p. 45.

long been known that during the spawning-season the Pilchard is so dry and tasteless as to be scarcely eatable.

Man is not the Pilchard's only enemy. Fishes and Dolphins make havoc among its shoals. Among them Sharks (such as *Squalus acanthias* and *Carcharias glaucus*) and Sciaenoids are the most destructive.

COUCH[a] has described and figured a *Clupea squamo-pinnata*, which is stated to have larger scales than the Shads, and has therefore been explained by GÜNTHER[b] as a hybrid between the Pilchard and either the Twaite or the Allice Shad, though the two last-mentioned forms do not breed, so far as we know, in salt water. The defective specimen, the only one known, can only serve, which was all that COUCH intended, as an incentive to further investigations. More noteworthy is another form, also found in English waters, which resembles the Pilchard in the striation of the opercula and the large scales on one side of the body, but has smaller scales, like those of the Herring, on the other side. This form has been figured and described by DAY[c] as a cross between the Pilchard and the Herring.

THE SHAD (SW. STAMSILLEN).

CLUPEA ALOSA.

Fig. 248 and Plate XLIII, fig. 2.

Length of the maxillaries at least about 45 % of that of the head. Longitudinal diameter of the eyes[d] at most about 50 %, least depth of the tail about 75 %, length of the suboperculum[e] at most about 49 %, of the length of the maxillaries. Number of scales in a row along the sides of the body at least about 60.

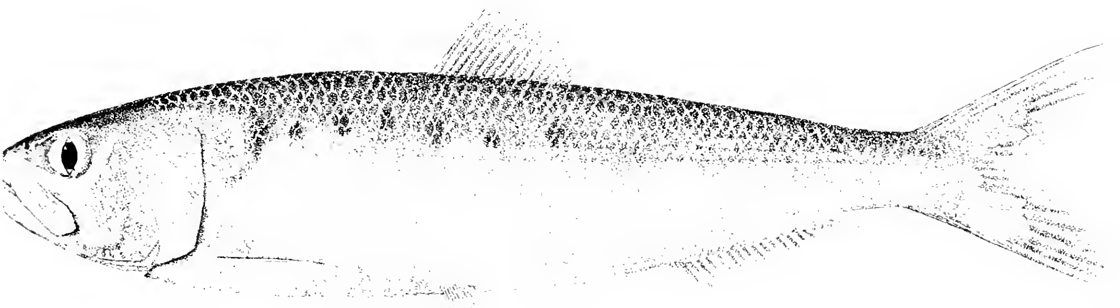

Fig. 248. *Clupea alosa*, var. *finta*, ♀, ½ of the natural size. Taken in a Salmon-trap off Killingholm (Stromstad Fjord) on the 18th July, 1881 by Mr C. A. HANSSON.

[a] l. c., p. 123, pl. CCVI.
[b] *Cat.*, l. c., p. 436.
[c] Proc. Zool. Soc. Lond. 1887, p. 129, pl. XV.
[d] In specimens more than 1 dm. long.
[e] At the suture with the operculum.

A. Var. *finta* — *Twaite Shad* (Sw. *Staksill*). Fig. 248.

Gill-rakers on the first branchial arch about 40—60 (fig. 249, *a*).

R. br. 8—9; *D.* $\frac{5}{14-16}$; *A.*[a] $\frac{3}{17-21}$; *P.* $\frac{1}{14-16}$; *V.* $\frac{1}{7-8}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 60—65[b]; *L. tr.* 17[c]; *Vert.* 55—59[d].

B. Var. *alosa* — *Allice Shad* (Sw. *Majfisk*). Pl. XLIII, fig. 2.

Gill-rakers on the first branchial arch about 90—120 (fig. 249, *b*).

R. br. 7—8; *D.*[e] $\frac{5}{15-16}$; *A.*[f] $\frac{3}{22-24}$; *P.* $\frac{1}{14-15}$[g]; *V.*[h] $\frac{1}{8}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 70—80; *L. tr.* 20—23; *Vert.* 57—58[i].

a *b*

Fig. 249. First left branchial arch of *Clupea alosa*. Natural size.
a: of a Twaite Shad (var. *finta*); *b*: in the Allice Shad (var. *alosa*) shown in Pl. XLIII, fig. 2, together with a gill-raker (× 2) from the middle of the arch.

Syn. *Agon, Pucelle, Alose*, BELON., *Nat., Divers. Poiss.*, pp. 267, 302, 307. *Thrissa*, RONDEL., *De Pisc. Mar.*, p. 220. *Alosa*, vel *Alausa*, aut *Thrissa*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 13. *Shad*, WILLUGHB., *Hist. Pisc.*, p. 227, tab. *P.* 3. *Clupea* apice maxillæ superioris bifido, maculis nigris utrinque, ART. *Ichthyol.*, *Gen. Pisc.*, p. 7; *Syn.*, p. 15; *Spec.*, p. 34 (ubi: "Apophyses in parte concava" (branchiarum) "osseæ, albæ et satis robustæ"; varietatem *fintam* igitur descripsit).

Clupea Alosa, LIN., *Syst. Nat.*, ed. X, tom. I, p. 318 (ex ART.; *finta* igitur); BL., *Fisch. Deutschl.*, part. 1, p. 209, tab. XXX, fig. 1; RETZ., *Fna Suec. Lin.*, p. 353; FLMNG, *Brit. Anim.*, p. 183; v. YHLEN, Fiskaren, 1878, p. 38; MÖB., HCKE, *Fisch. Osts.*, p. 141.

Alausa vulgaris, CUV., VAL., *Hist. Nat. Poiss.*, vol. XX, p. 391, tab. 604; HCKL. KN., *Susswasserf. Östreich. Mon.*, p. 228; v. BEMM. in HERKLOTS, *Bouwstoffen voor eene fauna van Nederland*, pt. III, p. 382; CANESTRINI (*Alosa*), Arch. Zool., l'Anat., cett., vol. IV, fasc. 1 (Apr. 1866), p. 141; STEIND. (*Alausa*), Stzber. Akad. Wiss. Wien. Math. Naturw. Cl., LVII, 1 (1868), p. 737; CANESTR. (*Alosa*), *Fna d'Ital.*, pt. III, p. 22.

Var. *A.*

Alosa ficta aut *falsa*, DUH., *Tr. Pêch.*, pt. II, sect. III, p. 320, tab. I, fig. 5; tab. II, fig. 1.

Twaite Shad, PENN., *Brit. Zool.* 1776, vol. III, p. 307.

Clupea fallax, LACEP., *Hist. Nat. Poiss.*, vol. V, p. 452.

Clupea (*Alosa*) *finta*, CUV., *Regn. Anim.*, ed. 2, tom. II, p. 320; NILSS., *Prodr. Ichthyol. Scand.*, p. 22; YARR. (*Alosa*), *Brit. Fish.*, ed. 1, vol. II, p. 131; SCHAGERSTR. (*Clupea*), Fysiogr. Sälls. Tidskr., p. 291; KR. (*Alosa*), *Danm. Fisk.*, vol. III, p. 202; TROSCHEL (*Alausa*), Arch. Naturg., Jahrg. 18, Bd. 1, p. 228; NILSS. (*Alosa*), *Skand. Fna, Fisk.*, p. 527; SIEB., *Susswasserf. Mitteleur.*, p. 332; GTHR (*Clupea*), *Cat. Brit. Mus., Fish.*, vol. VII, p. 435; COLL. (*Alosa*), Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 195; CEDERSTR., Öfvers. Vet. Akad. Förh. 1876, No. 4, p. 67; MALM, *Gbgs. Boh. Fna*, p. 587;

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[a] *A.* 20—25, according to DAY.

[b] 60—75, according to DAY; 63—71, according to FATIO.

[c] 16—17, according to KROYER; 16—19, according to FATIO; 15—16, according to LILLJEBORG.

[d] The latter number, according to FATIO.

[e] *D.* $\frac{4-5}{14-17(19)}$, according to FATIO.

[f] *A.* $\frac{3}{20-24}$, „ „ „

[g] Sometimes 13, „ „ „

[h] *V.* sometimes 10, „ „ „ and DAY.

[i] According to FATIO.

WINTH., Naturh. Tidskr. Kblvn. ser. 3. vol. XII (1879), p. 50; FEDDERS, ibid., p. 81; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 456; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 167; DAY (*Clupea*), *Fish. Gt. Brit., Irel.*, vol. II, p. 236, tab. CXLI; COLL., N. Mag. Naturv. Chrnia, Bd. 29 (1884), p. 113; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 120; FATIO (*Alosa*), *Fn. Vert. Suisse*, vol. V, part. 2, p. 40; TRYB. (*Clupea*), Sv. Fiskeritidskr., Arg. 1 (1892), p. 120.

Var. *B.*

Clupea major, [illegible] DUH., l. c., p. 316, tab. I, fig. 1.

Allice Shad, PENN., l. c.

Clupea alosa, LACEP., l. c., p. 147.

Clupea (Alosa) alosa, CUV., l. c., p. 319; GTHR. l. c., p. 433; DAY, l. c., p. 234, tab. CXL; COLL., N. Mag., l. c., p. 112; LILLJ., l. c., p. 113.

Alosa communis, YARR., l. c., p. 136.

Alosa vulgaris, SEL. LONGCH., *Fn. belge*, p. 220; TROSCH. (*Alausa*), l. c.; SIEB. (*Alosa*), l. c., p. 328; WINTH., l. c., p. 49; MOR., l. c., p. 453; STORM, Vid. Selsk. Skr. Trondhj. 1883, p. 31; FATIO, l. c., p. 29.

Alosa Cuvieri, MALM, l. c., p. 654.

C. Var. *sapidissima*, forma americana, pinna anali *finta*, branchiospinis *alosæ*.

Clupea sapidissima, WILSON, in REE'S, Cyclop., Univ. Dict. Arts, Sc. Lit., p. 461; JORD., GILB., Bull. U. S. Nat. Mus. No. 16, p. 267; MCDON. in BR. GOODE, Fisher., Fisher. Industr. U. S., sect. I, p. 594, tabb. 212 et 213.

Alosa prastabilis, DEK. *N. York Fna*, pt. IV, p. 255, tab. XV, fig. 41.

In form of body the Shad resembles the common Herring even more closely than the Pilchard does, the greatest thickness seldom rising to $\frac{1}{2}$ of the greatest depth, and usually measuring between 35 and 45 % thereof. The alterations of growth in this respect are, however, considerable, the rule being that young Shads are most like the Herring, and that in older specimens the hind part of the body is prolongated to such an extent as to reduce the greatest depth (across the middle of the preabdominal part), which is commonly between 23 and 28 % of the length of the body, to about 22 % thereof. The body then acquires a compressed, clavate shape, quite different from the handsome type of the Herring. The least depth varies between about 8 and $6\frac{1}{2}$ % of the length. The Shad is also far more vigorous of growth than the Herring. It almost ranks among the large fishes, though the above-mentioned varieties differ in this respect. The Twaite Shad seldom attains a length of 6 dm.[a] or a weight of 1 kilo., whereas the Allice Shad, it is stated, often measures 7 dm. in length and weighs $2\frac{1}{2}$ kilo., and the North American Shad attains in modern times, according to MCDONALD, a weight of at least $3\frac{2}{3}$ kilo., which it formerly exceeded, sometimes turning the scale, it is said, at $6\frac{1}{2}$ kilo. or more.

The length of the head in Young Shads measures about $23\frac{1}{2}$ % of that of the body. During growth to a length of 4 or 5 dm. this percentage falls to 22 or $21\frac{1}{2}$, and in still larger Shads to about 19, judging by a stuffed specimen. To the covering of adipose membrane on the head and shoulders the same remarks apply as in the case of the Pilchard; nor do the lateral ridges on the top of the head coalesce behind in the occipital crest. In old specimens the tip of the snout is incised, more than in the Pilchard and most in the Twaite Shad, which has the deepest sinus at the head of the angular or S-shaped indentation in the margin of the intermaxillaries. In younger specimens and in the Allice Shad the tip of the snout is more even, showing only the above-mentioned sinus at the middle of the margin. The eyes are about as large in young Shads as in the common Herring, in old specimens perceptibly smaller. In a Shad 12 cm. long both the vertical and the horizontal diameters of the eyes are nearly $\frac{1}{4}$ of the length of the head, in males 3—4 dm. long little more than $\frac{1}{5}$ of the same, and in females of this size the proportion is only about 18 %. The corresponding proportions to the length of the maxillaries are respectively about $\frac{1}{2}$ (50·7 %), 45—41 %, and about 43—39 %. In the smallest specimen the diameter of the eyes is somewhat greater than the interorbital width at the middle of the eyes, in old males about 90—80 %, and in old females about 80—70 % thereof. The length of the snout is somewhat less in the first-mentioned specimen than the diameter of the eyes, in the others equal to or a little greater than the same. The nostrils are set almost as in the Herring; but the distance between the two pairs is comparatively somewhat greater, being in young specimens $\frac{1}{2}$, in old about $\frac{2}{3}$, of the breadth of the snout at the articulation of the maxillaries. The length of the maxillaries is about $11\frac{1}{2}$—$9\frac{1}{4}$ % of that of the body or 49—45 % of that of the head, and these bones extend back to about a line

[a] A stuffed specimen from Alexandria and in the possession of the Royal Museum measures about 61 cm. to the ends of the caudal lobes.

with the posterior margin of the eyes, the length of the cheek behind them being less than its height below the eyes. The length of the lower jaw is 14—13 % of that of the body[a] or about 62—58 % of that of the head. The height of the dental part is less than in the Herring, measuring about $\frac{1}{3}$ of the length of the lower jaw. At the symphysis the lower jaw is most like that of the Pilchard and only slightly prominent; but in old or lean specimens the symphysis is more truncate (deeper), and has two pairs of comparatively small chin-protuberances above. The jaw-teeth disappear more or less completely with age, most in the Allice Shad; but even in old specimens a fairly regular row may be found on the intermaxillaries, a tooth or two in the front of the lower jaw, and traces of the dentiform crenelation on the hind part of the maxillaries. There are no other teeth in the mouth. The differences in the gill-rakers of the two varieties have been mentioned above, and may be seen in the figures. The opercular apparatus differs from that of the Herring in the greater extension of the preoperculum backwards and downwards and in a corresponding reduction of the operculum below, the obliquely set inferior margin (the suture with the suboperculum), which is fairly straight or incurved, measuring only about $17\frac{1}{2}$—21 % of the length of the head, 35—47 %[b] of that of the maxillaries, or 29—35 % of that of the lower jaw. An equally perceptible alteration of growth appears in the form of the suboperculum, which becomes narrower, as a rule, during growth, its breadth at the middle decreasing from about 60 to 40 % of the length of the said suture. As the length of the body increases from 12 to 40 cm., the postorbital length of the head rises from about $45\frac{1}{2}$ to 58 % of the entire length thereof, or from about $25\frac{1}{2}$ to 30 % of the distance between the dorsal fin and the articular knobs of the maxillaries. When the postorbital length is measured in an oblique direction (to the lower posterior angle of the operculum), these percentages increase respectively from about $52\frac{1}{2}$ to $62\frac{1}{2}$ and from $29\frac{1}{2}$ to 32.

The length of the pectoral fins, which are obliquely pointed, is about 16—14 %, that of the ventral fins about $10\frac{1}{2}$—$8\frac{1}{2}$ %, of the length of the body. The preabdominal length varies between about 22 and 26 %, the postabdominal between 21 and $24\frac{1}{2}$ %, of the length of the body.

The dorsal fin begins at a distance from the articular knobs of the maxillaries measuring about 42—$44\frac{1}{2}$ % of the length of the body, or 90—99 % of the distance between the ventral fins and the same points. Its height decreases with age from about 15 to 11 %[c], and the length of its base varies between about 13 and 15 %, of the length of the body, the latter proportion seeming as a rule to be somewhat less in young specimens than the former, greater in old. The caudal fin is deeply forked, the middle rays measuring only $\frac{1}{4}$—$\frac{1}{5}$ of the length of the longest ones, which varies between about $22\frac{1}{2}$ and 19 % of that of the body. The inferior lobe of the caudal fin is, as usual, somewhat longer than the superior.

The anal fin is of special interest from a systematic point of view. The form is indeed highly variable, but we have failed to discover any rule for its variations. Sometimes the fin is comparatively high, the length of its longest ray measuring as much as $\frac{2}{5}$ of its base. In other specimens it is as low as in the preceding Clupeoids, the height being but little more than $\frac{1}{4}$ of the base. But the extent of the fin, the length of its base, seems to afford a distinction both between the sexes and the varieties. In each variety of the Shad, so far as our observations have been carried, the females have a comparatively longer anal fin than the males; and the base of the anal fin is comparatively longer in the Allice Shad than in the Twaite Shad. We may here adduce the following examples of the rule:

[a] It sinks in the oldest Shads to 12 % thereof, judging by a stuffed specimen.

[b] About 55—58 % in the Pilchard.

[c] Or even to 9 %, judging by a stuffed specimen.

	Clupea finta					*Clupea alosa*				
Length of the body expressed in millimetres	121	281	302	318	393	147	147	321	358	385
Base of the anal fin in of the length of the body	14.7	16.0	13.0	11.6	16.0	16.0	18.1	17.0	17.6	17.1
„ „ „ „ „ „ „ „ „ „ „ „ head	62.8	71.2	60.8	61.4	72.0	61.3	75.8	85.1	71.1	79.5
„ „ „ „ „ „ „ „ „ distance between the anal fin and the tip of the snout	21.8	21.2	20.7	21.1	24.0	22.6	27.2	29.6	26.9	26.1
„ „ „ „ „ „ „ „ „ postabdominal length	63.6	75.8	56.7	61.8	72.1	70.3	86.4	87.1	80.0	79.6
„ „ „ dorsal fin in of the base of the anal fin	93.8	80.2	105.6	92.7	91.7	80.0	74.6	74.2	79.3	75.7
Length of the maxillaries	78.6	63.7	80.0	71.4	65.1	71.1	63.6	53.8	63.5	56.5
„ „ „ lower jaw	95.5	86.8	98.8	90.8	84.1	93.3	84.2	68.5	74.6	75.3
„ „ „ pectoral fins	109.1	96.7	102.3	99.6	90.5	103.5	90.0	75.0	84.1	80.3
„ „ „ ventral fins	72.1	61.5	68.1	63.7	54.7	60.0	58.0	45.0	52.1	50.0
Least depth of the tail	57.8	46.1	57.1	52.0	48.5	53.3	46.8	39.9	42.8	38.8

The rule is clear: the young and the males have the shortest anal fin, and the Allice Shad is characterized by the long base of its anal fin. But in this character the young male of the Allice Shad — a Mediterranean specimen 147 mm. long and sent here by HEDENBLAD — ranks beside the female Twaite Shads, and is so closely approximated to them that the difference is useless as a specific character. The character is, however, not without importance, for we find on comparison that in most of the relations the base of the anal fin is much shorter in male Twaite Shads than in Allice Shads less than half as long. A development of form, determined by the female characters, has evidently advanced from *finta*[a] to *alosa*; but this development has not yet attained such definiteness that true species can be distinguished. The specific character first pointed out by TROSCHEL, the difference in the number of the gill-rakers — greater in *alosa* (fig. 249, *b*) than in *finta* (fig. 249, *a*) — is impaired by the same indefiniteness. STEINDACHNER and MOREAU showed that their number increases with age, whereupon LILLJEBORG remarked with justice that the character can only be employed in comparisons between specimens of about equal size. The case appears to be the same here as in the Gwyniads (see above), where we also failed to arrive at more than variety distinctions by the aid of the differences in the gill-rakers. And even if we could prove that the character derived from this source agrees in our European Shads with other characters[b], the North American Shad apparently baffles our systematic calculations, for it is furnished, according to JORDAN and GILBERT, with the gill-rakers of the Allice Shad, but externally resembles, according to TODD's figure in BROWN-GOODE (l. c.), the Twaite Shad.

The form and texture of the scales (fig. 245, *b*) we have described above. They are more firmly attached to the skin in most cases than in the Herring. The irregularity of their arrangement and the absence of a lateral line render it difficult to compute their number with certainty. The number of spiniferous scales at the ventral margin is 37[c] in all the specimens examined by us, 23 or 22 in front of the ventral fins and 14 or 15 behind them. Here too these scales are covered to the greater part of their extent by the nearest lateral scales.

The coloration is essentially the same as that of the Herring. The dark (blackish blue) spots characteristic of the subgenus *Alosa*, set in a straight or an interrupted (zigzag) row on the sides of the body, the largest — sometimes as large as the eyes, but commonly smaller — first, are most usual in young specimens. They formerly ranked as a character of the Twaite Shad, but are of very irregular occurrence even in this variety. Our figure (Plate XLIII, fig. 2) also shows that they may be quite numerous in the Allice Shad; and FATIO relates that, on boiling adult Allice Shads from the Rhine in order to prepare their skeletons, as many as 15 spots appeared on the sides of the body. "On the sides of the head too," writes KRÖYER of the Twaite Shad, "a black spot may sometimes be seen above the preoperculum"; and in one of our Twaite

[a] Or perhaps from the North American *Clupea chrysochloris*, with its still shorter anal fin, unless this form be an instance of retrogression in development.

[b] LILLJEBORG has adduced the different form of the tip of the snout and the greater number of the scales in *alosa* (see above).

[c] 37—42, according to VALENCIENNES.

Shads this spot is the only one left, with the exception of that on the shoulder. Nor is the black colour of the tip of the snout, the point of the lower jaw, and the tongue constant. But the scale follicles of the whole body as well as of the head are strewn, more densely than in the Herring, with fine dots of brownish black; and at the top of the dorsal fin this colour gathers in a black spot, the hind margin of the caudal fin being also black.

If we include, as we have reason to do, within the limits of this species the North American Shad (and perhaps the Skipjack, *Clupea chrysochloris*), the species has an extensive range on both sides of the Atlantic. On the eastern side it occurs from the neighbourhood of Trondhjem[a] to the Mediterranean; on the western side it lives somewhat further south, being found from the Gulf of St. Lawrence to St. John's River, Florida[b]. In the Pacific it was unknown until the 2nd of July, 1873. On that date LIVINGSTON-STONE, instructed by the Fisheries Commission of the United States, stocked the Sacramento at Tahama (California) with 35,000 Shad-fry from the Hudson River, delivered to him on the 25th of June from the Shad Hatchery of New York State at Castleton. This proved one of the greatest triumphs achieved by pisciculture; a productive Shad-fishery was bestowed upon California. The enterprise is also of general interest, as calculated to throw light on the wanderings of other fishes[c]. We are told by McDONALD: "It is a common belief among fish-culturists that the mature individuals of all anadromous species, including the Shad, are led back to the waters in which they were spawned by a conscious wish on their part to return to those very localities in which they spent their young life. Important exceptions to this rule are, however, well established by recent observations. For instance, it is well established that the runs of Shad into the Susquehanna and Potomac Rivers are characterized by alternations of abundance; that is to say, an excessively large yield for any given season in the one involves a corresponding diminution in the yield for the same season in the other, thus precluding the possibility of each individual returning annually to its native stream. Again, it was confidently expected that all the young Atlantic Shad which were transferred to and planted in the Sacramento River would, on their return from the Pacific Ocean as mature fish, find their way back to this stream. This was not, however, the case, for, to the utter astonishment of many fish-culturists, a considerable number of these now mature fish made their appearance in many streams of the Pacific lying far north of the Sacramento River—streams to which Shad had never been indigenous and in which none had ever been planted. These facts go a long way to disprove the theory of instinct of locality, and indicate that the river movements of the Shad are regulated by involuntary and extraneous influences. The migration and colonisation of this fish northward along the Pacific coast has been so general that at the present day new generations of a single plant are found in every stream on the Pacific from the Sacramento River to Puget Sound."

In Scandinavia the Shad may be considered as a stranger. North of Germany it does not appear anywhere in numbers. But it is not rare. Several large Allice Shads have been taken during the summer months, according to STORM, in Salmon-nets by the fishermen of Trondhjem Fjord, and COLLETT states that an Allice Shad was caught in the autumn of 1881 off Namsas (64½° N. lat.). The *finta* variety has not been observed so often in Norwegian waters, and, according to COLLETT, only in Christiania Fjord and near Bergen. In Denmark the Shad is fairly common, but almost without exception in the *finta* form. This variety was frequently observed by KRØYER among the fish taken on the Danish coast of the Cattegat, and he was told by fishermen that they sometimes caught hundreds of Twaite Shads in Liim Fjord. But only three Allice Shads, all taken during May (1871 and 1878) in Liim Fjord, are mentioned by WINTHER. On the west coast of Sweden the case is about the same. The Royal Museum has received from Strömstad, through Mr. C. A. HANSSON, two females of the Allice Shad, one of them measuring about 44 cm., the other 36 cm., and taken respectively at the beginning of June, 1887 (the original of our coloured figure) and the beginning of September, 1892. No other Allice

[a] Even on the coast of Iceland the Shad is found, according to a statement in FABER (*Fisch. Islands*, p. 182). The fishermen told him that on the east coast of Iceland a kind of Herring was taken, similar to the common Herring, but with black spots along the sides They called it *Ógna-síld*, i. e. Herring with eye-shaped spots.

[b] The Skipjack strictly belongs to the Mississippi Valley and the neighbouring parts of the Gulf of Mexico. It is uncertain whether the true Shad is indigenous to the Alabama, where attempts to introduce it have been made since 1848. In the tributaries of the Mississippi, above all in the Ohio, it has been planted by the U. S. Fisheries Commission.

[c] Cf. above, on the migrations of the Salmon, pp. 858—859.

Shads are known from the west coast of Sweden. The Twaite Shad is commoner, and is taken off the coast of Bohuslän, according to MALM, "now and then, most frequently on Haddock-lines, both in spring and autumn, but usually in October and November." At the beginning of July, 1832, according to NILSSON, about a score of Twaite Shads were taken in Flounder-nets off Malmö (Bohuslän). On the Halland coast the Twaite Shad is fairly common, at least in Laholm Bay, where it is called *Blanksill* and *Stafsill*, and in summer it ascends to the lower part of the River Laga. It is found quite often, according to SCHAGERSTRÖM, in Schelder Bay at the foot of the Kulla Cliffs. In the Sound it is rather rare, but commoner than in the Belts (WINTHER). On the Prussian coast, according to BENECKE, it formerly entered the Haffs in great numbers, but is now rare, being taken only on few occasions among the hauls of Strömming. NILSSON states that in April, 1850, the fishermen of Abekas (Southern Scania, west of Ystad) caught, partly in gill-nets set for other fish, partly in Salmon-seines, 8 or 10 Twaite Shads. From Calmar Sound off Borgholm Dr. ARÉEN sent to the Royal Museum a male Twaite Shad about 3 dm. long that had been taken in a trap on the 13th of October, 1892. The Twaite Shad thus occurs in the Swedish part of the Baltic, but the specimens are probably solitary rovers; and this is, no doubt, the case with the Allice Shad too, which has been found still higher up. The Museum of Upsala contains a female Allice Shad 57 cm. long that was taken on the 6th July, 1864, in the Dal Elf off Elfkarleby (LILLJEBORG).

No Shad-fishery of importance can therefore be carried on in Sweden, unless successful attempts be made to plant this fish in suitable places within Scandinavia. Things are different in the Shad's true home. In the Old World its habitat is of about the same extent as the Pilchard's, and there the Shad is one of the most important fishes from an economical point of view, its manner of life reminding us strongly of the Salmons.

The Shad commonly passes the greater part of its existence in the sea; and its life there is little known, but it probably roves in scattered companies to seek its food. This consists not only of small Evertebrates and lower algæ, but also of moderate-sized fishes. In the stomach of a Twaite Shad 47 cm. long COLLETT found about a score of Sprats 65—68 mm. in length.

When its propagative instinct begins to awake, or even some time beforehand — this depending seemingly on the temperature of the water — the Shad musters in shoals to commence its migration to fresh water. According to MCDONALD the American Shad ascends the St. John's River (Florida) as soon as the temperature of the water has fallen in autumn to about 60° Fahr., which happens at the end of November; but the spawning is not in full progress till the beginning of April. In the Potomac, on the other hand, the Shad presses on with the greatest eagerness when the temperature of the river, at about the middle of April, is 56° Fahr. Large and small, ripe and unripe, the fish make their approach, but only the former continue their advance, until they find a temperature of 65°—70° Fahr., whereupon the spawning is begun, the Shads not yet in breeding condition halting at a temperature of 60° Fahr. The further north the mouth of the river lies, the later is the appearance of the Shad. This seems also to be the case in Europe. According to BLANCHÈRE[a] Shads are taken in French rivers from March till July, and according to VALENCIENNES[b] the fish appears earlier in the Loire than in the Seine. According to VAN BEMMELEN (l. c.) the Shad (*alosa* first) ascends most of the Dutch rivers in April and May. It is a rule too that the Twaite Shad arrives about a month after the Allice Shad. In England, according to YARRELL, the two varieties have a preference for different rivers: in the Severn the Allice Shad preponderates, in the Thames the Twaite Shad. In Ireland both varieties are fairly common, in Scotland somewhat rare.

At the commencement of its sojourn in fresh water the Shad is in its best condition, and it retains its fatness until the spawning begins. For the purpose of spawning it roves, like the Salmon, but with less vigour, as far as it can penetrate up the rivers and their tributaries, in the Rhine up to Basel, in the Elbe into Bohemia, and in the Loire into Haute Loire, a distance of more than 800 kilom. (MOR.). During the early part of its ascent it is as timid as the Herring and cautious, retreating at the approach of a thunderstorm or a spring freshet; but as the sexual instinct gains sway, the fish lay aside all fear, and "grumble and grunt, like a herd of swine" (BALDNER, in WILLUGHBY). Meanwhile, as the males and females press together and thrash the surface with their tails, the eggs are deposited and im-

[a] *Nouv. Dict. Gén. Pêches*, p. 16.
[b] CUV., VAL., l. c., p. 412.

pregnated. When the spawning is over, the Shad's powers are exhausted, and its value lost. Many perish, others are carried half-dead by the current back to the sea; and by the end of the summer all the full-grown Shads have usually quitted the rivers and streams.

Each adult female lays, it is stated, 100,000—200,000 eggs[a] 1[b] or 2[c] mm. in diameter, which sink to the bottom, and are hatched in a few days. In October YARRELL obtained young Twaite Shads 2 1/2 in. (63 mm.) long; and in the following spring he found young Twaite Shads 4 in. (1 dm.) long and young Allice Shads 6 in. (1 1/2 dm.) in length[d]. Where the Shad spends the intervals of its existence, and how it lives in the sea, until it attains a length of about 3—4 dm., and appears after 2 or 3 years in fresh water as an adult fish, is unknown to us.

As the Salmons occur in fresh-water forms that never reach the sea, so the Shad is sometimes confined for its whole life in lakes and their feeders. To this category belong, according to FATIO, the so-called *Agoni*, a kind of Twaite Shad, that inhabit the great lakes of Lombardy and South-eastern Switzerland. The large Twaite Shads, known as *Cheppie*, ascend the Po from the Adriatic, and spawn during June and July in this river and its tributaries, returning in August to the sea. The *Agoni*, on the other hand, though they attain, according to DE BETTA, a length of 3—4 dm. and according to FATIO, a weight of 1 1/2 lbs., pass the whole year in the lakes of Ticino and Lombardy, where they spawn in May and June.

In its best condition, after living a day or two in fresh water, the Shad, especially the fat Allice Shad, is said to be excellent eating, in spite of the numerous bones, which are more troublesome even than in the Herring. After the spawning the flesh is lean and dry.

GENUS **STOLEPHORUS.**

Mouth large, the length of the maxillaries being more than half that of the head. Tip of the snout projecting more or less distinctly beyond the lower jaw. Gill-openings large, the branchiostegal membranes being for the greater part of their extent free from each other and from the isthmus. Anal fin free from the caudal.

Ranged beside the preceding genus the European Anchovy may indeed appear to be so sharply distinguished therefrom that it might lay just claim to a place at least in a separate subfamily. But on a comparison with the other genera of the family the differences disappear, and even the genus *Stolephorus* is difficult to define with natural limits. VALENCIENNES[e] pointed out this circumstance, and restored to the genus those species which CUVIER[f], on account of the backward prolongation of the maxillaries (extending behind the articulation of the lower jaw and even behind the head), had removed to a separate genus *Thrissa*. Among the Anchovy forms typical in other respects we find species in which the hind extremities of the maxillaries are very obliquely truncate, with the lower corner longer than the upper and even pointed — as for example in *Stolephorus heterolobus* from the Red Sea and India — so that the generic character depended merely on a greater or less degree of prolongation. To the genus *Coilia*, which in form of body calls to mind the Macruroids, we find among the Anchovies transition forms that SWAINSON[g] proposed to isolate in a genus *Setipinna*[h], characterized by the long anal fin, which sometimes occupies more than half the length

[a] In American Shads weighing 4—5 lbs. MCDONALD found only 20,000—40,000 ova; but he adds that in other females the number sometimes exceeds 100,000.

[b] BENECKE.

[c] FATIO.

[d] Cf., however, EHRENBAUM (Sonderbeilage zu den Mittheilungen der Sektion für Küsten- und Hochseefischerei, Jahrgang 1892, p. 12), who is of opinion that young Twaite Shads of the said size are a year older, and have already paid one visit to the sea.

[e] CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 5.

[f] *Règne Animal*, ed. 1, tome II, p. 176.

[g] *Nat. Hist. Fish., Amph., Rept.*, vol. II, p. 292.

[h] GÜNTHER'S *Telara* and *Heterothrissa*, *Cat. Brit. Mus., Fish.*, vol. VII, p. 385.

of the ventral margin, and the filamentous elongation of the first pectoral ray, a peculiarity that extends to still more of the pectoral rays in *Coilia*. BLEEKER[a] indeed attempted, following a suggestion of GÜNTHER's[b], to find a limitation for such a genus in the number of rays in the anal fin, more than 50. But a comparison[c] between the two Indian species *Stolephorus* (*Setipinna*) *telara* and *St. purara*, the latter with 38—47 (or, according to GÜNTHER, 50) anal rays and pointed pectoral fins, is enough to show how nearly the said characters run into each other. Another generic character recognised by BLEEKER is the peculiarity first observed by GÜNTHER in some Anchovies[d], and consisting in a more vigorous development of the jaw-teeth, among which some are prominent as canines. But in other respects these species resemble those with small teeth. Lastly BLEEKER has directed attention to the varying development of the spiniferous scales at the ventral margin. In conjunction with a more elongated and terete form of body, these spiniferous scales disappear in some forms of the genus, either in the postabdominal region alone or throughout a great portion of the preabdominal as well. These forms are also characterized by the shortest anal fin, with at most 23 rays, and BLEEKER proposed to reserve the generic name of *Stolephorus*, coined by LACEPÈDE[e], for them alone. But in these respects too there are intermediate forms, and even in the most typical of the last-mentioned species — as for example in the European Anchovy — traces of spiniferous scales may be found at the preabdominal margin. The genus has been most generally known under the later name of *Engraulis*[f], and about 50 species have been described from temperate and tropical regions all round the globe, most of them purely salt-water fishes, but some visitors to the rivers or at least to the estuaries.

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[a] *Atl. Ichthyol. Ind. Or. Néerl.*, tome VI, p. 135.

[b] *Cat.*, l. c.

[c] See, for example, DAY, *Fish. Ind.*, tab. CLVIII, fig. 2 (*telara*) and tab. CLVII, fig. 2 (*purara*).

[d] GÜNTHER's subgenera *Lycengraulis* and *Lycothrissa*.

[e] *Hist. Nat. Poiss.*, vol. V, p. 381. From στολή, *equipment, adornment*, and φέρω, *bear*; with reference to the silvery band along the sides of some species.

[f] CUV., *Règn. Anim.*, ed. 1, tom. II, p. 174.

THE ANCHOVY.

STOLEPHORUS ENCRASICHOLUS.

Fig. 250.

Maxillaries rounded at the hind extremity, and not extending behind the articulation of the lower jaw, but about equal in length to the base of the anal fin (somewhat longer or shorter), which is at most about $^2/_3$[a] of the length of the head, or $^7/_{10}$ of the postabdominal length, or 85 % of the length of the peduncle of the tail, which is greater than the length of the lower jaw. Dentition feeble and without canines, but complete. Greatest thickness of the body about $^2/_3$ (63—70 %) of its greatest depth, which measures about 14—17 % of its length. Least depth of the tail about $^3/_{10}$ (29—31 %) of the length of the head. No spiniferous scales, or only restiges thereof, at the ventral margin. No sharply defined, silvery band embedded in the skin along the sides of the body.

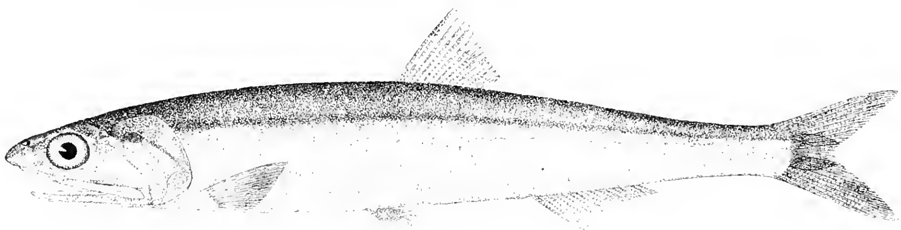

Fig. 250. *Stolephorus encrasicholus*, ♂. Natural size. Taken at Strömstad in 1878. C. A. HANSSON.

R. br. 12—13; *D.* $\frac{3}{13-15}$; *A.* $\frac{2}{15^b-16}$; *P.* $\frac{1}{15-16}$; *V.* $\frac{1}{6}$; *C.* $x + 1 + 17 + 1 + x$; *L. lat.* 44—50; *L. tr.* 7; *Vert.* 46—47.

Syn. Halecula, BELON, *Nat., Divers. Poiss.*, p. 167. *Encrasicholus*, ROND., *De Pisc.*, p. 211. *Lycostomus balticus*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 46, tab. V (fig. inf.). *Clupea* maxilla superiore longiore, ART., *Ichthyol., Gen. Pisc.*, p. 7; *Syn. Pisc.*, p. 17. *Anchois* et *Melet*, DUHAM., *Pêches*, pt. II, sect. III, p. 457, tab XVII, fig. 5; sect VI, p. 157, tab. III, fig. 5.

Clupea Encrasicolus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 318; BL., *Naturg. Fisch. Deutschl.*, pt. I, p. 212, tab. XXX, fig. 2; RETZ., *Fn. Suec. Lin.*, p. 354; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 212; CUV., (subg. *Engraulis*), *Règn. Anim.*, ed. I, tom. II, p. 175; RISSO (*Engraulis*), *Eur. Mér.*, tom. III, p. 454; CUV., VAL., *Hist. Nat. Poiss.*, vol. XXI, p. 7, tab. 607; KR., *Danm. Fisk.*, vol. III, p. 221; NILSS., *Skand. Fn., Fisk.*, p. 531; V. BEMM. in HERKL., *Bouwst. Fn. Nederl.*, pt. III, p. 383; GTHR, *Cat. Brit. Mus., Fish.*, vol. VII, p. 385; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 194; 1879, No. 1, p. 99; N. Mag. Naturv. Chrnia, Bd. 29 (1884), p. 112; MALM, *Gbgs. Boh. Fn.*, p. 569; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 47; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 460; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 206, tab. 138, fig. 1; MOB., HEKE, *Fisch. Osts.*, p. 142; PETERSEN, Vid. Meddel. Naturh. For. Kbhvn 1884, p. 159; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 33; EHRENB., Sonderbeil. Mittheil. Sekt. Küst., Hochseef., Jahrg. 1892 (D. Fisch. Ver.).

Engraulis meletta, CUV., *Règn. Anim.*, edit. 2, tom. II, p. 323 (ex DUHAM.).

Engraulis vulgaris, NILSS., *Prodr. Ichthyol. Scand.*, p. 25.

The Anchovy sometimes attains a length of 2 dm.[c], but is commonly no more than 12—15 cm. long. As we have already mentioned, it is characterized by an elongated body, fairly terete both at the dorsal margin and the ventral, and of a handsome and regular, fusiform shape, pointed in front. Only the head is compressed below, its sides converging towards each other. The pointed snout is one of the most distinctive characters belonging to the Anchovy and its nearest con-

[a] 65—60½ % in our specimens.

[b] Sometimes 14, according to DAY.

[c] 20½ cm., according to EHRENBAUM.

geners. The ethmoidal region is prolongated in front of the mouth and above the intermaxillaries, which are even more reduced than in the preceding Clupeoid forms.

The head in its remaining form and structure lends itself most readily to a comparison with that of the Greater Scopelus (*Myctophum elongatum*). This resemblance may be seen in the large, horizontal cleft of the mouth, with the gill-slits extending far forward in the lower jaw, the very strongly constricted cheek-region below the eyes, and the backward and downward prolongation of the opercular apparatus, the preoperculum having lost the lower, horizontal arm that else projects in a forward direction. The cheek behind the eye is also of the same triangular form as in the said Scopeloid.

In Anchovies 13—15 cm. long the length of the head occupies about $21^1/_2$—$22^1/_2$ % of that of the body. So great, however, is the extension of the pharyngeal and opercular apparatus that the head itself, from the tip of the snout to the occiput, measures only about $^4/_7$ of the above length. The longitudinal diameter of the eyes, which are round, but incline to an oval shape, is between 24 and $21^1/_2$ %, their vertical diameter about 20 %, of the length of the head. The eyes and the sides of the snout in front of them are covered by an adipose membrane, which is quite continuous, without aperture or eyelid, but transparent on the pupil. The interorbital width at the middle of the eyes is slightly greater than their vertical diameter, but less than the longitudinal. The length of the snout is slightly less than the said vertical diameter, the difference being least in old specimens. The nostrils on each side are set close together, being divided only by a narrow strip of skin, which may, however, be elevated so as to form an obliquely cut groove, open in front. They are set at the edge between the flat or faintly convex top of the snout and its converging sides, about halfway between the tip of the snout and the anterior margin of the eyes or a little nearer to the latter. The small, stiletto-shaped, and curved intermaxillaries are attached to the lower anterior margin of the long maxillaries. The latter bones increase uniformly, but slightly, in breadth behind, where each of them is furnished with two narrow jugal bones, pointed in front, their greatest breadth, including the jugal bones, being only about $^1/_{10}$ of their length. The lower jaw is also shallow and long, in contradistinction to that of the preceding Clupeoids; it is slightly turned up at the tip. The length of the maxillaries is about 61—65 %, that of the lower jaw about 68—71 %, of the length of the head. The intermaxillaries, maxillaries, and lower jaw are each furnished with a row of small pointed teeth, somewhat curved and of uniform size. Similar teeth may be found on almost all the bones of the palate[a], but are more or less deciduous. In old specimens the teeth of the maxillaries, and sometimes, at least in part, those of the lower jaw, also disappear. The tongue is small, cartilaginous, and toothless, but free. Close to its base begins the fine denticulation of the long and narrow row of copular bones. Both the upper and lower pharyngeals are armed with small teeth. The gill-rakers are long and fine, numbering about 62—72 on the first branchial arch.

The top of the head, which is almost flat, is coursed at the middle by a longitudinal ridge from the very tip of the snout (the upper margin of the ethmoid bone) to the occiput; and from the inner side of each pair of nostrils, obliquely outwards to each supraorbital margin, and thence obliquely inwards to the occiput, there run the same ridges as in the Clupeoid forms immediately preceding the Anchovy. The cephalic system of the lateral line is generally less developed than in the said forms, but here too varies considerably in its development. In some instances only faint traces thereof appear; in others the whole top of the head, the temples, the upper parts of the scapular region, and the triangular cheeks are covered with numerous, verrucose elevations and pores, sometimes with a network of confluent ducts belonging to this system, and the hind margins of the operculum, the preoperculum, and the scales on the scapular region are pierced by the straight, backward ramifications of these ducts. The preoperculum is crescent-shaped, though the lower corner is somewhat prolongated, forming a thin, rounded lobe. The operculum is quadrangular and of uniform breadth, but curved like a sickle, its upper anterior margin, above the articular head, being perpendicular, and its whole posterior margin forming a fairly regular curve of about a quarter of a circle. Its lower posterior

[a] On the sides of the head of the vomer, on the palatines, on the entopterygoids, and, in a small card, on the hind part of the ectopterygoids.

margin shows an arcuate indentation. Obliquely across its surface, from the articular head to the lower posterior corner, runs a groove, in front of which the lower anterior, triangular part of its surface is somewhat tumid, but smooth. The suboperculum has a rounded triangular form, with the hind margin sharply curved. The length of its upper margin, which coincides with the breadth of the operculum, is about 10—12 % of the length of the head. The interoperculum is of about the same shape as the suboperculum, but much smaller. All the opercular bones are very thin. The branchiostegal membranes are narrow, hardly perceptible at the hind margins of the operculum and suboperculum. In front (below) they follow the branches of the lower jaw, their breadth being but slightly greater than that of these bones or, at the extreme front, less. The branchiostegal rays are also comparatively short, gradually increasing behind (with the exception of the last one) in length and breadth. The anterior are subulate and curved, the posterior of more and more uniform breadth and sabre-shaped, with obliquely set, terete shaft;

Fig. 251. Composite scale from the left side of the inferior caudal lobe in an Anchovy 16 cm. long. × 3.

but the hindmost is of a rounded triangular shape, resembling in form and position a lower suboperculum. The nine middle rays are set on the ceratohyoid bone, the last two on the epihyoid.

The distance between the dorsal fin and the tip of the snout is about 44 ($44^1/_2$)—48 %, its height as well as its base about 10—11 %, of the length of the body. The first ray is extremely small, the second about $^1/_3$ as long as the third (the last simple ray), which is slightly shorter than the first branched ray. The last ray in the fin is scarcely elongated. The distance between the anal fin and the tip of the snout is about 60—$63^1/_2$ %, its base about 14 %, and its height (the length of the first branched ray) about $6^1/_2$—7 %, of the length of the body. It is thus both longer and lower than the dorsal fin, and has a more concave outer margin, the last ray being somewhat elongated. The first of the two simple rays at the beginning of the fin is hardly $^1/_3$ as long as the second, which is almost equal in length to the first branched ray. The caudal fin is deeply forked, the length of the middle rays (about 5—$5^1/_2$ % of the length of the body) being even less than $^1/_3$ of that of the longest ones (in the inferior lobe). On each side of the fin are set, as in the Clupeoid forms immediately preceding the Anchovy, a pair of so-called composite scales — much smaller, however, than the largest body-scales — one on the superior lobe, the other on the inferior, and each consisting of a scalpel-shaped dermal flap, with diamond-like reticulation, and covered with a considerable number (20—25) of small scales. These are set in imbricated rows, and each of them is marked with a row of brownish black pigment-spots (fig. 251).

The pectoral fins are comparatively short, their length being about equal to the height of the dorsal fin or a little greater, and are obliquely truncate, their shape reminding us strongly of the pectoral fins in those Anchovies where the first ray of these fins shows a filamentous elongation. The ventral fins are also obliquely truncate, but much shorter than the pectoral, their length being only about $7^1/_2$—7 % of that of the body. The position of the ventral fins is such that the distance between them and the tip of the snout measures about

Fig. 252. A scale from the left side of an Anchovy 16 cm. long. Three times the natural size.

40—44 % of the length of the body, or 90—92 % of that between the dorsal fin and the same point. The preabdominal length is about 18—22 %, and the postabdominal about 20 %, of the length of the body.

The scales are extremely thin and transparent, rather large, but short, and of a quadrangular shape, rounded at the corners (fig. 252). Their posterior (free) part is as large as the anterior (covered) portion, and is also finely striated, the concentric striæ being even twice as numerous as on the latter. The radiating grooves are sharply defined, originating both at the anterior margin and the posterior. The scales of the pectoral fins, and the pointed axillar scales of the ventral fins are long, extending respectively $^1/_5$ and $^3/_4$ of the distance along the fins. The basal scales of the dorsal and anal fins are about the same as in the Shads. The median line of the belly is covered, it is true, with ordinary scales; but vestiges of the spiniferous scales that appear in the preceding Clupeoid forms may sometimes be found. These take the shape of linear thickenings of the skin in the preabdominal region, answering to the lateral processes of the spiniferous scales; and outside (below) each pelvic bone, just in front of the outermost (first) ray of the ventral fins, lies an extremely thin, squamoid covering-bone, which sends out a wand-shaped process in the skin, extending about $^1/_3$ of the distance up the sides of the body, and corresponding to the ordinary double process that rises at this point in the Herrings (cf. p. 958, fig. 240, *c*).

The coloration is essentially the same as in the Herrings, but is characterized by a steely longitudinal band on the upper part of the sides, forming a sharp line of demarcation between the back, which gleams chiefly with a greenish lustre, and the lower parts of the sides, which are silvery white. On the articular head of the operculum lies a dark, elliptical spot, the length of which is scarcely half the diameter of the eyes.

The Anchovy's range in the Atlantic coincides with that of the Pilchard[a]. Its true habitat lies in the Mediterranean and the neighbouring part of the Atlantic, and hardly extends north of England and Holland, though numerous specimens have been taken in Christiania Fjord, and solitary individuals occur along the Norwegian coast up to Bergen. It also roves into the Cattegat and the Baltic, probably in the train of the Herring and Strömming, up to the island-belt of Stockholm, where Professor HJALMAR HOLMGREN took a female Anchovy about 18 cm. long[b] on the 15th of August, 1869. In the south-west of the Baltic it is caught somewhat more frequently — "though rare", wrote SCHONEVELDE in 1624 — off Kiel (MÖBIUS and HEINCKE) and Travemünde (LENZ). On the north coast of Fünen FEDDERSEN obtained 7 specimens in the middle of June, and PETERSEN caught 4 at the end of the year 1885. On the north coast of Zealand KRØYER saw two Anchovies. In the Sound north of Saltholm WINTHER secured a specimen 16 cm. long in June, 1870. The Royal Museum has received from Baron GYLLENSTJERNA a specimen 17 cm. long, taken off Kullen in August, 1829. BURMAN sent two specimens that had been caught in Herring-nets off Strömstad in July, 1862, and the Museum has more recently received through Mr. C. A. HANSSON two more from the same locality. MALM mentions 4 specimens from Bohuslän. The Anchovy, though rare, is thus not to be reckoned among the rarest fishes of the Cattegat and Skager Rack. In Christiania Fjord it is so common, according to COLLETT, that it appears every summer, at least in small numbers, at the fish-market of Christiania; and in August, 1873, COLLETT met with a considerable number, both large and small, in the fjord. In October, 1875, he found several specimens among common Herrings off Christiania, one of them nearly 19 cm. long, another only 68 mm., whence he infers that the Anchovy spawns in those waters. The adequacy of this evidence may, however, be questioned, if EHRENBAUM be correct in his opinion that Anchovies of the latter length may be in their second year and have passed one winter in the sea.

That the Anchovy is outside the bounds of its true habitat, or at the northern limit thereof, on the coast of Holland — though it spawns there, and is sometimes extremely plentiful—appears from the great irregularity to be observed in its occurrence. VAN BEMMELEN relates, on MARTINET's authority[c], that in 1765 or 1766 fifty fishermen could not secure more than three Anchovies during the whole summer in the Zuyder Zee, though some years before the Zee had been "so full of Anchovies as to be almost unnavigable for smacks." Even so far south as in the English Channel it is far less common, according to MOREAU, than in the Mediterranean.

From the large gape of the Anchovy and its other resemblances to the Greater Scopelus we may conjecture that its manner of life is also much the same, and that it is strictly a pelagic fish-of-prey. But in quest of food and in order to spawn it approaches the coast, and for the former purpose it enters brackish or even fresh water. It is found both in the Zuyder Zee and the mouths of the Dutch rivers. The Seine it ascends, according to VALENCIENNES, up to Quillebeuf. It spawns in the Mediterranean, according to RISSO, and on the coasts of Holland and Hanover, according to HOFFMAN[d] and EHRENBAUM, in spring and early summer, from April till the beginning of July. This seems also to be the case on the English coast, to judge by an observation of Mr. JACKSON's (DAY), who took Anchovies

[a] According to GÜNTHER (l. c.) the Anchovy is found off Tasmania and New Zealand, in a variety distinguished by a somewhat greater number of rays in the anal fin.

[b] The specimen is so greatly damaged that the length of the body cannot be stated exactly.

[c] *Verh. Haarlem* 1754—93, XI, pars 2, p. 236.

[d] *Verslag van den Staat der Nederlandsche Zeevisscherijen over 1884 en 1886.*

full of roe off Southport (Lancashire) on the 9th June, 1878[a]. The actual course of the spawning has not yet been observed; but the eggs, which are easily distinguished from the more or less spherical ova of other fishes by their ellipsoidal form, and which measure 0·7[?]—1·5[?] mm., have been found on several occasions. EHRENBAUM met with them in large numbers at the beginning of June at the surface and in open water 9—10 fathoms deep off the island of Norderney (East Friesland). In the innermost parts of the Zuyder Zee Anchovy-eggs have been found; but the actual spawning is probably performed in salt water. According to WENKEBACH (EHRENBAUM), the ova are hatched in three days. According to HOFFMANN, the fry measure 32—55 mm. at the beginning of August, and 50—100 mm. at the beginning of September. A Dutch Anchovy-salter stated too that in August and September such enormous quantities of young Anchovies 50—70 mm. long are often taken that they are salted and consumed in the same way as the larger ones, in spite of the fact that a firkin contains 8,000—10,000 of these small fish, whereas only 3,200—4,000 full-grown Anchovies go to the barrel. EHRENBAUM is, however, of opinion that these small Anchovies belong to the spawning of the preceding year[d], and assumes that larvæ less than 3 cm. long grow very slowly during their first winter and spring in the sea. If this opinion is correct, the Anchovy does not attain sexual maturity until its third year, which we should else date a year earlier.

The food of the Anchovy consists principally of *Copepodæ*, *Mysidæ*, and young shrimps.

The Anchovy is taken partly in fine-meshed drift-nets, sailing-seines, and shore-seines, partly with hoop-nets and stationary engines, such as *ryssjor* (traps) etc. In the Mediterranean the fishery is carried on chiefly by torchlight, the glare enticing the Anchovies to the boat, where the fisherman splashes in the water so as to frighten them into the meshes of the nets spread round about. The value of the fishery is generally much less than that of the Pilchard-fishery; but the Anchovy commands a higher price than the Pilchard, and in certain places the Anchovy-fishery is consequently the more valuable. The annual take of Anchovies on the Palermo coast is stated[e] at 400,000 kilo., valued at the same number of francs; while the Pilchard-fishery brings in 600,000 kilo. of fish, but only 200,000 francs. In France the take of Anchovies for 1881 was nearly 6,000,000 kilo., valued at rather more than 500,000 francs; whereas in 1882 the quantity fell to 1,500,000 kilo., but the price rose to somewhat over 700,000 francs[f]. Holland had an average annual export for the years 1883—1890 of nearly 1,750,000 kilo. or 35,000 barrels of salt Anchovies, which fetched a price per barrel of 8—78 Dutch guldens[g] (on an average, according to EHRENBAUM, 20—30 guldens).

The Anchovy is recommended not only by its fleshiness and fatness, but also by its flavour, a peculiar bitter taste, which combined with its saltness tickles the gourmand's palate and whets his appetite. This bitterness, which becomes disagreeable unless the head as well as the liver and intestine be removed before salting, was prized by the Romans, to whom Anchovy sauce (*garum*) was known. From this too the ancient Greeks derived their name for the fish, a name which the species still retains, *encrasicholus* (with the gall in the head).

[a] Both DAY (l. c.) and OLSEN (*Piscatorial Atlas*), however, state that in English waters the Anchovy spawns in autumn, September—December.

[b] According to WENKEBACH, quoted by EHRENBAUM.

[c] According to HOFFMAN, quoted by EHRENBAUM.

[d] On the assumption that a growth from 4—32 mm. is impossible during the interval between the end of the spawning-season and the beginning of August. But this growth is not so inconceivable from the beginning of the spawning-season.

[e] Esposiz. intern. di Pesca, Berlino 1880, Sez. Ital., Catal., p. LXVII.

[f] *Statistique des pêches maritimes*, 1882, pp. 235 and 237.

[g] A Dutch gulden = 1s. 8d.

ESOCIFORMES.

Physostoms with the shoulder-girdle suspended, as usual in the Teleosts, from the head, and without precoracoid bones. The first four abdominal vertebræ normal in form and development. Air-bladder, where present, simple, without connexion with the cranial cavity. Hyomandibular and pterygopalatine arches complete, as well as the opercular apparatus. Maxillaries fully developed. No adipose fin.

The Esociform series corresponds to the order established, under the name of *Haplomi*[a], by Cope[b]. It includes the Pikes (*Esocidæ*), the Mud-Minnows (*Umbridæ*, named after the Austrian and Hungarian *dogs'-fish*[c]), the Toothed Carps (*Cyprinodontidæ* — see above, p. 702 — three species of which family occur in Southern Europe), and the Blind-fishes (*Heteropygii*, inhabitants of caves and brooks in North America, a family whose maxillaries, like those of the Toothed Carps, form no part of the margin of the mouth, and which is especially distinguished by the forward situation of the vent, in front of the pectoral fins). In the Scandinavian fauna the series is represented by the first-mentioned family alone.

The series contains very dissimilar forms, predatory fishes like the Pikes, and more harmless fishes of small size, principally insectivorous or even mud-eaters. This dissimilarity manifests itself, as usual, most clearly in the form of the head and especially of the mouth. In addition to the above-given characters, however, the series has a peculiarity characteristic of the great majority among its members in the backward position of the dorsal fin, which lies above or even behind the anal.

Fam. ESOCIDÆ.

Dorsal fin situated, at least for the greater part, behind the perpendicular from the vent. Gape large. Snout depressed and long (at least as long as the postorbital part of the head or only a little shorter). Margin of the upper jaw formed by the tip of the ethmoid bone, the intermaxillaries, and the maxillaries. Mouth furnished with canine teeth. The pneumatic duct of the simple air-bladder runs from the anterior part thereof to the œsophagus.

The family of the Pikes differs considerably from the preceding family: a Pike and a Herring have not much in common. But one of the most characteristic external peculiarities of the Esocoid family, the caudal position of the dorsal and anal fins, reappears in a Mediterranean fish *Alepocephalus*, the type of a family very nearly allied to the Herrings, and also in the above-mentioned *Paralepidinæ*. The more predatory instincts of the Pikes, however, accompanied as they are by a simplification of the intestinal canal, the pyloric appendages having entirely disappeared, range these fishes nearer to the Salmonoids, in spite of the numerous pyloric appendages of the latter. The lateral margins of the upper jaw are also formed almost as in the Salmonoids — short, toothed intermaxillaries (fig. 253, *C* and *F*, *pmx*) and long, though here toothless, maxillaries (*mx*), each with a well-developed supplementary bone (*j*) — but show a peculiarity which we have not seen in the preceding fishes, and which is all the more important, from a systematic point of view, to the explanation of the forms immediately following this family. The intermaxillaries, which we have hitherto found to be more or less closely applied to each other at the tip of the snout, are here (fig. 253, *C*, *pmx*) separated by the cartilaginous end of the ethmoid bone (fig. 253, *A*, *C*, and *E*, *eter*), which

[a] ἁπλοός, *simple* and ὦμος, *shoulder*: i. e. without precoracoid in the shoulder-girdle.

[b] Trans. Amer. Philos. Soc., Philad., n. ser. vol. XIV (1871), p. 455.

[c] Heckel and Kner: *Süsswasserf. Östreich. Mon.*, p. 294.

forms the very tip of the snout, and its inferior covering-bone, the head of the vomer. This peculiarity shows that the Pikes occupy a comparatively low rank in the system of the Teleosts, during whose evolution the rostro-ethmoidal part of the snout has suffered reduction, while the parts of the upper jaw have been more strongly developed. In the head of the Pikes too the primordial chondrocranium is persistent to about the same extent as in the Salmonoids. The hyomandibular bones of the Pikes (fig. 253, *A* and *F*, *hm*) show a great resemblance to those of the Gadoids in the long, backward process (*hmp*) with the top of which the operculum (*op*) articulates. The anterior of the two articular heads (*hma*) which serve to articulate the hyomandibular bone with the cranium, is directed so obliquely inwards that it meets the petrosal bone (*ptr*, *prooticum*, fig. 253, *E*), instead of having its articular cavity, as is usually the case, on the under surface of the postfrontal bone (*spho*, *sphenoticum*).

This family contains only one genus.

GENUS ESOX.

Body elongated, with the abdominal part longest and of uniform depth[a], *more or less terete or compressed. The dorsal and anal fins, which are opposed to each other, short and of the same size. Caudal fin forked. Middle-sized or small cycloid scales cover the body entirely, the head partially. Pseudobranchiæ hidden. Branchiostegal rays numerous (11—20).*

The genus of the Pikes, with its five or six species, is distributed over the rivers and lakes of the north temperate zone both in the Old and New Worlds, a relic of the period when a land communication, with collections of fresh water within its bounds, existed between Europe and North America[b]. But only one species is found in the Old World.

The generic name of *Esox* was adopted by ARTEDI[c] from PLINY[d], who applied it to a large fish of the Rhine. GESNER[e] had already conjectured that the Pike was probably the fish meant; but not even he was confident of the correctness of his opinion. In his works, as in most of the ancient authors, the genus was called *Lucius*, the Italian *Luzzo*, from the Greek *λύκος*[f].

THE PIKE (SW. GÄDDAN).

ESOX LUCIUS.

Plate XLIV, fig. 4.

Cheeks and temples, together with the upper part of the opercula and the posterior part of the occiput (to a line with the upper end of the preoperculum) covered with scales: the rest of the head naked. Usually 14 (13—15) branchiostegal rays. Sides of the body spotted with yellow or yellowish white, the unpaired fins with brown.

R. br. 13—15[g]; *D.* $\frac{6-8}{15-17}$; *A.* $\frac{(5)6-8}{12-13(14)}$; *P.* $\frac{1}{14-15}$; *V.* $\frac{1}{9-10}$; *C.* $x + 1 + 17 + 1 + x$; *Lin. lat.* ca 125—130; *L. tr.* ca 26—28 supra pinn. ventr.; *Vert.* (58)59—62.

Syn. ESOX (?), PLIN. l. c. *Lucius*, AUSON., *Mos.*, vers. 122; BELON, *Nat. Divers. Poiss.*, p. 292; RONDEL., *Pisc. Lacustr.*, p. 188; GESN., l. c., p. 500; SCHONEV., *Ichthyol. Slesv. Hols.*, p. 44; WILLUGHB., *Hist. Pisc.*, p. 236. *Esox* rostro plagioplateo, ART., *Syn. Pisc.*, p. 26; *Descr. Spec. Pisc.*, p. 53; LIN., *Fn. Suec.*, ed. 1, p. 114.

[a] With the exception of gravid females with pendent belly.

[b] SMITT, *Ryggradsdjurens geologiska utveckling och slägtskapsförhållanden*, p. 59.

[c] *Gen. Pisc.*, p. 14

[d] Lib. IX, cap. 15.

[e] *Hist. Anim.*, lib. IV, p. 368.

[f] BELON derived the name from the Latin *lucere*, "because the fish when dried shines in the dark" (see GESNER, l. c., p. 502).

[g] Sometimes 16, according to FRIES and EKSTRÖM.

Esox Lucius, LIN., *Syst. Nat.*, ed. X, tom. I, p. 314; BL., *Naturg. Fisch. Deutschl.*, part. I, p. 229, tab. XXXII; RETZ., *Fna Suec. Lin.*, p. 350; PALL., *Zoogr. Ross. Asiat.*, vol. III, p. 336; EKSTR., Vet. Akad. Handl. 1831, p. 75; NILSS., *Prodr. Ichthyol. Scand.*, p. 36; RICHARDSON, *Fna Bor. Amer.*, part. III, p. 124; FR., EKSTR., *Skand. Fisk.*, ed. 1, p. 19, v. WR., tab. X; CUV., VAL., *Hist. Nat. Poiss.*, vol. XVIII, p. 279; SUNDEV., Öfvers. Vet. Akad. Förh. 1851, p. 164; KR., *Danm. Fisk.*, vol. III, p. 236; NILSS., *Skand. Fna, Fisk.*, p. 348; SUNDEV., *Fiskyng. Utveckl.*, Vet.-Akad. Handl. 1855, p. 11; Stockh. L. Hush.-Sällsk. Handl., II. 6 (1855), pp. 82, 91, 167; HCKL, KN., *Süsswasserf. Östr. Mon.*, p. 287; SIEB., *Süsswasserf. Mitteleur.*, p. 325; MGRN, *Finl. Fiskfna*, (disp. Helsingfors 1863), p. 66; GTHR, *Cat. Brit. Mus., Fish.*, vol. VI, p. 226; CANESTR., *Fna Ital.*, pt. III, p. 21; LUN., *Poiss. lac Lem.*, p. 161, tab. XIX; COLL., Forh. Vid. Selsk. Chrnia 1871, Tillaegsh., p. 175; 1879, No. 1, p. 94; OLSS., Öfvers. Vet.-Akad. Forh. 1876, No. 3, p. 131; 1882, No. 10, p. 48. MALM, *Gbgs. Boh. Fna*, p. 550; FEDDERS., Naturh. Tidskr. Kbhvn. ser. 3, vol. XII, p. 81; BNCKE, *Fisch. Fischer., Fischz. O., W. Preuss.*, p. 165; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 466; MELA, *Vertebr. Fenn.*, p. 355; tab. X; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 353; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 139, tab. CXXVI; MÖB., HCKE, *Fisch. Osts.*, p. 134; REUT., SUNDM., *Finl. Fisk.*, tab. XII; LILLJ., *Sv., Norg. Fisk.*, vol. II, p. 476; FAT., *Fn. Vert. Suisse*, vol. V, p. 419.

Esox estor, LE SUEUR, VAL. p. p., nec DEKAY; vide JORD., GILB., l. c.

The maximum size attained by the Pike in Sweden may be estimated, on the authority of several trustworthy statements from different places, at a length of 19 dm. and a weight of 26 kilo[a]. Pike of this size are, however, at least in our times, of rare occurrence; most of the specimens taken measure between 3 and 12 dm. The relation between the length and weight varies in different individuals. In old and nearly full-grown Pike the weight increases in a greater proportion than the length.

The elongated body becomes shallower at the head and tail; but between these points the depth is almost uniform, so long as the belly is not distended with food or tumid organs of generation. The greatest depth measures as a rule $15\frac{1}{2}$—17 % of the length, and the greatest breadth is rather more than half, as a rule about 52—57 %, of the greatest depth. In a transverse section the body is more or less distinctly quadrilateral, with rounded angles, and broadest in the dorsal region, growing more or less compressed towards the belly. The back is always broad and convex, the belly mostly flat. The least depth of the body measures in the fry about 35—36 %, in adult Pike about 38—43 %, of the greatest depth, or in the former about 17—20 %, in the latter about 24—28 %, of the length of the head.

The length of the head measures in the fry (about $\frac{1}{2}$ dm. long) about 32 % of that of the body, in full-grown Pike about 27—30 % thereof. Its posterior outlines form an uninterrupted continuation of those of the body, but in front of the eyes it is depressed into a hollow, with the sides somewhat widened in front, and the tip rounded in an horizontal direction, thus acquiring a resemblance to a duck's bill. The cleft of the mouth is large, extending below the anterior margins of the eyes[b]. The mouth shows a structure peculiar to the Pike and intimately connected with its well-known voracity, in which respect it is surpassed by few fishes. The bones entering into the apparatus of the jaws are endowed with great mobility, the mouth being capable of considerable distension; and both jaws, the palate, and the pharynx, including the branchial arches, are well armed with sharp, retrorse teeth. The mobility and expansiveness of the jaws are supplemented by the free articulation of the opercular apparatus.

As we have mentioned above, the intermaxillaries (*pmx*, fig. 253) are widely separated by the broad, flat, prominent, and cartilaginous ethmoid bone (*etcr*), which grows broader in front, and, supported by the vomer (*vom*), forms the anterior margin of the upper jaw. The ethmoidal cartilage is furnished not only with this inferior covering-bone, the vomer, but also with two pairs of upper covering-bones, the supraethmoids, called by others the nasal bones (*spet*, 1 and 2), the anterior pair situated above and beside the long nasal processes (*frn*) of the frontal bones, which processes extend almost to the tip of the snout. By means of cartilaginous joints the small intermaxillaries articulate with the anterior outer angle of the ethmoidal cartilage and the last-mentioned nasal bones. An ascending process, flat and incurved, of the intermaxillaries overlies the anterior extremities both of the maxillaries and of the concave articular head on the anterior outer end of the

[a] The Fisheries Commission of 1881—83 received from several provinces information of Pike 15—19 dm. long and 17—26 kilo. in weight.

[b] The length of the upper jaw from the middle of the tip of the snout to the hind extremities of the maxillary bones occupies in the fry (about $\frac{1}{2}$ dm. long) about 38 %, in Pike 4—5 dm. long about 46—49 %, of the length of the head; and the length of the maxillaries measures in the latter about 38—40 %, and their greatest breadth (across the supplementary bone) about 7—8 %, of the same. The length of the lower jaw is about 65—69 % (in the young about 60 %) of that of the head.

palatines (*pl*), where the anterior extremity of the maxillaries has its articulation; while the posterior part of the intermaxillaries is inserted under the anterior extremity of the maxillaries. In addition to the above-mentioned covering-bones the ethmoidal cartilage has a further ossification at each anterior outer corner, answering to the true ethmoid bone (*et*), which forms the prominence where the anterior extremity of each palatine bone has its mobile articulation. The hind extremity of the palatine is joined as usual by a firm suture to and covered by the geniculate pterygoid bone (*pt*), the lower arm of which is applied and united by a firm suture to the anterior margin of the quadrate bone (*qu*), while the upper arm sends out above the bend an ascending process which is linked by a mobile, cartilaginous articulation to the lateral ethmoid (*etl*, prefontal bone). The articulations of the hyomandibular with the under surface of the squamosal bone (*squ*) and with the upper posterior angle of the petrosal (*ptr*), which there meets the latter bone, have already been mentioned. The whole apparatus of the upper jaw, the palate, and the suspensory apparatus of the lower jaw are thus capable both of lateral and upward distension, the lower jaw simultaneously expanding, for

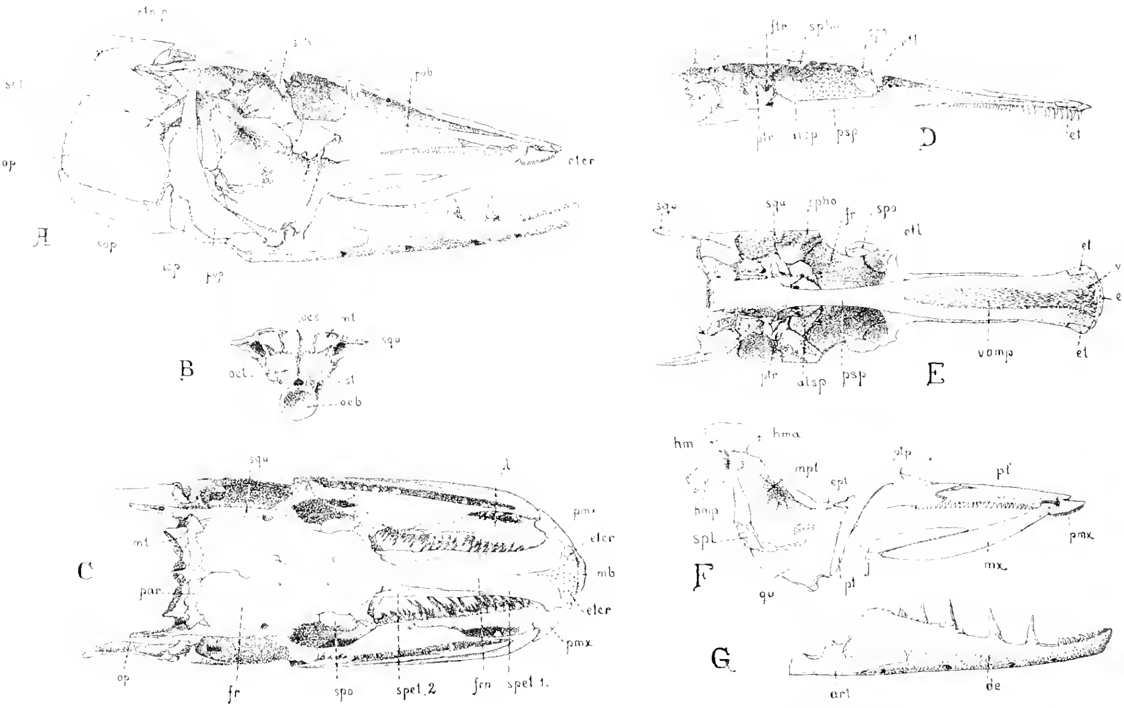

Fig. 253. Bones of the head in a Pike. 1/2 the natural size. *A*, from the right; *B*, the skull, seen from behind; *C*, the head, seen from above; *D*, the skull, seen from the right; *E*, the skull, seen from below; *F*, the upper jaw, palate, and suspensory apparatus of the lower jaw, right side, seen from without; *G*, the lower jaw.

alsp, alisphenoid; *art*, articular part of the lower jaw; *de*, dental part of the lower jaw; *ept*, entopterygoid; *et*, ethmoid; *eter*, tip of the cartilaginous part of the ethmoid; *etl*, lateral ethmoid; *fr*, frontal; *frn*, part of the frontal bones that projects above the ethmoidal cartilage; *ftr*, exit of the *nervus trigeminus*; *hm*, hyomandibular; *hma*, anterior articular process of the hyomandibular; *hmp*, hyomandibular articular process, with the end of which the operculum articulates; *iop*, interoperculum; *j*, supplementary (jugal) bone of the maxillary; *mb*, tip of the lower jaw; *mpt*, metapterygoid; *mt*, mastoid; *mx*, maxillary; *ocb*, basilar part of the occipital; *ocl*, lateral part of the occipital; *ocs*, squamosal part of the occipital; *op*, operculum; *par*, parietal; *pl*, palatine; *pmx*, intermaxillary; *pob*, preorbital, the foremost bone in the suborbital ring; *pop*, preoperculum; *psp*, parasphenoid; *pt*, pterygoid; *ptmp*, post-temporal; *ptp*, ascending process of the pterygoid; *ptr*, petrosal; *qu*, quadrate; *scl*, supraclavicula; *sob*, hindmost (fifth) bone in the suborbital ring; *sop*, suboperculum; *spet* 1 and 2, supraethmoids; *spho*, postfrontal bone; *spl*, *os symplecticum*; *spo*, supraorbital; *squ*, squamosal part of the temporal bone; *st*, styloid (*opisthoticum*); *vom*, head of the vomer; *vomp*, shaft of the vomer.

its two halves are joined in front (*mb*), at the symphysis, merely by cartilage instead of the ordinary firm suture.

The long maxillaries (*mx*), which are somewhat curved and twisted, are toothless, and the single or sometimes (in front) double row of intermaxillary teeth are not very large; but all the greater is the size of the teeth on the head (*vom*) of the vomer, in the inner rows on the palatines (*pl*), and, above all, in the lower jaw (*de*). In the long, posteriorly pointed patch of teeth that occupies the shaft (*vomp*) of the vomer, extending back to a line with the nasal cavities, the dense teeth decrease in size behind, a diminution which also appears, both outwards and backwards, in the somewhat broader card of palatine teeth, which extends a little further back than the vomerine card. The mandibular teeth of young Pike are set throughout in one row; in large Pike there are two rows at the extreme front, both being incurved (recurved) nearest to the symphysis, but only one row throughout the rest of the jaw margin. The front teeth are comparatively small, about twice as large as the intermaxillary teeth; but the size increases backwards, while the teeth become more scattered, the posterior two-thirds of the jaw margin being armed with only about 6 large canines. Among these canines the middle ones are the largest, being of so considerable a size that in Pike 9 dm. long the largest mandibular tooth measures together with its base 19 mm. and above the gum 14 mm. The tongue is cartilaginous, somewhat broader in front, but incised at the truncate tip. The hind part of its lingual bone and the three copular bones (the first and largest of which is formed by the coalescence of two), are set with dense cards of small teeth. The roof of the pharynx is armed with two pairs of cards, on the upper pharyngeals, containing teeth about equal in size to the foremost in the lower jaw, the anterior cards pointed in front, and both cards together of about the same size and form as either of the two cards on the lower pharyngeals. The last-mentioned bones are slender (resembling branchial arches), but furnished on the posterior inward side with an elevated, flat process, over which the card of teeth extends, being thus raised free above the hind part of the pharyngeal itself. All the bones already enumerated in the mouth and pharynx may be dentigerous in most of the Teleosts; but in the Pike we further find that the gill-rakers, on the front of the branchial arches, are transformed into dense cards of teeth, divided into quadrilateral or rounded (verrucose) groups, and containing teeth about equal in size to the intermaxillary ones. The number of the teeth is thus augmented so considerably that KRØYER succeeded in counting "certainly more than three thousand teeth" in the mouth and pharynx of a Pike. All the teeth are ophidian in type, pointed, for the most part curved, rigid in an outward direction, flexible towards the interior of the mouth, with the tip directed inwards and backwards, thus affording a ready ingress to the prey, but preventing its egress. Exceptional in form are the straight small teeth on the branchial arches, and the largest canines in the lower jaw, which are also straight, but dagger-shaped and two-edged.

The number of the branchiostegal rays varies between 13 and 16, being not unfrequently different on either side. All of them are sabre-curved, the posterior sharp, the anterior rather more terete. The anterior (lower) 6 or 7 are set on the ceratohyoid bone, and are somewhat separated from the posterior (usually 8), which belong to the epihyoid. The branchiostegal membranes are free and separate underneath to the root of the tongue, where they are attached, the very extremities crossing each other. This arrangement further contributes to the distensibility of the pharynx.

The top of the head is flat, with a concavity between the eyes. These are large[a], oval[b], rather far apart[c], and set high, about half-way along the head[d]. Above their anterior part projects a semi-elliptical or rounded quadrilateral bone (fig. 253, *spo*) that calls to mind the superciliary shield in birds of prey, and gives the Pike a similar fierce and savage look. The nasal cavities are large, and lie just in front of the eyes, each containing two apertures, the anterior round, the posterior furnished with a rounded dermal lid, originating from the fairly broad ridge of skin between them.

[a] The longitudinal diameter of the eyes measures in the young about $^1/_6$, in Pike 4—5 dm. long about $^1/_8$—$^1/_9$, of the length of the head.

[b] The vertical diameter of the eyes is about 80—85 % of the longitudinal.

[c] The interorbital width at the middle of the eyes is about $^1/_5$ (19—21 %) of the length of the head.

[d] The length of the snout is about 42 (sometimes 40)—45 %, and the posterbital length about 43 (in the fry 37)—46 %, of the length of the head.

The cephalic system of the lateral line has very distinct and deep pores in the thick skin. In each fronto-rostral branch there usually appear 4 pores along the forehead and snout; in the suborbital branch (fig. 253, *sob—pob*) 9 or 10 in a row surrounding the lower part of the eye and advancing along the snout to a point just in front of the nostrils; in the mandibular branch 5 pores on the under surface of the lower jaw (*de*) and 6 at the preopercular margin. The occiput is crossed on each side by a serpentine groove (the supraorbital branch, cf. above, fig. 104, p. 368), ending at the outer extremity in a similar pore, from which a row containing 3 or 4 pores runs back, along the temple, to the upper angle of the gill-opening. The body is covered with soft, middle-sized, and imbricated scales (fig. 254), each enclosed in a thin follicle and naked only at the tip, which appears in a small, angular opening, usually of a distinctive colour. In shape they are rounded and oblong, or (on the belly) more or less pointed behind; and they are most distinguished by the cleavage of the anterior (inserted) part into three or four lobes. The lateral line is straight, and runs somewhat nearer to the back than to the belly. It is marked by scales incised at the tip, but is interrupted here and there by scales with entire tip. On each side of the lateral line, especially on the tail, there are scale-rows similar in the structure of the scales to the lateral line, but varying in number, extent, and position. At the outer angles of the ventral fins the usual scale-flap[a] is wanting.

The anal aperture, which is large, lies so near to the caudal fin that its distance therefrom is only $\frac{1}{3}$ of the length of the abdomen, measured from the anterior (lower) end of the shoulder-girdle.

Among the seven fins the vertical, which are situated on the tail, are most developed, forming the propeller by the aid of which the Pike darts like an arrow on its prey. The dorsal fin is high and rounded. It begins vertically above the vent, at a distance from the tip of the snout measuring 67—69 % of the length of the body, and terminates above the end of the anal fin. Its base measures about $11\frac{1}{2}$—$13\frac{1}{2}$ %[b], and its longest ray about $10\frac{1}{2}$—$11\frac{1}{2}$ %[c], of the length of the body. The anal fin is similar to the dorsal, but shorter, usually almost as high as it is long. Its distance from the tip of the snout is about 71—74 %[d], its base about $10\frac{1}{2}$—$9\frac{1}{2}$ %, and its height about 10—11 %, of the length of the body. The caudal fin is slightly forked. The middle rays, which occupy about 6—7 % of the length of the body, are about half as long as the longest rays in the fin.

A. *B.* *C.*

Fig. 254. Scales of the Pike. × 2. *A*, from the anterior part of the body, above the lateral line; *B*, from the lateral line; *C*, from the ventral side.

The pectoral fins are obliquely rounded and set low. Their length in adult Pike is about 10—13 % of that of the body. The ventral fins are of about the same size. They are situated half-way along the body, and the preabdominal length is about $\frac{1}{4}$ (in gravid females as much as $\frac{3}{10}$), the postabdominal about $\frac{1}{5}$ (in gravid females somewhat more), of the length of the body. Without any examination of the internal organs, the sex may be determined by the fins, which are generally larger and more rounded, with thicker rays, in the male than in the female. The length of the pectoral fins, in particular, is somewhat more in the male, less in the female, than half of the preabdominal length.

[a] Cf. above, on the Loaches (p. 709 and note *d*) and on the Minnow (p. 756).

[b] In the fry about 36—38 %, in Pike 4—5 dm. long about 44—47 %, of the length of the head.

[c] In the fry about 34—38 %, in Pike 4—5 dm. long about 38—43 %, of the length of the head.

[d] In the fry about $\frac{2}{3}$; in the males commonly less than in the females.

The coloration of the Pike is black above, white below. The sides are grayish green, with transverse bands of greenish yellow, more continuous in the young, broken up in old Pike into almost round or oval spots, sometimes elongated, like a ribbon, in the longitudinal direction of the body. The ground-colour of the fins is grayish yellow, waved with a darker tint. The anterior margins of the ventral and anal fins and the inferior lobe of the caudal are of a purer yellow. The iris is yellow, with a dark, grayish brown spot both in front of and behind the pupil. From the eye two sinuous, greenish yellow stripes run to the hind margin of the operculum, and some irregular spots of the same colour appear on the lower part of the said bone. The snout has an elongated, triangular patch, coursed by a longitudinal black stripe, on the sides in front of the eyes. On the sides of the body the scales, as we have mentioned above, have a naked, crescent-shaped or angular spot, with the angle pointing forwards, and of a metallic lustre, with a dash of yellow or white. The ordinary dress of the fish, as described above, shows variations dependent on age, the fluctuations in the supply of food, and the nature of the surrounding water. Old specimens have a purer, more defined coloration. The Pike that live in turbid water are always darker than those that inhabit clear lakes or streams; and in small lakes with dark water almost black specimens have been found. In the inner island-belt of the Baltic small Pike are taken at the beginning of winter which have a dark lemon-yellow coloration instead of the white tone. The islanders believe that these Pike have just arrived from the outer islands or the sea outside, and have therefore conferred upon them the name of *Nyländare* (new-comers).

On an examination of the internal organs the liver is found to consist of a single lobe, long, obtuse, and arched, which lies principally on the left side of the body, and extends back to a point just short of the insertions of the ventral fins. On the concave upper surface of the liver, at the extreme front, but to the right, lies the gall-bladder. The intestinal canal is simple. When the stomach is empty, it apparently composes together with the œsophagus a tube of almost uniform width, extending to about a line with the beginning of the last third of the ventral fins when folded. At this point it bends abruptly, and with a slight constriction at the pylorus is continued in a forward direction by the intestine, which advances below its right side to the gall-bladder, and bends there with equal abruptness, to return in a straight line to the vent. The spleen is triangular, and lies close to the termination of the stomach. The gall-duct is long, and enters the intestine at some distance below the pylorus. The air-bladder is long, almost cylindrical, and is connected with the œsophagus by a short and narrow duct from its anterior extremity. The testes and ovaries are long, and follow the direction of the abdominal cavity. The kidneys, which lie above the air-bladder along each side of the spinal column, are dark red. The urinary bladder is thin, cylindrical, and rather long, and shares with the sexual organs a special aperture behind the orifice of the intestine.

The Pike has a very extensive geographical range — about the same as the Minnow's (see above, p. 757) — from North-eastern Siberia west to the east of North America. According to PALLAS it inhabits the River Amoor[a], which falls into the Sea of Okhotsk, and the Rivers Indigirka and Chatanga, which disembogue into the Arctic Ocean. BREHM found it in the lower course of the River Obi[b], and in the great lakes of the Baraba Steppe (the upper basin of the Obi and Irtish) it is extremely common, according to PALLAS, and attains a considerable size. It also occurs in the Caspian Sea, but not in Transcaucasia, nor in the Black Sea, though it is found in the Sea of Azov and the basin of the Danube. It is met with in rivers and lakes throughout Russia, North and Central Europe, including Great Britain and Ireland, and Italy, including Sicily (CANESTRINI); but is said to be wanting in Greece and on the Pyrenean Peninsula. It inhabits almost all the waters of Scandinavia; but in Norway COLLETT has observed that its range, like that of the Perch and several other fresh-water fishes, is interrupted, the gap extending over the Province of Trondhjem, Nordland, and the whole west coast. Though really belonging to lakes and rivers with fresh water, it is also found in the island-belt of the Baltic. That salt water is not its true home, appears from the fact that among the said islands the Pike shows a de-

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[a] Assuming that PALLAS here refers to our common Pike. From the Onon, a Daurian tributary of the Amoor, he describes a "variety" of a coloration more suggestive of the American *Esox nobilior*.

On the Kamchatkan Peninsula, according to PALLAS, the Pike is wanting.

[b] BREHM's *Thierleben*, 2:te Aufl., Gr. Ausg. (1879), Bd. 8, p. 249.

crease both in size and numbers the nearer it approaches to the open sea, at last disappearing entirely. It ascends to a great altitude among the mountains; but in Switzerland, according to FATIO, stops short at a height of 700—800 m. above the level of the sea, though it has been planted with success 1,100 m. or even 1,400 m. above the sea-level. In Tornea Lappmark it inhabits the alpine lakes above the birch-region; in Jemtland, according to OLSSON, it ascends to lakes at least 650 m., perhaps 740 m. above the level of the sea. In its American range too, the Pike is common from the Arctic regions (RICHARDSON) south to Ohio; but it is not included in BEAN's list of the fishes of Alaska. From Greenland and Iceland it is unknown.

The Pike chooses its spring and summer haunts by preference in shallow inlets with a weedy bottom and shores overgrown with reeds and rushes. Towards autumn it betakes itself to precipitous, stony shores, which it again forsakes when the winter is at hand, and the inlets freeze. Most of the Pike then return to their summer stations; but the larger ones seemingly follow the shoals of other fishes to the depths, being seldom caught during winter in shallow water. To these a more plentiful supply of food is, no doubt, necessary than the shallows afford in winter-time.

When the Pike has chosen its station for the season, it restricts its wanderings to the immediate neighbourhood, leading a solitary life, and never seen in company except during the spawning. Its attachment to one spot may be gathered from a circumstance related to us on trustworthy authority. A Pike that had taken a trolling-hook and escaped was recaptured after several years in a seine at the same place, and the hook was found in its stomach.

The Pike is undoubtedly the most voracious among the fresh-water fishes of Scandinavia. It devours indiscriminately other fishes, young waterfowl, small mammals, and carrion. From the dense bed of grass or rushes where it usually passes the day in stationary watch, it pounces with the speed of an arrow on its unwary victim. It almost always seizes its prey crosswise, and retains its hold until the latter is dead or so exhausted as to desist from all struggles. Then the Pike turns the prize in its jaws till the head points towards the interior of its mouth, and commences its meal. This operation is a protracted one when the victim is large, for the end first swallowed and received in the stomach must digest to make room for the remainder. Mr. C. FR. WÆRN has kindly communicated the following observation in point: "I have kept Pike together with a Salmon in a pond fed with running water. The former were usually stationary, the latter kept constantly on the move. On one occasion I saw a Pike of 7 or 8 lbs. weight dart forward and seize the Salmon, which was quite as large, in its formidable jaws right across the body. The combat was fierce. The Salmon leapt out of the water and made desperate, but fruitless struggles to shake off its relentless captor. In a couple of hours' time the Salmon was utterly exhausted, and the Pike began to swallow it head first. The meal lasted three days before the whole body had disappeared. The process of digestion must have taken much longer, for all the following week the Pike had a very swollen appearance, and could hardly be induced to move by touching it with a long stick." This voracity grows to ravenous and insatiate hunger, and blood-thirsty tendencies are inherent in the Pike from its earliest youth. Baron C. J. CEDERSTRÖM relates[a] from his experiments in pisciculture that on the 17th of June he had four small Pike, two of them measuring about 26 mm., the other two about 20 mm., living together in a bowl of water. They had been fed with small Ide-fry, the larvae of gnats, and water-fleas (*Daphnia*). In darkness they ate nothing, their rapacity was excited only by the moving objects appreciable to their sight. During the night their bowl had been covered with a lid. When he removed the lid at 5 a. m., they were to be seen all four; but when he returned a quarter of an hour later, one of the larger pair had begun to devour one of its smaller comrades. Half of the victim's body still stuck out of the other's mouth, and moved for some moments, while the stomach of the latter was monstrously distorted and distended. Soon afterwards he observed how the other pair kept a jealous watch on one another. The larger of them soon made an assault, but was foiled, the smaller escaping by a dexterous movement, yet without fleeing to any distance. But the second attack was rewarded with complete success, and the two victors now swam about, glutted

[a] In SUNDEVALL, Öfvers., l. c.

with prey. After two hours had elapsed, the tails of the victims had disappeared into the maws of their devourers.

The strength of the Pike is fully proportionate to its size and voracity. We have just seen that a Pike can come off victoriously from a battle with a Salmon of its own size; but EKSTRÖM adduces[a] a more singular proof of its powers. In the back of a Pike that did not weigh more than $8^1/_2$ kilo., he found the skeleton of an osprey (*Pandion haliaetus*), which had rashly attacked the fish, but been drawn into the depths and drowned. Similar tales are told of sea eagles that have perished in the attempt to capture and carry off the Pike.

Though not very tenacious of life, the Pike may be kept alive for a long time in a well, especially if it has some smaller fish to prey on, for it retains its rapaciousness even in captivity. In contradistinction to other fishes, it continues to feed during the spawning-season. On the 9th of June, 1893, we purchased in Stockholm a gravid female $4^1/_2$ dm. long strongly distended[b] by the ovaries, which were quite ripe, and voided the eggs at the least pressure. In the stomach, however, lay a Roach 12 cm. long, only the head of which had digested.

The spawning is of long duration, its season depending on the age of the fish. The young spawn first. When they have finished, the middle-aged Pike begin, and last of all the oldest and largest. In spring, before there is open water in the lakes, the Pike commences to ascend towards the shores. A tradition, handed down among the fishermen of Central Sweden from time immemorial and still surviving, states that on St. Gregory's Day (March 12th) the Pike turns its head towards the shore, and on St. Gertrude's Day (March 17th) begins its ascent. It repairs to those parts of the shore where streams and brooks fall into the inlets, rendering them in the Swedish fisherman's parlance *landlösa* (*landless*). The Pike that arrive first are known as *Gertrude's* or *Ice Pike*. A great portion of the roe they deposit is probably destroyed, for it is often committed to the open lake, where it is exposed to so many dangers. When the spring is so far advanced that the lakes are ice-free, the brooks clear, and the low-lying meadows round the shore under water, the larger Pike make their way to these inundated places, and begin to spawn. As this generally coincides with the pairing-time of the frog, the Pike that breed at this season are called *Frö-gäddor* or *Gloss-gäddor*, from *Kallfrö* and *Glossa*, names applied by the peasantry to the frog (*Rana temporaria*). They are also known as *Gräs-gäddor* (Grass Pike) and *Ängs-gäddor* (Meadow Pike), from the nature of their spawning-place. Last of all come the largest Pike. These usually begin to breed at the end of May, when the trees are in leaf, and several flowers in bloom; and are hence called *Löf-gäddor* (Leaf Pike) or *Blomster-gäddor* (Flower Pike). They are few in number, like the Ice Pike, and spawn in water of some depth within weedy inlets. The earliest Pike, which are often of a brassy yellow colour, also bear the name of *Messings-gäddor* (Brass Pike). The somewhat older fish are known, on account of their slender form, as *Langstjert-gäddor* (Long-tailed Pike), and the oldest, with their thicker body, as *Kortstjert-gäddor* (Short-tailed Pike).

The further north the Pike has its home, the later is the spawning-season. In the Tornea Elf the Pike does not breed until the middle of June. The *Frö-gädda* or *Gräs-gädda* always spawns in shallow water; and as the breeding fish are neither timid nor massed in numbers at the same place, they may be closely observed. The females, which are always largest, come first, each attended by two or three, seldom four males. The female swims so high in the shallow water that, when the weather is calm, the surface is faintly rippled by her movements. Now and then the dorsal and caudal fins may be seen above the surface. As soon as the female halts, the males approach and surround her, one on each side, and, if there are more than two, one under the tail and another above the back. They rub themselves against her body, during which operation she keeps still, only moving the fins. After a while she disperses the males with a sudden lash of her body, and darts to another point, where the same operation is renewed. Meanwhile she deposits on the grassy bottom the yellowish and coarse-grained roe, which is impregnated by the milt. In a Pike weighing 6 German pounds ($2^1/_2$ kilo.) BLOCH counted 136,500 ova; in a female weighing 28 lbs. avoirdupois (12·7 kilo.), and with ovaries

[a] Vet.-Akad. Handl. 1831, p. 79.

[b] The greatest depth 21 % of the length of the body.

weighing 21 oz. (607 grammes), BUCKLAND[a] found 292,320 eggs, and in another weighing 32 lbs. ($14\frac{1}{2}$ kilo.), and with ovaries weighing 5 lbs. ($2\frac{1}{4}$ kilo.), 595,200. The Pike is thus fairly prolific, but its fecundity is not above the average, as compared with that of other fishes. The eggs, which are at first rather adhesive, lie free on the bottom, and in spring (April) require about three weeks to hatch.

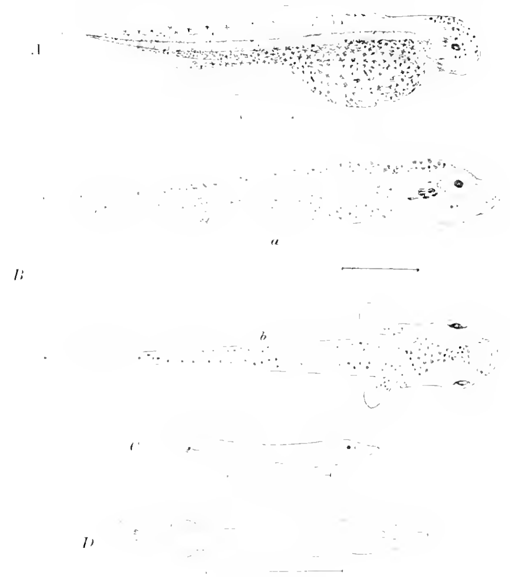


Fig. 255. *A*, young Pike 2 days old and hardly 10 mm. long. The vent has not yet divided the vertical embryonic fin. Pectoral fins rudimentary. No fin-rays. Immediately after hatching the larva is hardly 9 mm. long. *B*, young Pike 11 days old and 15 mm. long; *a*, from the side; *b*, from above. Vent open. Ventral fins have appeared about half-way along the embryonic fin in front of the vent. No fin-rays. Distinct teeth in the lower jaw. Opercula developed. *C*, young Pike 5 or 6 weeks old and 20 mm. long. Dorsal and anal fins begin to separate, before the rays are formed. In the caudal fin the base seems to develop first, the rays being rather short. *D*, young Pike 7 or 8 weeks old and 26 mm. long. Of the vertical embryonic fin only a small remnant to be seen under the caudal fin and another, very narrow, from the anal aperture to the ventral fins. All the fins, though thick and rigid, have the complete number of rays. In the ventral fins the rays are separated at the base. The upturned tip of the tail still lies, rather large, in the form of a compressed, membranous lobe, above the caudal fin, but is confluent therewith, and no longer shows increase in size. — SUNDEVALL.

Even in a larva 15 cm. long and between 6 and 7 months old (killed on November 10th and born of an artificial impregnation performed in April) the development of all the fins and the cleavage of the branched rays are not much further advanced than in Hemibranchs and Lophobranchs (see above), these rays being compressed, with remote articulations, and with short and imperfect, almost exclusively simple division.

"The new-hatched fry", writes SUNDEVALL, "are short and thick in shape, with rather large belly (fig. 255, *A*). The coloration is yellowish, but quite transparent, and densely punctated on the surface with black dots, a dark band running from the eye along the sides of the belly. In coloration, external form, and movement they have some resemblance to tadpoles; but some are much more sparsely punctated with black, and consequently of a lighter tone. At first the larva remains for the most part still, preferring to lie close to the surface beside plants or floating straws and the like, to which it seems, as it were, to hang, or else at the bottom in less than an inch of water. On being touched, it swims rapidly about, with hasty movements of the tail, but soon resumes its former position. In about 10 or 11 days (fig. 255, *B*) the yolk is absorbed, and the belly much reduced in size, but the head prolongated, with large mouth. It now begins at once to swim more steadily, in the same manner as its elders, and goes in quest of prey. It soon abandons the habit of lying at the bottom or resting alongside floating objects, repairs to somewhat deeper water, remaining for the most part stationary, as if on the watch for prey, and seizes small fishes and other aquatic animals of a size considerable enough in comparison with its own, but only those which it sees moving, just as older Pike . . . . The external form in which the specific characters of the Pike may be traced (fig. 255, *D*) seems to be fully developed at an age of nearly 2 months and a length of about a Swedish inch (25 mm.)." Subsequently the growth proceeds rapidly, as usual, at first, but with very considerable variations, depending on the different supply of food under circumstances favourable in other respects. According to some observations a one year old Pike is only 15 cm. long, according to others 30 cm. BLANCHÈRE states the growth as follows[b]:

		M. M.
Maximum length of the Pike at the age of	1 year	0·25—0·30
,, ,, ,, ,, ,, ,, ,, ,, ,,	2 years ...	0·36—0·42
,, ,, ,, ,, ,, ,, ,, ,, ,,	3 ,, ...	0·55—0·60
,, ,, ,, ,, ,, ,, ,, ,, ,,	6 ,, ...	1·00
,, ,, ,, ,, ,, ,, ,, ,, ,,	12 ,, ...	1·35.

[a] *Nat. Hist. Brit. Fish.*, p. 387.

[b] *Dictionn. Gén. Pêches*, p. 116.

How widely such computations may differ, appears from EKSTRÖM's observations. He found that Pike-fry 37—49 mm. long, kept in a spring with muddy bottom, only attained in 5 years the size of a common Herring; but that a specimen 15 cm. long, kept in another spring with smaller fish to feed on, attained in 5 years a length of 4 dm. The statements we possess of the Pike's duration of life — according to old accounts over 200 years — whatever may be their authenticity, only show that this fish may probably live to a very great age.

As a food-fish the Pike is of no small value. The flesh is white, firm, wholesome, and comparatively free from bones. Fresh Pike is by no means bad eating; and the flesh has an advantage over that of many other fishes: it may be kept for a long time, without deteriorating, in a salted or dried condition. The great havoc wrought by the Pike among other species of fish has given rise to proposals for its extermination, at least in small pieces of water. But the only result of such a procedure would be the increase in number of the smaller species to so great an extent that the supply of food would at length fall short, the development of the fish be arrested, and a great proportion of them die out.

Some stated peculiarities in the history of this species may lastly be adduced. The fishermen in general believe that at certain seasons of the year the Pike entirely abstains from food (*tager icke svalg* as the Swedish fishermen say), and at others is excessively voracious. These seasons are said to be periodical and regular in occurrence, the observant fisherman being able to predict the time when the Pike is *on its feed* (*i taget*), as it is called. But these periods are said not to occur at the same time year after year, and according to some observations they are determined by the spawning-season, for the period of voracity begins in the same change of the moon (waxing or wane) as the Pike finishes spawning. There is one exception, however, the Pike being always *on its feed* throughout the dog-days. This periodical voracity and moderation is said to depend on the circumstance that, when the Pike is *off its feed*, the gums are so swollen that the points of the teeth hardly project above the flesh, some tenderness of the gums being thus the curb of the Pike's usual rapacity. Perhaps we have here some observation of the manner in which the Pike casts its teeth, or we may find a more probable explanation in the fact that the fish requires some time to digest the great quantity of food which it devours during the period of voracity. Another singularity is that the Pike can disgorge its prey, a consequence of the structure and simplicity of the intestinal canal.

Most of the fishing methods employed for the Pike depend for their success on its rapacity. It is this quality too that entices the Pike to the spawning-places of most other fishes, where it finds prey in abundance, and is always on the alert. The Pike is consequently taken on many occasions in the tackle set for other spawning or schooling fishes. We may also assume that the Pike is caught with almost all kinds of fishing engines. We shall confine our attention, however, to those which are used in Sweden especially for Pike. Among them we find:

The *ryssja* (fig. 7, p. 33, above), in which Pike are taken principally during the spawning-season, when they ascend into inlets and channels, to low-lying, inundated meadows or marshland, and to grassy shores where the water is shallow.

Nets (ordinary gill-nets, Pike-nets, with a mesh of more than 25 mm.) may be employed all the year round, so long as there is open water, but are always unproductive tackle. When used for Pike, they are set in shallow, grassy inlets, and sometimes to close broader pieces of water and thus guide the Pike into *ryssjor* or similar traps.

The *trammel-net* (fig. 183, p. 741, above) is plied only in summer, and always with success off shores fringed with reeds and rushes, where the Pike usually takes its station on bright and warm summer days.

The *long-line* (*backa, gädd-ref*) is used from the end of May, when the Pike has finished spawning, till late in autumn. The warmest part of the summer is, however, an unfavourable season, partly because the high temperature of the water soon kills the bait, which should always be alive in this method of fishing (fig. 256), partly because the Pike then has an abundance of small fish to feed on. In early summer the lines should be set on grassy shores and round shallows and islets, some yards outside the edge of the reeds, but from September and during the rest of autumn in deep inlets, with stony or sandy shores thinly fringed with reeds.

The *angelkrok* (really *triangle-hook*, originally in the form of a triangle with one side open, fig. 257). The winter is the only season. The fisherman chooses his pitch in bays or creeks of no great depth, with

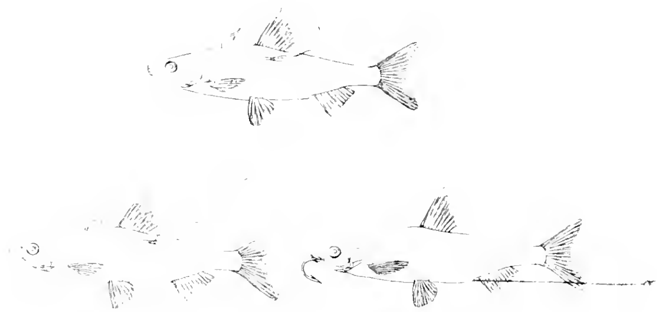


Fig. 256. Different methods of fastening live bait on the snood hooks of a Pike-line.

reedy shores, but else clear of weeds, so that the hooked fish cannot run the line foul. Though this fishing may be practised all the winter, it succeeds best and is attended with least difficulty early in the season, before the ice has attained any considerable thickness,

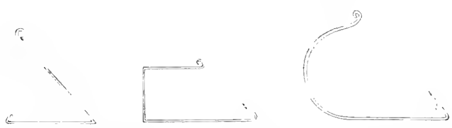


Fig. 257. Different forms of triangle-hook for Pike-fishing under the ice with live bait. The bait is attached by inserting the point of the hook in the fleshiest part of the back beside the spinal column and drawing it out in the direction of the head, so that, when the bait is left in the water, the hook keeps it in a natural position, and the point of the hook is directed backwards.

and after some snow has fallen, to render the ice less transparent and to give the fisherman a foothold.

The *stangkrok* (fig. 258), with the *stang* (a thick rod) obliquely thrust into the bottom, and with the line wound up, so that the Pike can run to its entire length until the fisherman comes to examine his tackle, may be used not only in summer, but also, with some modification of its setting, in winter. In all seasons

Fig. 258. *a* and *b*, the tops of two rods as used in *stangkrok* fishing (as much as should be visible above the water): *a*, with the line wound on a *bow* (hazel best); *b*, with the line wound on a forked stick (juniper best). *c*, bait fastened on the hook (see above, fig. 256), but also suspended from the line by a fine thread (attached to a pin stuck through its back), so as to keep it in an horizontal position. *d*, dead bait suspended in a triangle, where the line (the thick line in the figure) forms one side of the triangle, the hook and the bait form the base, and a fine thread, attached as in *c*, forms the third side.

the *stangkrok* is invariably set near the edge of the reeds, off rocks, promontories, and holms, in such inlets as the Pike is supposed to haunt.

The *klumpkrok* (fig. 259), with the rod of the preceding method replaced by a floating *klump* (a piece of timber 3 or 4 feet long), one end of which is anchored with a stone, the line, wound up on a *bow*,

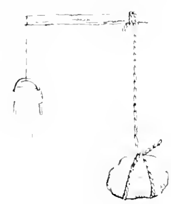


Fig. 259. *Klumpkrok*.

being suspended from the other end. Used at the same season as the *stangkrok* and at similar spots.

The *palkrok* (fig. 260), with one end of the line anchored by means of a stone but fastened at a distance from this point somewhat less than the depth of the water, by means of a running noose, in a notch at the end of a floating *påle* (a splinter of spruce-fir about 3 feet long), so that about a third of the splinter projects above the surface. Employed at the same season and in the same places as the *klumpkrok*, to which it has no slight resemblance.

Fig. 260. *Pålkrok.*

Trolling (Sw. *slant*), an old and well-known method of angling, the description of which would carry us too far, if we attempted to give every detail. IHRE derives the Swedish name from the Belgian *slonden* (to gorge). The rod and line are plied from a rowing-boat by one man, while another pushes the boat cautiously along the edge of a bed of reeds or in some other place supposed to be haunted by Pike. The line runs through a loop at the end of the rod, or is attached by a loop (*öska*) to a straight pin of wire fixed there, and can be let out or taken in at pleasure by means of a reel (*lekare*) fastened above the butt of the rod. The snood with the hook at its end is passed through the bait (a Roach, Bleak, Crucian Carp, or other Cyprinoid with bright scales) from the mouth to the end of the tail. The hook is shanked with lead, has one or two prongs (fig. 261, *d—f*), and should be barbless, the prongs being left to project backwards from the mouth of the bait. The snood is lashed with thread to the tail of the bait, and all the fins are then cut off, to prevent the bait from running foul of the grass or weeds that grow at the bottom or in mid-water without reaching the surface, in which case they may be avoided by the angler. Lastly the snood — a suitable violin-string (silver-string) is best — is fastened with a peculiar kind of knot (fig. 261, *g*), tied in the loop at the end of the line. Now the *trolling* begins: the bait is dropped where the fisherman hopes to find a Pike, but soon drawn up again, so as to keep it bobbing up and down. This motion entices the Pike to seize the bait, which the angler easily perceives by the check. As soon as the Pike has taken the bait, the fisherman instantly jerks back the rod sufficiently to allow the loop to slip off the pin at the end of the rod. The line is now free, and is let out until the Pike stops, when the boat is kept stationary, either by heading it towards the reeds and holding it fast, or by thrusting the butt of the rod into the bottom of the lake. The fisherman now waits a while, at most 15—20 minutes, for the Pike to pouch, when it again begins to move: and now is the time to haul in both line and fish. Trolling may be practised with success from spring, after the close of the spawning-season, till late in autumn, though it should be observed that cloudy weather and a light breeze are more favourable than calm, fine days, on which the fisherman is seldom rewarded. The fishing-place is chosen during summer in grassy and shallow inlets, during autumn off stony shores and in deep water.

Springkrok (fig. 262) is a modification of the preceding kind of fishing, and is conducted most commonly at times when the fisherman suspects that the Pike is off its feed. The place should be the same as in trolling.

Fig. 261. *a*, reel (*lekare*); *b* and *c*, baiting-needles of different form (7 or 8 in. long, of wood or brass), in which the snood is wedged when it is to be passed through the bait; *d—f*, gorge-hooks of different form; *g*, lower part of the loop at the end of the line and the upper end of the snood, showing how the knot between them is tied.

Fig. 262. *Springkrok*, hollow, with the elastic arms held back by their pressure against the sides of the tube, as in *a*, or drawn out, as in *b*.

Drag (spinning), also called *Dragspan*, *Oppror*, *Bottenror*, etc., is a well-known kind of angling. A deceptive hook (fig. 263), or a range of hooks on a bright metal bait imitating a fish, is towed with a long line, which can be wound in on a reel (fig. 261, *a*), after a boat rowed at an even and rather rapid pace. The fisherman's object is to attract the attention of the Pike in the same parts of the water as when trolling; but in this case he can manage without assistance if he holds the line between his teeth. Spinning is practised

Fig. 263. Spinning-bait for Pike.

throughout the summer and autumn, but the best season is from the middle of August till the end of September.

Spearing by torchlight (*eldstödjning*) is perhaps one of the oldest kinds of fishing, and has advantages as being one of the least expensive. The method of using the light we have seen in the Stickleback-fishery (see above, p. 657, fig. 164); but when spearing Pike, the fisherman must find out the spot where the fish is standing, and when he strikes with the leister (*ljuster*, fig. 264), he must aim the blow at the head of the fish, in case it should take to flight. Spearing is practised in spring and autumn, when the nights are dark, and off shores with shallow and clear water.

Fish may also be speared in broad daylight. This kind of fishing is called *ljustring* (leistering), and is most often employed for Salmon on their upward journey, but also for Pike when they are spawning on inundated meadow-land. The fisherman always goes alone, and either stands on the shore or wades, with his creel on his back to receive the speared fish. But

Fig. 264. Salmon and Pike spear, with the lower part of the shaft.

as the fish are more difficult of approach in the daytime, he must be skilled in the special art of hurling the spear at his quarry.

Spearing by torchlight is now less in vogue than formerly: more effective methods of fishing have been invented, and men of the craft have learnt by experience that it frightens the fish from shore, and thus harms the fishery.

We should mention one more way of catching Pike, though it can never be rewarded with any great success. When the Pike is spawning or standing among grass where it thinks itself hidden from sight, it may be captured by cautiously passing a noose of copper wire, attached to a stick, over its head until the noose is past the gill-openings, when the fish should be pulled up at once.

(Ekström, Smitt).

ENCHELYMORPHI.[a]

Shoulder-girdle detached above from the head and suspended at the sides of the spinal column behind it. No præcoracoideum. Anterior vertebræ normal; air-bladder destitute of osseous connexion with the auditory apparatus. Opercular apparatus complete; but the hyomandibular arch without symplecticum. Palatine arch and maxillary arch incomplete. Ventral fins none.

Regarded either from a biological or a morphological point of view the Enchelymorph series is one of the most remarkable among fishes. The life of the Eels, especially their sexual life, though studied for thousands of years, was shrouded in a veil of mystery to a time within the memory of man; and the morphological elucidation of their structure shows the Teleosteous type in a singular simplicity, whether this should be explained as a primordial condition or as a retrogression in the direction of older types.

The suspension of the shoulder-girdle in our common Eel has a certain resemblance to the analogous arrangement in the Rays and Sharks, though the suspensory bones do not correspond. The posttemporal bone as well as the postclavicular is wanting, the girdle itself consisting on each side only of the clavicle and supraclavicle. The latter of these (fig. 265, *scl*), with its flattened, more or less distinctly forked top, hangs loose, embedded in the outermost layer of the dorsal half of the great lateral muscle, but the clavicle (fig. 265, *cl*), which retains its ordinary relation to this muscle, is attached by means of an horizontal tendon (a part of the aponeurosis between the dorsal and ventral halves of the lateral muscle) to the sides of the fifth and sixth abdominal vertebrae[b]. The shoulder-girdle is similarly suspended, behind the head, in the said cartilaginous fishes; but an essential difference consists in the absence of both clavicle and supraclavicle in the last-mentioned forms, the suprascapular part (the upper parts of the primordial shoulder-girdle) being attached to the upper side of the spinal column. In the Eel this resemblance to the cartilaginous fishes is consequently of a secondary origin, probably connected with the great development of the branchial cavity, which has forced the shoulder-girdle backwards, loosening its attachment to the cranium, and causing the disappearance of the posttemporal bone. The girdle is

Fig. 265. Half of the shoulder-girdle in *Anguilla vulgaris*, seen from in front, $^3/_2$ times the natural size. *scl*, left supraclavicle; *cl*, left clavicle; *sc*, left scapula; *co*, left coracoid; *b*, brachial bones of the left pectoral fin.

completed below by the ligamentous connexion between the two clavicles, which are curved at an obtuse angle; and this lower part of the girdle is joined by a long muscle to the short urohyoid bone (fig. 268, *A* and fig. 271, *B* and *C*, *uh*), which is directed backwards,

[a] Gr. ἔγχελυς, *eel*, and μορφή, *form*.

[b] In our Conger the shoulder-girdle is suspended in the same manner and at the same point, but still more superficially, with the upper parts nearer to the skin. The posttemporal bone is thus wanting there as well; but a row of cartilaginous ducts, belonging to the lateral line, runs under the skin from the head (the temples) to the supraclavicle.

[c] In our Conger the urohyoid bone is longer, but preserves the ordinary Teleosteous type, being flattened only at the base, where it articulates with the basihyoid bones (coalescent, as in the common Eel, with the ceratohyoids), and furnished with a raised median keel on its upper surface. Its posterior extremity is more or less deeply divided into three spinous points (fig. 282, p. 1036).

and has the form of a flattened cone. High up on the superior arms of the clavicles are attached the scapular disks. These are thin and in great part cartilaginous, each consisting of a circular scapular part (fig. 265, *sc*), with an angular incision above and a small, round hole (scapular fenestra) below, and a semicircular coracoid part (fig. 265, *cr*), both of them fitted into the membrano-cartilaginous disk. A scapular disk as simple as this belongs to the earliest stages of development in other Teleosts; but a manifest relic of the morphological alliance with more primitive piscine types appears in the great number of supporting bones (brachial bones — fig. 265, *b*) possessed by the pectoral fins of the Eels. In almost all[a] the preceding Teleosts the number has been 4; in our common Eel it is 7 or 8. *Amia*, a Ganoid genus, has the same number; and *Polypterus*, another Ganoid genus, has 13—17 brachial bones. These Ganoids have besides retained one or more bones belonging to the innermost (proximal) row of the primordial cartilage (GEGENBAUR's pterygium) of the pectoral fins, which has entirely disappeared in the Teleosts. During the evolution of the Teleost type the basal parts of the pectoral fins have thus suffered reduction[b]; and the Eels are most nearly approximated in this respect to the primitive forms. The loss of the ventral fins, on the other hand, as we have seen in many of the preceding Teleosts, is, here too, secondary in its significance; and in foreign Eels the pectoral fins may share the same fate[c].

The skeleton of an adult Eel is firmly ossified, and characterised by its numerous vertebræ — generally more than 100, sometimes about 160 — of almost uniform shape and with feebly developed appendages. In our common Eel the anterior vertebræ, to the seventh inclusive, have their shallow but long, almost contiguous neural spines broken up into several (as many as 9) spicules[d]. The said vertebræ are furnished both with upper[e] and lower[f] transverse processes. The former are alary spines, directed backwards and of fairly uniform strength, which are, however, exchanged on the seventh and following vertebræ for scleral bones, directed backwards and upwards in the dorsal half of the great lateral muscle (fig. 266, *na*). The lower transverse processes (*ptra*) of the first vertebra are only small, pointed protuberances. On the following vertebræ they grow broader, but from the seventh vertebra inclusive they become pointed spines, directed outwards, backwards, and downwards, and bearing at the tips short and weak ribs (*pl*), which in their turn give place towards the

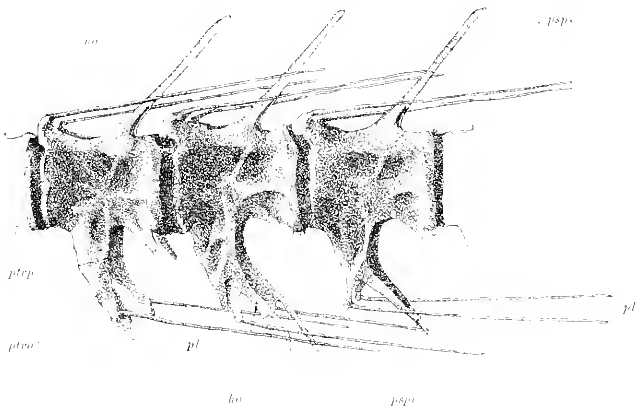


Fig. 266. Three abdominal vertebræ (44—46) in *Anguilla vulgaris*, seen from the left and magnified.
na, scleral bone (epineural, cf. fig. 236, p. 917); *psps*, upper spinous process; *ptrp*, lower posterior transverse process (*processus transversus posterior*); *ptra*, lower anterior transverse process; *ha*, hæmal arch; *pspi*, lower spinous process (*processus spinosus inferior*); *pl*, ribs.

[a] For exceptions see the Batrachoids (p. 133, above) and the Lophioids (p. 136). *Ostracion*, a Plectognate, has 5 basal bones.

[b] Cf. SMITT, *Ur de högre djurens utvecklingshistoria*, pp. 222 seqq.

[c] Cf. the Lophobranchs, see above, pp. 667 seqq.

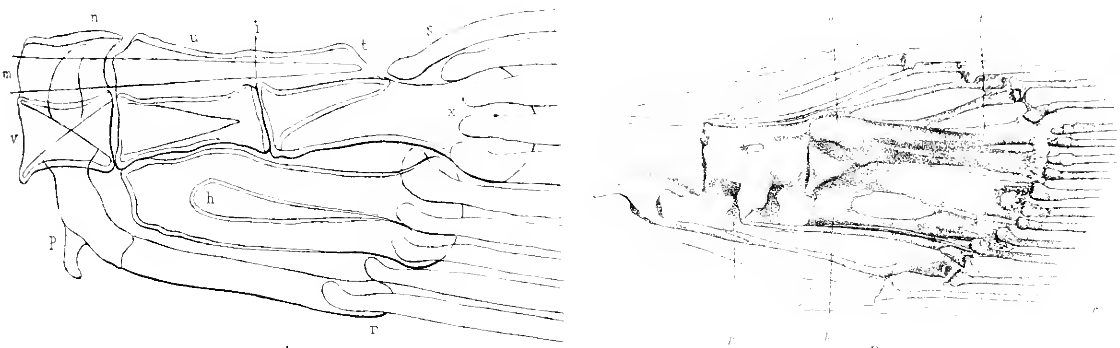
[d] In the Conger this division is restricted to the formation of lateral grooves on the neural spines, but is perceptible in this form even in the 13th vertebra.

[e] Diapophyses.

[f] Parapophyses.

tail to scleral bones in the ventral half of the lateral muscle. Throughout the greater part of the abdominal region, from the 8th vertebra to the 44th inclusive, we find in the common Eel another pair of lower transverse processes (parapophyses, *ptrp*), behind the last-mentioned processes and always smaller than these. On the 45th vertebra, or sometimes on the 44th, this posterior transverse process on each side of the bone disappears, or is at least reduced more perceptibly than before; but the anterior transverse process divides instead into two (three) branches, the anterior (outer) supporting the rib, the posterior (*ha*), which is simple or double, curving inwards. On the 46th vertebra this posterior branch springing from one side of the vertebra joins the corresponding branch of the other side, to form (an inner) transverse process, the former continued by a row of transverse processes at the middle of the sides of the caudal vertebrae (which row is wanting in the common Eel), the latter by the row which curves downwards and inwards to form the haemal canal of the caudal region. The skeleton of the Eel, for all its simplicity, thus shows with the greatest distinctness how the vertebral appendages may be homologous in the lower grades of differentiation, although, when the differentiation is more advanced, they are different both in origin and functions.

The tip of the tail presents the appearance of a rather primitive (diphycercal) structure. Only the outermost (last) two vertebrae — the outermost of which is composed, at least in our common Eel, of two prim-



A B

Fig. 267. Skeletal parts of the tip of the tail in *Anguilla vulgaris*, seen from the left side and magnified. *A*: from a young Eel (Elver, Fr. *Civelle*), after ROBIN; *B*: from a full-grown Eel.

v, vertebra, originally the antepenultimate, subsequently the penultimate; *p*, its haemal arch; *n*, its neural arch; *m*, its spinal canal; *u*, originally penultimate vertebra, afterwards confluent with the last vertebra; *l*, primordial articulation between these vertebrae; *h*, hindmost haemal arches, surrounding the cavity of the lymph-heart; *t*, termination of the spinal canal; *r*, lowest, *s*, uppermost ray of the caudal fin; *x*, posterior expansion of the urostyle.

the closed haemal arch and its haemal spine (*pspi*). In the Conger the said posterior parapophysis appears only on a few vertebrae in the hindmost part of the abdominal region, and even there is not always present, or is sometimes developed only on one side of the vertebrae. But the parapophyses of the abdominal vertebrae are broad, as in the Codfishes, and pierced at the base[a]; and in the last 9 or 10 abdominal vertebrae the anterior parapophysis divides into an upper (outer) and a lower ordial vertebrae — enter into the structure of the apparatus supporting the caudal fin. Although the vertical fins of the Eels are, as a rule[b], so confluent that no separate caudal fin can be distinguished externally, the presence of such a fin is indicated internally by the circumstance that the hindmost fin-rays — 10, both in our common Eel (fig. 267, *r*—*s*) and in the Conger[c] — do not articulate like the others by means of a flat articulary surface with separate interspinal bones, but

[a] In the Muraena the posterior parapophysis divides on the 25th vertebra, and from the 73rd vertebra inclusive its lower branch enters into the structure of the closed haemal arch: see OWEN, *Anat. Physiol. Vertebr.*, vol. I, p. 45.

[b] In some, however, as in *Ophichthys*, the tip of the tail is free, without any trace of caudal fin.

[c] In the Muraena 6.

include within their cloven base the margin of the hypural bones and urostyle. The spinal canal extends straight back towards the end of the last vertebra (*t*), the body of which is compressed to form the urostyle (*x*), also directed straight backwards. The first (posterior) hypural bone (*h*) is really composed, in analogy to the primordial confluence of the last two vertebræ, of two hæmal parts, which have been united in an arch at the base (proximally), just below the last vertebra, and have closely applied their outer (distal) extremities to each other, thus including an elliptical cavity, in which the pulsating lymph-heart of the Eels is situated[a]. The lower (anterior) hypural bone (between *p* and *r*) answers to the hæmal spine of the penultimate vertebra, which also supports the hindmost hæmal arch (*p*). In young Eels, as well as in the Conger, Robin found this hypural bone to be fairly well developed[b] and originally divided by a suture from the hæmal arch. In older Eels (fig. 267, *B*) it is extremely narrow, and lies, in the form of an osseous rod, close to the under margin

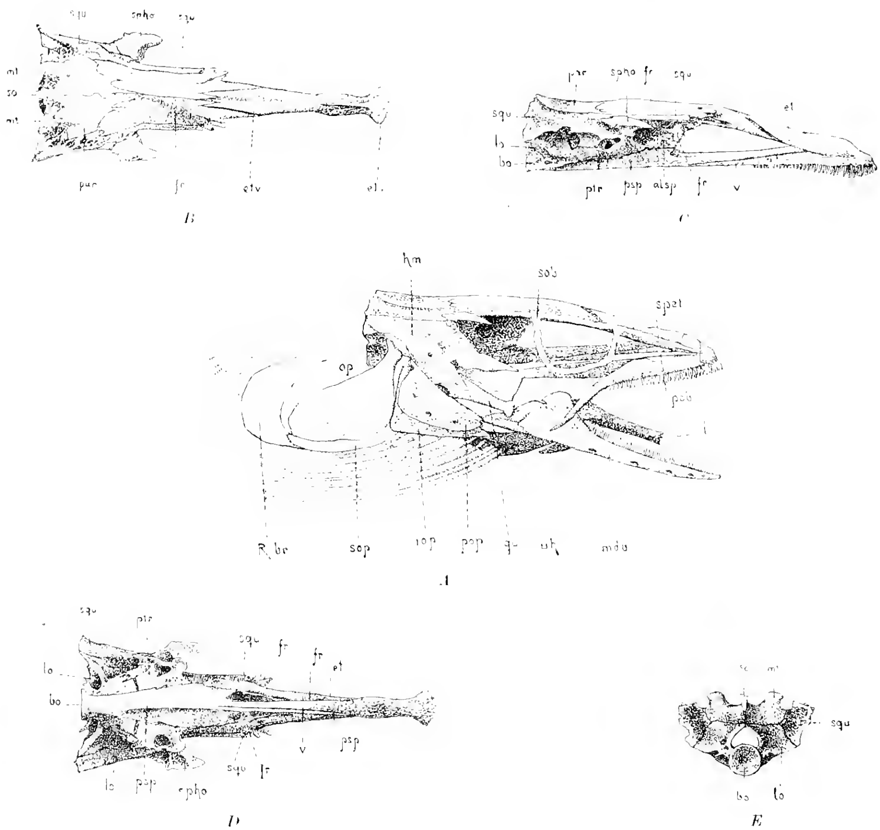


Fig. 268. Skull of an *Anguilla vulgaris*. 3/2 times the natural size. *A:* with branchial apparatus, jaw-bones, and orbit. *B:* cranium, seen from above. *C:* the same, from the right; *D:* the same, from below; *E:* the same, from behind.

alsp, alisphenoid; *bo*, basilar part of the occipital; *et*, *etv*, and *v*, ethmoid (*et*) and vomer (*v*), confluent in front; *fr*, frontal; *hm*, hyomandibular; *iop*, interoperculum; *l*, lingual; *lo*, lateral parts of the occipital; *mdb*, mandible; *mt*, mastoid part of the temporal; *op*, operculum; *par*, parietal; *pob*, preorbital; *pop*, preoperculum; *psp*, parasphenoid; *ptr*, petrosal; *qu*, quadrate; *R. br.*, branchiostegal rays; *so*, squamosal part of the occipital; *sob*, hindmost part of the suborbital ring; *sop*, suboperculum; *spet*, supraethmoidal; *spho*, postfrontal (sphenotic); *squ*, squamosal part of the temporal; *uh*, urohyoid.

[a] In the Conger the upper (posterior) part of this hypural bone coalesces with the lower edge of the urostyle. See Robin, Journ. Anat., Phys. 1880, pl. XXV, figs. 1 and 2.

[b] Cf. Robin, l. c., pl. XXV, fig. 3 and pl. XXIV, fig. 4.

of the first (posterior) hypural bone. A continued reduction would thus seem to obtain here; and the diphycercal caudal fin of the Eel, a character which would else be the token of a low degree of evolution, rather suggests a far advanced, retrogressive metamorphosis.

Among the peculiarities that characterize the skull of the Eel, the first to attract attention are the comparatively great expansion of the parietal bones (fig. 268, *par*), which form almost half the roof of the cranial cavity, and the excessively elongated squamosal bones *squ*), which by means of a long process on the upper side of the skull extend forward to a line with the hind extremities of the upper ethmoids (*et* and *etr*), and at about the middle of their length support the postfrontals (*spho*). The last-mentioned bones rest below on the petrosals (*ptr*), and have lost their importance as a point of suspension for the hind extremity of the suborbital ring. This (*sob—pob*), which in our common Eel — as well as the prefrontals (its anterior suspensories) and turbinals (*spet*) — is cartilaginous, is attached behind on each side of the skull to a process (*fr* in *D*), broken up into spines and originating from the side of each frontal bone just before the anterior extremity of the squamosal bone. The breaking-up of this process into spines, whereby firmer muscular attachments are secured, and which we have previously seen in the upper spinous processes of the anterior abdominal vertebræ, extends to the lateral occipitals (*lo*) and the squamosals, that expand backwards like wings, and, as well as the other bones in the lateral walls of the skull, are characterized by a spongy texture. There is no orbito-muscular canal; and the true sphenoid (basisphenoideum, *bsp* in fig. 282) is closely superposed on the parasphenoid, with upward processes towards the descending processes (*fr* below in fig. 268, *C*) of the frontal bones and towards the alisphenoids (*alsp*) behind them. There are no orbitosphenoid bones.

Great diversity of opinion still prevails as to the composition of the palatine and maxillary arches — assuming that both these arches should really be regarded as distinct in the present series. In that case each of them consists on each side of only a single bone. The inner bone (fig. 269, *pt*), in the common Eel of a thin and oblong, lanceolate form, often imperfectly ossified in front, joins the oblique hyomandibular (*hm*) and the quadrate (*qu*) to the anterior part of the parasphenoid (fig. 268, *psp*). In the Conger it is expanded and bifid behind, one branch meeting the hyomandibular, and the other forming the connexion with the quadrate. The outer bone (fig. 269, *mp*) lies anteriorly and throughout the greater part of its length in the same plane as the inner, and is there united by ligaments with the latter, the two bones thus forming on each side a palatine roof continuous with the parasphenoid bone. But the hind extremity of the outer bone is twisted and bent downwards, and is folded outside the mandible, being united by strong, but loose bands of sinew to the outside of the coronoid process of the latter. In the common Eel this end is pointed, in the Conger flattened, somewhat expanded, and inserted between the outer and inner bands of sinew by which the great cheek-muscles are attached to the mandible. In the latter species the hind extremity of the outer bone also glides on the outside of the coronoid process of the lower jaw, by means of a flat and cartilaginous, articulary surface on each bone. In the Muræna, according to JACOBY[a], it is joined by a special band of sinew to the outside of the quadrate. The anterior extremity of the outer bone is tightly articulated with the compound bone formed by the coalescence of the vomer and the ethmoid (fig. 268, *et*, *etr*, and *v*), a striking resemblance to the corresponding connexion between the intermaxillaries in the Pike, where we found the said bones (fig. 253, *pmx*) similarly furnished with a flat, ascending process. But here these processes (fig. 268, *A*) are so closely applied to the constricted and carinated anterior extremity of the ethmoid that they almost meet above, behind the expanded head of the vomer (*etr*, to the right in *B*). This connexion reminds us most of the ordinary position in the Teleosts of the palatine bones. The analogy between the outer bone and a palatine is further strengthened by the disposition of the teeth. In most of the fishes we have hitherto seen furnished with teeth both on the vomer and the palatines, the transverse row of teeth on the anterior extremity of the first-mentioned bone (the head of the vomer) forms an arch together with the palatine teeth, and here too the teeth are so arranged. The long and narrow vomer (*v*), the posterior end of which extends on the under side of the parasphenoid bone a little beyond the orbits in the common Eel, is armed underneath and in front, for rather more than

[a] Zeitschr. Ges. Naturw. 1867, p. 270, taf. I, fig. 1 (*a*).

half its length, with an unbroken[a] card of teeth, which are straight or slightly recurved at the tip, in young Eels pointed, in old more obtuse. In the extreme front, at the tip of the snout, the bone has an expansion, like a vomerine head (fig. 268, *D*), and behind this point it is constricted. The form of the dental card follows that of the bone. Into the said constriction on each side is fitted the outer bone with its card of teeth, which resembles in composition the vomerine card, and extends, gradually narrowing behind, to the very corner of the mouth, working against an exactly similar card on each half of the mandible.

It is easy to perceive that the structure of the palatine roof and the upper jaw may give rise to the most conflicting interpretations. That a comprehensive reduction has taken place, is obvious. The inner bone

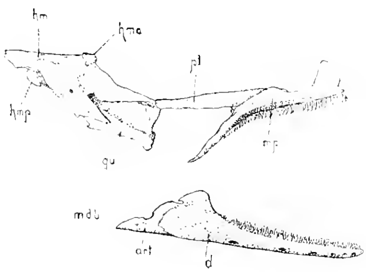


Fig. 269. Bones of the palatine roof and jaws in *Anguilla vulgaris*. $^3/_2$ times the natural size.

hm, hyomandibular; *hma*, its anterior articulary process; *hmp*, its posterior articulary process, with the end of which the operculum articulates; *qu*, quadrate; *pt*, entopterygoid; *mp*, palato-maxillary; *mdb*, mandible; *art*, its articular part; *d*, its dental part.

(*pt*), which serves to connect the hyomandibular and quadrate with the anterior part of the parasphenoid and with the bone which we have hitherto called the outer bone, cannot be explained as anything but a pterygoid. Such is the position occupied on each side of the palate in all the Teleosts — where these bones are distinct from each other — by the inner pterygoid (*entopterygoideum* l. *mesopterygoideum*) and the posterior pterygoid (*metapterygoideum*), the latter of which has coalesced in the Eels, according to OWEN[b], with the hyomandibular. The outer bone (*mp*) has received three interpretations: as a *palatine* (1), a maxillary (2), and an intermaxillary (3).

The first-mentioned interpretation (1), which was suggested by OWEN[c], presupposes that the maxillaries as well as the intermaxillaries have disappeared in the process of reduction, and that the tip of the snout is formed, as in the Pike, by the ethmoid and vomer. Tendencies to such a reduction we have seen above, e. g. in the maxillaries of the Glanomorphs and in the intermaxillaries of *Argentina*. The hind extremity of the assumed palatine occupies a peculiar position, it is true, in relation to the lower jaw; still it is not so superficial and free as the extremity of the maxillaries in other, more typical Teleosts, and it is also joined, according to JACOBY, by a band of sinew to the quadrate bone.

The second explanation (2) — according to which the margin of the upper jaw is formed on each side by

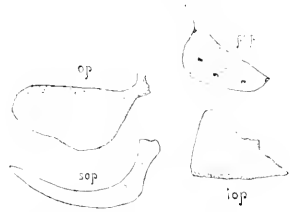


Fig. 270. Opercular apparatus of *Anguilla vulgaris*. × $^3/_2$.
op, operculum; *pop*, preoperculum; *sop*, suboperculum; *iop*, interoperculum.

the maxillaries — was first given by ROSENTHAL[d] and MECKEL[e], and has subsequently been adopted by PETERS and his pupil JACOBY in Berlin, by BRATTSTRÖM[f] and his teacher LILLJEBORG, and others. It is based on the presumption that palatines are wanting, and that the intermaxillaries, in their confluence with the ethmoid and vomer, form the tip of the snout. The relation of the assumed maxillary to the pterygoid and the horizontal expansion inwards of its anterior part, however, do not agree with this interpretation, nor can the assumed coalescence of the intermaxillaries and the other bones at the tip of the snout be regarded as by any means fully demonstrated.

[a] The gap mentioned by JACOBY (l. c., p. 291) I have not been able to detect, even in young Eels 66 mm. long.
[b] *Compar. Anat., Physiol. Vertebr.*, vol. I, p. 122.
[c] l. c., pp. 113 and 118.
[d] *Ichthyotom. Tafeln*, taf. XXIII, *c*.
[e] *Syst. Vergleich. Anat.*, Bd II, p. 356.
[f] *Om kraniet och skuldergordeln hos Muræna anguilla*, LIN., disp. Ups. 1875, p. 17.

The third interpretation (3) — according to which the margin of the upper jaw consists laterally of the intermaxillaries and anteriorly of the vomer (there coalescent with the ethmoid) — was first proposed by CUVIER[a], and has long been the most generally accepted. It presupposes that true maxillaries and palatines are wanting.

The history of the Eels' development has not yet pronounced judgment on these three opinions; and a fourth explanation might reasonably be suggested, namely that the palatines and maxillaries were originally independent, but have coalesced, as MECKEL and, after him, PETERS assumed of the relation between the intermaxillaries and the ethmoid and vomer. From the evolutional history of the higher vertebrates we know[b] that the maxillaries as well as the palatine roof are primordial excrescences of the mandibular arch, and that the incipient palatine roof may appear as a se-

Fig. 271. Hyoid arch of *Anguilla vulgaris*. × 3/2.
A: hyoid arch with branchiostegal rays; *B*: lingual bone; *C*: the same, seen from below.
l. lingual; *uh*. urohyoid; *bbr*. first copula (basi-branchial); *ech*. ceratohyoid; *eph*. epihyoid; *R. br*., branchiostegal rays.

condary growth in an inward direction, originating from the maxillary arch. Whether an equally intimate relation between these parts has possibly arisen during their reduction in the Eels, is a question which only the history of evolution can solve. We accordingly consider it still doubtful whether intermaxillaries and maxillaries are wanting in the Eels or have coalesced with more internal bones, and in the present state of the question the describer is fully entitled to speak of maxillary and vomerine teeth.

In conjunction with the great development of the branchial cavity the Eels have very broad branchiostegal membranes and long branchiostegal rays (*R. br.*). But the former are united throughout by far the greater part of their margins to the skin and joined to each other, thus leaving only small, slit-like gill-openings; and all the latter, except the uppermost (hindmost) ones, are slender, filamentous, and coiled backwards, upwards, forwards, and finally downwards, so as to include within their curve both the operculum and the suboperculum. In the Conger (fig. 282, p. 1036) the last two branchiostegal rays of each membrane are expanded at the top; in the common Eel (fig. 271) the expansion is confined to the last ray, but is so great that the ray is sometimes equal in breadth to the comparatively narrow, obliquely semi-elliptical operculum (fig. 270, *op*). The sabre-shaped — in the Conger (fig. 282) elongated triangular, posteriorly pointed, but curved — suboperculum (*sop*) follows the curved inferior margin of the operculum, and is weaker both in the common Eel and the Conger than the triangular, anteriorly pointed interoperculum (*iop*), which is even larger than the thin, crescent-shaped preoperculum (*pop*).

The Eels are exceedingly voracious; and their digestive canal is accordingly rather short and simple. Our common Eel may serve as an example. The main abdominal cavity of this species varies considerably in length, between about 26 and 30 % of the length of the body; but in the caudal part it has on each side a prolongation, of which we shall give a fuller description when treating of the sexual organs. The thin-walled and rather wide œsophagus passes into the stomach without a break, except that the longitudinal folds (ridges) in which the mucous membrane lies on the inside become thicker and higher in the stomach, while the wall of the stomach is also thicker than that of the œsophagus. Straight backwards the stomach is prolongated in the form of a cone; but from the right and lower side of its anterior part it sends out a pyloric portion, with equally thick walls, which runs forward to the hind margin of the liver, where it bends abruptly in a narrow crook, so that the beginning of the intestine, which runs backwards, lies close to its under surface. There are no cæcal diverticula. At the middle of the crook is a funnel-like valve (an annular fold on the inside), marking off the pylorus from the intestine; and on the inside of the latter the mucous membrane is disposed in a honeycombed network of deep, confluent

[a] *Mém. Mus. d'Hist. Nat.*, tome I, p. 118.
[b] Cf. SMITT, *Ur de högre djurens utvecklingshistoria*, p. 167.

folds. Beside the termination of the stomach the intestine forms a curve of varying size, with one or more small convolutions, before passing into the rectum, from which it is divided internally by a more or less distinct, annular fold[a]. The liver is generally almost entire, having only a more or less deep incision in the hind margin. Its length is about $^1/_4$ of that of the abdominal cavity proper, somewhat more than $^1/_2$ of that of the stomach, or $^3/_4$ of the distance between the termination of the stomach and the vent. Sometimes, however, its length is equal to the last-mentioned distance. Its upper, concave side surrounds the under side of the œsophagus and the beginning of the stomach, as well as the gall-bladder, which is rather large and lies to the right. The spleen is oblong, rather more than half as long as the liver, and is situated on the right side, at the fold between the pylorus and the intestine. On the left side of this fold, as well as on both sides of the intestine and rectum, hangs a lobulated peritoneal fold, which has been developed into an omentum-like fold of adipose membrane, consisting of connective-tissue meshes filled with fat-globules. In appearance these folds are so like generative organs that they have been described both by ERCOLANI[b] and by BALSAMO-CRIVELLI and MAGGI[c] as testes. The air-bladder varies considerably in length, between $^1/_2$ and $^1/_3$ of that of the abdominal cavity proper. It is of a pointed fusiform shape, but in front, for almost half its length, is divided into an upper and a lower cone, the latter joined by the pneumatic duct to the œsophagus, though in the specimens examined by us the communication has invariably been closed. The kidneys lie, as usual, close below the spinal column, above the air-bladder and without the peritoneal cavity. They extend not only throughout the length of the abdominal cavity proper, but also into the backward continuation of the haemal canal, in the caudal region, above the prolongations of the abdominal cavity, to which structures we shall return in our description of the generative organs. The urinary bladder lies just behind the downward curve of the rectum towards the vent, and has its orifice just behind the anal aperture. In our common Eel it has the form of an equilateral triangle, with one angle (the so-called neck) directed downwards and passing into the urogenital aperture.

The generative organs are suspended on each side of the abdominal cavity and throughout the greater part of its length, side by side with and outside the

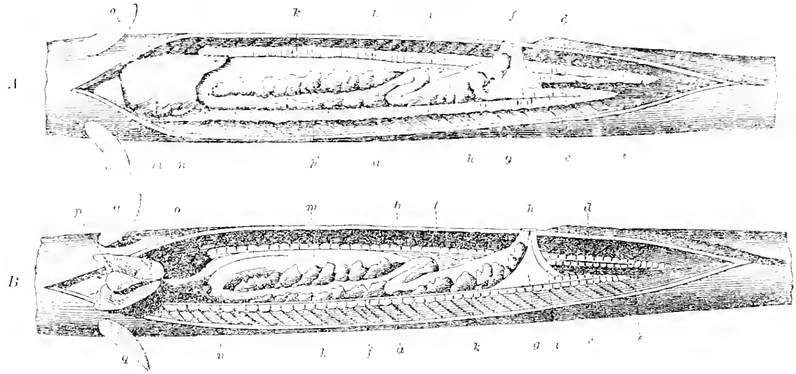


Fig. 272. Abdominal viscera of *Anguilla vulgaris*. After SYRSKI. *A*, female; *B*, male.

A: *a*, right, *b*, left ovary; *c*, right, *d*, left prolongation of the ovary in the caudo-abdominal cavity; *e*, septum (prolongation of the mesentery) between the caudo-abdominal cavities; *f*, vent; *g*, urinary bladder; *h*, fold of adipose membrane on the right side of the intestine; *h'*, fold of adipose membrane on the stomach; *i*, fold of adipose membrane on the left side; *k*, stomach; *l*, pylorus; *m*, liver; *n*, gall-bladder; *o*, pectoral fins.

B: *a*, right, *b*, left testis; *c*, right, *d*, left prolongation of the testis in the caudo-abdominal cavity; *e*, septum between the caudo-abdominal cavities; *f*, efferent duct of the testes (*vas deferens*); *g*, seminal vesicle; *h*, vent; *i*, urinary bladder, mainly concealed by the seminal vesicle; *k*, *k'*, and *l*, corresponding to *h*, *h'*, and *i* in *A* (see above); *m*, stomach; *n*, pylorus; *o*, liver, turned up to show how it is applied to the œsophagus and stomach; *p*, gall-bladder; *q*, pectoral fins.

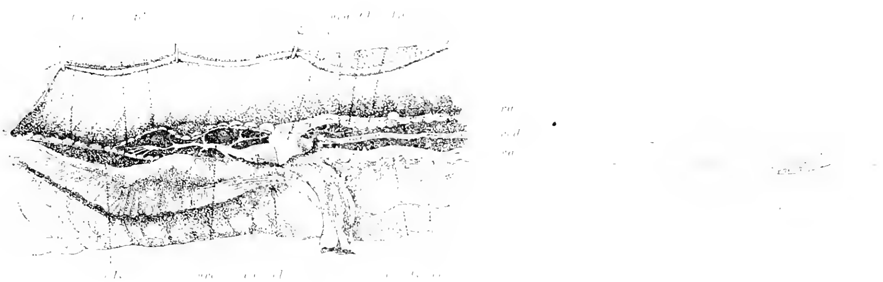
[a] The honeycombed mucous membrane of the intestine and rectum, as well as the thickness of their walls and that of the pyloric part, is apparently subject to considerable variations.

[b] Mem. Accad. Sc. Bologna, 1872, p. 529.

[c] Mem. Ist. Lomb. Sc., Lett. Milano, XII, 1872, p. 229.

above-mentioned folds of adipose membrane, the right beginning farther forward than the left, but not extending so far back. The structure and significance of these organs, especially in our common Eel, has long been an obscure question, which was not elucidated until recent times.

From the preceding pages (p. 829) we know that the Salmonoid family and some other fishes, among them the family of the Eels, are destitute of oviducts, at least closed ones, such as appear in the remaining Teleosts, and that the eggs of these fishes fall, when ripe, loose into the abdominal cavity, whence they are expressed through a more or less developed peritoneal canal on each side, opening into the genital pore just behind the vent or into the urogenital aperture common to the genitals and the urinary bladder. The testes, on the other hand, are furnished, even in the Eels, with efferent ducts (*vasa deferentia*), which have hand, they occupy as caudo-abdominal cavities the same relation to the skeleton as the abdominal cavity proper. The peritoneal fold in which the intestine is suspended (*mesenterium*) crosses from the intestine to the urinary bladder, which lies behind the rectum — leaving in the females a triangular opening (peritoneal canal) between the lowest part of the rectum and the neck of the bladder — and is continued backwards in the middle of the haemal canal (or a little obliquely). It thus forms a partition wall between the two caudo-abdominal cavities, suspended from a continuation of the peritoneum proper, which lines the walls of these cavities and divides them from the superposed prolongations of the kidneys (caudal kidneys). The most striking peculiarity in the generative organs of the common Eel is, however, the duplication of the parts contained in the caudo-abdominal cavities, each organ consisting there of two blades running side by side.



A B

Fig. 273. Portions of the testes in *Anguilla vulgaris*. *A*, abdominal cavity (posterior part) and caudo-abdominal cavity, opened and with the walls folded back to show the enclosed organs; natural size; after Brock. *B*, a portion of the young testes, at an early stage of development, in an Eel 23 cm. long, taken at Trollhättan in 1848; magn. about 8 diam., to show how the testicular lobes (*t*) originate in a thin and transparent mesorchial fold (at first of uniform breadth) of the peritoneum.

ts, left, *td*, right testicle in the abdominal cavity; *tse*, left, *tde*, right testicle in the caudo-abdominal cavity; *vds*, left, *vdd*, right testicular duct (*vas deferens*); *vs*, seminal vesicle; *vu*, urinary bladder; *ra*, abdominal, *re*, caudo-abdominal divisions of the kidneys; *ura*, abdominal *ure*, caudo-abdominal urethra; *r*, rectum, detached and laid to the left; *vcd*, *vena cava dextra*; *cl*, cloaca (*anus*).

their common aperture, as usual, in the anterior wall of the neck of the urinary bladder. Characteristic of the majority of the Enchelymorph genera, but most developed in our common Eel, are two backward prolongations of the abdominal cavity and the continuations in these cavities of the generative organs, one below each side of the caudal (post-anal) prolongations of the kidneys. We have indeed seen a similar peculiarity in the Flounders, though the secondary abdominal cavities are there situated outside the haemal canal (see above, pp. 370 etc.). Here, on the other

The ovaries have the appearance of frilled bands; but their inner (median) side is smooth, and the appearance of frills is caused by elevated, transverse (vertical), simple or double, foliate lobules (ovarial lamellae, in which the eggs are developed) on the outer (lateral) side, though so arranged that in the caudo-abdominal part of the ovary the inner blade has these lobules on its inner side, and turns its smooth side outwards, to face the outer blade of the same ovary. The testes, on the other hand, so long as their real nature was unknown, bore the name, conferred on them for their appearance, of *lobulate organs* (Sw. *flikorgan*, Germ. *Lappenorgan*). They consist of a row of rounded lamellæ, coherent to each other just at the base, and suspended from the efferent duct (*vas deferens*).

In their internal structure the ovaries show a meshwork of connective tissue, so closely packed, when they are unripe, with strongly refractive fat-globules, that it is difficult enough to distinguish among these the exceedingly small eggs, which in the common Eel usually measure during the summer months at most about $^1/_{10}$ mm. in diameter, and late in autumn or even in December attain a size of about $^1/_4$ mm. The testes are essentially similar to the ovaries in the texture of their *stroma* (connective-tissue fold), but are without adiposis, being consequently more transparent and difficult of detection. Most easily perceptible is their white efferent duct (*vas deferens*). Their seminal cells (spermatogonia) are also exactly similar at first to newly-formed ova, and remain extremely small, measuring 0.015—0.03 mm. in diameter; but they multiply by fission as they pass from the germinal epithelium into the stroma, where they gather in their special cavities (spermatic ducts). In the Conger and Muræna the development of the spermatozoa has been traced; in the common Eel spermatozoa have not yet been observed.

Some Enchelymorphs, among them probably our common Eel[a], develop without any great metamorphosis. Others, such as the Conger, have a larval existence during which they are scarcely recognisable. These larvæ were first described under a generic name, *Leptocephalus*[b] or *Helmichthys*[c], and were long regarded as types of a distinct family *Leptocephalidæ* or *Helmichthyidæ*) or even of an order (*Lemniscati*[d]). The structure of these larvæ was described by KÖLLIKER in 1852[e]. They are thin (ribbon-shaped) or more terete (cylindrical), and so transparent that only the black eyes with silvery iris betray their presence, as they move with slow and languid undulations of their whole body, sometimes near the coast, sometimes in the middle of the ocean. The head is extremely small — hence their name[f] — and the skeleton most feebly developed, with hardly any signs of vertebræ, these being confined, as a rule, to the hindmost part of the body. The notochord (*chorda dorsalis*), entire or only marked with annular constrictions, advances without a break into the cartilaginous mass of the skull, and lies in the body, enclosed, together with the spinal cord and the great blood-vessels, in a mucous mass, which separates these parts from the surrounding musculature. The muscular mass is fastened to the skeleton only in front (at the head) and behind (at the tail), being attached elsewhere to the skin; but it is divided, as in other fishes, by the zigzag transverse bands (*myocommata*) into flakes (*myomeres*), each with an angle (directed forwards) at the middle of the sides of the body, another (directed backwards) at the back, and a third at the ventral margin. The mouth is armed, both in the upper jaw and the lower, with comparatively large and strong, rather scattered, straight and pointed teeth, set in a single row and directed obliquely forwards. Each nasal cavity is a depression in front of the eye, without proal nostril. The tubular abdominal cavity extends along the greater part of the ventral margin. The straight digestive canal includes, according to KÖLLIKER, a cæcum-like stomach, with two upward, cæcal diverticula and two similar appendages belonging to the intestine. The liver is faintly developed; spleen, air-bladder, and sexual organs are wanting. From this larval structure FACCIOLA[g] has succeeded in tracing a series of transition-forms that bring it to perfect identity with the young of the Congers, a metamorphosis at which GILL[h] had already hinted. The most singular point is, however, that these larvæ, retaining the structure proper to their first stage of development, can attain dimensions considerably greater than those of the stages in which the terete type and internal struc-

[a] In the Bull. Accad. Gioen. Sc. Nat. Catania (Fasc. 34—35; Nov. 1893 e Genn. 1894, p. 4) GRASSI and CALANDRUCCIO have expressed the supposition that the ova of *Anguilla vulgaris* are to be found floating in the sea, and that *Leptocephalus brevirostris* is the larval stage of this species.

[b] GRONOVII *Zoophylac.*, Fasc. I (1763), p. 135. MORRIS, an acquaintance of PENNANT'S, had found these fishes in St. George's Channel, off Holyhead, North Wales.

[c] RAFINESQUE, *Ind. Ittiol. Sic.*, where the name is, however, written *Helmictis*.

[d] RICHARDSON.

[e] Zeitschr. f. Wiss. Zool., Bd IV, p. 360.

[f] From Gr. λεπτός, *fine, small*, and κεφαλή, *head*.

[g] Il Naturalista Siciliano, Anno XII (1893), p. 194.

[h] Proc. Acad. Nat. Sc. Philad. 1864, p. 207.

ture of the species may be recognised without difficulty. Günther mentions Leptocephaloids as much as 10 Paris inches (270 mm.) long[a]; and Facciola found larvæ of the common Conger in the first stage of development (*Leptocephalus inæqualis*) that measured 76—140 mm., while almost typical fry of the same species were only 75 mm. long. Günther also considers it probable that not all these larvæ follow the normal course of development and become Congers, but that some of them — perhaps when they are borne by the current or some other agency out into the open sea or too far from the coast where the species develops under normal conditions — may lead a pelagic, but morbid (hydropic) life, increasing in size, though never attaining the typical structure of their species or propagating themselves. Among the *Leptocephali* of the Royal Museum we find a specimen, otherwise uninjured, and taken in the middle of the Atlantic, south-west of the Azores (Lat. 31° 13′ N.; Long. 35° 46′ W.), that has five vesicular

Fig 274. *Leptocephalus Morrisii* (?), from the Atlantic; taken in Lat. 31° 13′ N.; Long. 35° 46′ W. Natural size.

tumours — two of large size, occupying the whole depth of the body, and three smaller ones, in the dorsal region — full of fluid and with the myomeres more or less atrophied. Sickliness and an abnormal manner of life might well explain, as Günther has pointed out, the inconstancy both of form and structure that marks these larvæ. From the Mediterranean 35 species of the so-called genus *Leptocephalus* have been described[b], but without evidence to show that the specific characters are more than individual variations.

The Enchelymorph series is fairly rich in forms. Bleeker had examined in 1864 more than 250 species. In 1870 Günther adopted in his *Catalogue* 227 indubitable and 63 doubtful species; in 1883 Jordan and Gilbert[d] estimated the number of the species then known at about 280. The great variability of form indeed deprives any such estimate of conclusive authority; but the number of species is at all events considerable enough to necessitate the arrangement of the series in several divisions. Bleeker established six families within the series. Günther was of opinion that, considering the transition-forms and the variability of the Enchelymorphs, the whole series might be included within one family (*Murænidæ*); but at the same time he established ten subfamilies, the majority of which might well lay claim to the rank of distinct families. The Scandinavian fauna contains only two members of one among these families; but for the European fauna several of them possess interest. On the English coast there occurs, though seldom, the Mediterranean Muraena (*Muræna helena*), which we have mentioned above, the type of the *Gymnothoracidæ* (Bleeker's *Gymnothoracoidei*, Günther's *Murænidæ engyschistæ*, with narrow slits between the branchial arches), a family very rich in forms, especially in India, and with naked body, laterally compressed, and no pectoral fins.

The Enchelymorphs live both in fresh and salt water; but most of them are marine fishes. A great number are deep-sea forms — some of them taken in more than 4,000 fathoms of water — and show reductions still more comprehensive than those we have described above, the piscine type consequently appearing in such simplicity that it is sometimes difficult to decide in which order the forms have their right place.

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[a] *Cat. Brit. Mus., Fish.*, vol. VIII, p. 143.

[b] Carus, *Prodr. Fau. Medit.*, vol. II, p. 546. But Carus remarks with regard to these species, "Notæ specificæ tantum variant, ut species distinctæ vix describi possint."

[c] *Atl. Ichth. Ind. Orient. Néerl.*, tome IV, p. 5.

[d] Bull. U. S. Nat. Mus., No. 16, pp. 355, seqq.

[e] Günther (*Deep Sea Fauna*, Chall. Exped.) knew 14 such species, and Vaillant (*Exped. Scient. Travailleur Talisman: Poissons*) 36, exclusive of the Leptocephaloids.

FAM. ANGUILLIDÆ.

Gill-slits (between the branchial arches) wide; gill-openings (in the skin) widely separated. Heart situated just behind the branchial cavities. Vertical fins well-developed and confluent round the tail. Pectoral fins present. Anal fin separated from the tip of the snout by a distance of more than twice the length of the head. Posterior nostrils distant from the margin of the upper lip. Tongue with free tip.

Among GÜNTHER's *Platyschistæ* some (the *Synaphobranchidæ*) are characterized by the downward removal of the gill-openings towards the ventral side and their union. Others (the *Ptyobranchidæ*) are marked by so great a prolongation of the forepart of the body that the heart is situated far behind the branchial cavity. Others again (the *Nemichthyidæ*) have the vent far advanced, close to the gill-openings or separated from them by a distance less than the length of the head, and the beginning of the anal fin just behind this point. In others (the *Saccopharyngidæ*[a]) the mouth and pharynx are developed into a monstrous, funnel-shaped gorge, so large that it exceeds the abdominal cavity in length. Another division (the *Ophichthyidæ* and *Myridæ*, the former with finless tip of the tail) are distinguished by a singular downward removal of the nostrils, sometimes quite to the margins of the upper lip. Some (the *Murænesocidæ*) are without free tongue; others (the *Heterocongridæ*) are similar in all these respects to our common Eel, but destitute of pectoral fins. The rest compose the family that has its most marked type in the

GENUS ANGUILLA.

The slimy body furnished with scales immersed in the skin.

By this solitary character it is always possible to recognise one of the so-called *Fresh-water Eels*[b], all other distinctions being far too inconstant to be implicitly relied on. Another character, which is not peculiar, however, to *Anguilla*, though within the Scandinavian fauna it is sufficient to denote the genus, and besides has the advantage of being more conspicuous, consists in the fact that the tip of the snout falls short of the point of the lower jaw, or at least does not project beyond it.

"An infinite number of species," says GÜNTHER, "have been described; but most are so badly characterized, or founded on individual or so trivial characters, that the majority of ichthyologists will reject them." KAUP[c], who was the greatest authority on this head until GÜNTHER's time, adopted no less than 49 species; GÜNTHER[d] reduced the number to 23. DARESTE[e] acknowledged only 4 or possibly 5. As GÜNTHER has remarked[f], the genus is known throughout the Tropical and Temperate Zones, with the exceptions of South America, the west of North America, and Western Africa. In Scandinavia and the rest of Europe only one species is recognised at the present day.

[a] For the *Saccopharyngida* see GILL and RYDER (Proc. U. S. Nat. Mus., vol. VI, p. 262; vol. VII, p. 48), who founded a separate order (*Lyomeri*) to receive this family, and VAILLANT (*Expéd. Scient. Travailleur, Talisman, Poissons*, p. 193), who considered them to be as nearly allied to the Anacanthines as to the Enchelymorphs. Among their peculiarities it should first be remarked that the number of the branchial arches is 5 instead of 4, the usual number in the Teleosts.

[b] Fresh-water or at least brackish-water fishes indeed occur within other Enchelymorph genera, as in *Gymnothorax*, *Pisoodonophis*, *Sphagebranchus*, *Moringua*, and *Muraenesox*; but in these genera salt-water Eels predominate, and they are besides entirely foreign to the Scandinavian fauna.

[c] *Catal. Apodal Fish., Brit. Mus.* (1856), p. 32.

[d] *Cat. Brit. Mus., Fish.*, vol. VIII, p. 23.

[e] Arch. Zool. Expérim., tome IV, p. 224.

[f] *Introd. Study of Fishes*, p. 671.

THE COMMON EEL (SW. ÅL)

ANGUILLA VULGARIS

Plate XLV, fig. 1

The dorsal fin commences far behind the tips of the folded pectorals, being separated from the tip of the snout by a distance of more than twice the length of the head, and precedes the anal by a distance about equal to (somewhat greater or less than) the length of the head, the distance between it and the tip of the snout being about 29—33 %, that between the anal and the same point about 40—45 %, of the length of the body. The jaw-teeth straight (of an obtuse, conical form), or somewhat recurved at the tip, and set in quite continuous cards.

R. br. 10—12[a]; *D.* ca 245—275; *A.* ca 205—225; *C.* 10; *P.* 17—20[b]; *Vert.* 112—115[c].

Syn. *Muræna* unicolor; maxilla inferiore longiore, ART., *Ichthyol., Gen.*, p. 24; *Syn.*, p. 38 (ubi synon. vet. videantur); *Spec.*, p. 66; LIN., *Fna Suec.*, ed. I, p. 109.

Muræna anguilla, LIN., *Syst. Nat.*, ed. X, tom. I, p. 245; FABR., *Fna Groenl.*, p. 137; BL., *Naturg. Fisch. Deutschl.*, pt. III, p. 4, tab. LXXIII; AHL (*Ophichtus*), *Spec. Ichth. Mur. Ophicht.* (disp. Ups. 1789), p. 14; RETZ., *Fna Suec. Lin.*, p. 311; FAB. (*Muræna*), *Fisch. Isl.*, p. 59; PALL., *Zoogr. Ross. As.*, tom. III, p. 71; EKSTR., Vet. Akad. Handl. 1831, p. 285 (+ *Mur. oxyrhina* + *Mur. platyrhina*, p. 287); NILSS., *Prodr. Ichthyol. Scand.*, p. 65 (+ *Mur. latirostris*); ID., *Skand. Fna, Fisk.*, p. 661; SUNDEV., Stockh. L. Hush. Sällsk. Handl., VI (1885), pp. 83, 92, 181; WEGGN, Landtbr. Akad. Handl. 1858, pp. 181 et 210; NYSTRÖM, *Iaktt. Fauu Jemtl. Vattendr.* (disp. Ups. 1863), p. 20; V. BEMM. in HERKL., *Bouwst. Fna Nederl.*, part III, p. 388; OLSS., Öfvers. Vet. Akad. Forh. 1876, no. 3, p. 139; 1882, no. 10, p. 51.

Anguilla vulgaris, TURT., *Brit. Fna*, p. 87; MITCH., Trans. Lit., Phil. Soc. N. York, vol. I, p. 360; FLMNG, *Brit. Anim.*, p. 199; COSTA, *Fna Regn. Nap., Pesc.*, pt. I, *Malacott. Apod., Anguilla*, p. 52 (+ *Angu. platyrhynchus*, p. 50, ex CUV., + *Angu. acutirostris*, p. 51, ex YARR.), tabb. LIII—LX; BLANCH., *Poiss. d. eaux douces Fr.*, p. 491 (cujus formæ: *Angu. latirostris*, p. 495, ex RISSO, *Eur. Mér.*, tom. III, p. 199, + *Angu. mediorostris*, p. 496, ex RISSO + *Angu. oblongirostris*, ibid., + *Angu. acutirostris*, p. 467, ex RISSO, l. c., p. 198); SIEB., *Susswasserf. Mitteleur.*, p. 342; MGRN, *Finl. Fiskfna* (disp. Helsingf. 1863), p. 33; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 28 (+ *Angu. bostoniensis*, p. 31, ex LESUEUR, Journ. Acad. Nat. Sc. Philad., vol. I, p. 81, + *Angu. teraua*, p. 32, ex KAUP, + *Angu. latirostris*, p. 32, ex RISSO, + *Angu. Kieneri*, p. 35, ex KAUP); DARESTE, Arch. Zool. Expér., tom. IV (1875), p. 217; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 196; 1879, no. 1, p. 99; N. Mag. Naturv. Chrnia, Bd 29 (1884), p. 113; WINTH., Naturh. Tidskr. Kbhvn, ser. III, vol. XII, p. 50; FEDDERS., ibid., p. 93; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 560; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 173; MELA, *Vertebr. Fenn.*, p. 357, tab. X; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 241, tab. CXLII, fig. 1; MOR., HEKL., *Fisch. Osts.*, p. 143; BR.-GOODE, *Fisher., Fisher. Industr. U. S.*, sect. I, p. 630, tab. 239; SEELEY, *Freshw. Fish. Eur.*, p. 373 (+ *Angu. eurystoma*, p. 380, ex HEKL, KN.); LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 375; REUT., SUNDM., *Finl. Fisk.*, tab. XXXIII; CAR., *Prodr. F. a Medit.*, vol. II, p. 540.

Muræna rostrata (+ *bostoniensis*) LESUEUR, Journ. Acad. Nat. Sc. Philad., vol. I, p. 81 (+ *Mur. argentea* + *Mur. macrocephala*, p. 82); DEK., *N. York Fna*, part. IV, p. 312 (+ *Angu. tenuirostris*, p. 310); JORD., GILB., Bull. U. S. Nat. Mus., no. 16, p. 361.

Anguilla fluviatilis, AGASS. (ex CUV.?), *Rech. Poiss. foss.*, tom. V, p. 130, tab. F, fig. 2; HEKL. KN., *Susswasserf. Östr. Mon.*, p. 319 (+ *Angu. euryistoma*, p. 325).

Anguilla canariensis, VAL. in WEBB, BERTH., *Iles Canar., Poiss.*, p. 88, tab. 20, fig. 1.

Anguilla japonica, SCHLEG. in SIEB., *Fna Japon., Poiss.*, p. 258, tab. CXIII, fig. 2.

Anguilla callensis, GUICH., *Explor. Alger., Zool.*, V, p. 111, tab. 7, fig. 1.

Anguilla migratoria, KR., *Danm. Fisk.*, vol. III, p. 616 (+ *Angu. acutirostris*, p. 642, ex YARR. + *Angu. latirostris*, p. 656, ex YARR.).

Anguilla Kieneri, KAUP, *Cat. Brit. Mus., Apod. Fish.*, p. 32 (+ *Angu. Cuvieri* + *Angu. Bibroni*, p. 33 + *Angu. Savignyi* + *Angu. capitone*, p. 34 + *Angu. morena* + *Angu. melanochir*, p. 35 + *Angu. marginata* + *Angu. microptera*, p. 36 + *Angu. anguilla* + *Angu. mediorostris* + *Angu. altirostris*, p. 37 + *Angu. platycephala* + *Angu. latirostris*, p. 38 + *Angu. acutirostris*, p. 39 + *Angu. nilotica* + *Angu. ægyptiaca*, p. 40 + *Angu. callensis* + *Angu. canariensis*, p. 41 + *Angu. novaorleanensis*, p. 43 + *Angu. tenuirostris* + *Angu. punctatissima* + *Angu. cubana*, p. 44 + *Angu. aceraterra* + *Angu. texana*, p. 45 + *Angu. wabashensis*, p. 46); CARUS, l. c.

Anguilla Linnei, MALM, *Gbgs. Boh. Fna*, p. 590 (+ *Angu. latirostris*, p. 591).

[a] Sometimes 9, according to LILLJEBORG.
[b] „ 16, „ „ KRØYER.
[c] „ 116, „ „ DAY.

The Common Eel, with which most of our readers are, no doubt, familiar, attains a length of about $1\frac{1}{2}$ m. and a weight of about 5, perhaps 6 kilo.[a] Its ordinary length and weight, however, are respectively under 1 m. and 2 kilo. The snake-like body is so terete in front that the greatest breadth (thickness) is sometimes equal to the greatest depth, or even (when the branchial cavity is distended) greater than it; but the former is commonly no more than $\frac{4}{5}$ or $\frac{3}{4}$ of the latter, and at the termination of the abdominal cavity the body shows greater and greater lateral compression. The greatest depth, which occurs just in front of the dorsal fin, increases with age in the young, though even at a length of $4\frac{1}{2}$ dm. it sometimes measures, according to KROYER, only about $5\frac{1}{2}$ % thereof; but the rule is that it subsequently decreases during growth, falling in Eels measuring 4—7 dm. from 7 to 6 % of the length of the body. Still large Eels grow to the thickness of a man's arm. The males seem always to remain smaller than the females, for up to the present large specimens have been found in every instance to be of the latter sex.

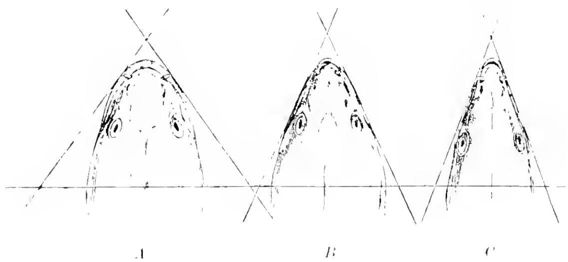

Fig. 275. Three varieties of *Anguilla vulgaris*. *A*. *Anguilla latirostris*; *B*. *Angu. mediorostris*; *C*. *Angu. acutirostris*. After BLANCHÈRE.

The head passes so gradually into the rest of the body that the limit between them is externally almost indistinguishable, being indicated only by the position of the small gill-openings, just in front of and partly below the pectoral fins. The size of the head is extremely variable. After the larval stage its relative length (to the middle of the anterior margin of the gill-opening) shows the usual diminution. While the length of the body increases from about $2\frac{1}{2}$ to $6\frac{1}{2}$ dm., that of the head decreases in our specimens from 13 to 11 % of the former[b], or from about 41 to 36 % of the distance between the dorsal fin and the tip of the snout. But in this respect we find that older Eels — we can speak here only of females — and certain individuals which it has been proposed to treat as a separate species or variety (*latirostris*), revert to the juvenile characters, or even exceed the limits of these, the length of the head sometimes measuring 15 % of that of the body or 46 % of the distance between the dorsal fin and the tip of the snout. The form of the head is also highly variable, in front more or less conical (*acutirostris*) or broader and depressed, wedge-shaped (*latirostris*), and behind more or less tumid, depending partly on the greater or less distension of the branchial cavity, partly (behind the eyes) on the varying development of the masticatory muscles. The usual proportions of the several parts of the head are such that the length of the snout is 20 % or somewhat less (17 %), the longitudinal diameter of the eyes 10 % or somewhat less (in young Eels at least 13 %, in old sometimes 7 %), and the postorbital length about 70 % (varying in individual cases between 68 and 75 %[c]), of the length of the head. The eyes, which are covered with a thin skin that still further enhances the snake-like appearance of the Eel, are sometimes set vertically, sometimes rather upturned. Partly in consequence of this variation in the position of the eyes, partly following the alterations of growth,

[a] According to the reports made to the Swedish Fisheries Commission of 1881—83, the Eel — which occurs in every province of Sweden — attains in Wermland, Westmanland, and Westernorrland a length of 5 Sw. ft. (148 cm.) and in the last-mentioned province a weight of 15 Sw. lbs. ($6\frac{1}{3}$ kilo.). According to DESMAREST the Eel attains a length of at least 17 dm. and a circumference of at least $3\frac{1}{2}$ dm.

[b] According to KROYER this percentage sometimes falls to 10.

[c] According to KROYER sometimes nearly 77 %.

the young having, as usual, comparatively larger eyes partly in connexion with the different environments and habits of the fish, and partly owing to the above-mentioned retrogressions of development, considerable variations appear in the relative dimensions of the eyes. In young Eels (sometimes even in specimens $3\frac{1}{2}$ dm. long) and in the variety known as *latirostris*, the longitudinal diameter of the eyes is about equal to the interorbital width or at least $\frac{3}{4}$ thereof. The eyes are comparatively smallest, as a general rule, in the migrating Eels, usually measuring less than $\frac{2}{3}$ (sometimes only about 43 %) of the interorbital width. In the last-mentioned specimens the interorbital width is also hardly less[a] than the length of the snout, in the former sometimes scarcely $\frac{3}{4}$ thereof, though the percentage for this relation increases with age. Each nostril in the posterior pair lies, in the form of a dermal fissure, set obliquely or in the longitudinal direction of the snout, just before the upper anterior corner of each eye; the anterior nostils are situated, in the form of dermal tubes, one on each side of the tip of the snout. The mouth is horizontal, with the tip of the lower jaw more or less prominent — most distinctly in old Eels and in *latirostris* — and with the corner situated below the eyes or, especially in *latirostris*, somewhat behind the perpendicular from the hind margin thereof. The lips are double, fleshy, and tumid, the outer folds being more or less expanded at the sides, in the upper jaw as though the free maxillaries of other Teleosts were here replaced by this dermal growth; but the underlips are usually broadest. The length of the upper jaw (of the cleft of the mouth), from the tip of the snout to the hind margin of the buccal corners, measures about 26—33 %, that of the lower jaw about 35—47 %[b], of the length of the head, the latter proportion in each case being characteristic of *latirostris*. The dentition of the mouth is partly described above. The most characteristic point in the dentition of our Eel, as opposed to East Indian and Australian forms otherwise very closely resembling it, is the absence in the jaw-cards of the longitudinal, toothless gap shown by the last-mentioned forms, though the innermost row in both jaws, even in the European Eel, is made up of smaller teeth, and may, as a rule, be distinguished more easily than the others. The tongue is fleshy, free, toothless, and elliptical, with a small, short tip. Gill-rakers and pseudobranchiae are wanting. The fine and pointed pharyngeal teeth, weaker than the jaw-teeth, form dense, velvety cards, two above, of an oval shape, on the upper pharyngeals, and two below, of a more elongated shape, on a thin inward expansion of the lower pharyngeals, which else resemble branchial arches. The upper half of the gill-openings, which are slit-like or curved forwards in a crescent, lies just in front of, the lower half below the base of each pectoral fin, their height being equal to this base and about the same as the interorbital width.

The dorsal fin is of about uniform height, though low in front and very gradually increasing in height behind, the increase being proportioned to the perceptible decrease in depth shown by the posterior third of the body. The longest rays, which measure about $\frac{1}{2}$—$\frac{2}{5}$ of the greatest depth of the body, thus lie in the hindmost part of the fin, just before it slopes to form, together with the caudal and anal fin, a lanceolate tip at the end of the tail. The anal fin is similar to the dorsal, but much shorter, commencing, as we have mentioned, considerably further back, so that the distance between the dorsal fin and the tip of the snout is about 70—75 % of that between the anal fin and the same point. In Eels $2\frac{1}{2}$—7 dm. long this difference increases, as a rule, during growth, until the body attains a length of about $4\frac{1}{2}$ dm., but afterwards diminishes, the length of the head thus being generally less in middle-sized specimens, especially in the migrating Eels, than this difference, in large Eels somewhat greater than the same. But the individual variations appear to deprive the difference of all systematic significance; nor does it seem to possess any importance as an external sexual character.

The pectoral fins, when expanded, are oval, often somewhat pointed, and the middle rays (about the 10th) are the longest. The relative length of these fins expresses both a distinct alteration of growth, the young having even relatively shorter pectoral fins than the old, and a difference of sex, the males in general having shorter pectoral fins than the females. In 6 Eels (4 ♂ and 2 ♀) 23—41 cm. long the average length of the pectoral fins proved to be 3·6 % of that of the body and 8·6 % of the distance between the anal fin and the tip of the snout. In 7 Eels (all ♀) 45—68 cm.

[a] According to Jacoby even greater.

[b] According to Kloyer up to 54 %.

long the corresponding percentages were respectively 1·3 and 10. In the males the former percentage varied between 3·0 and 3·7, in the females between 3·8 and 4·5. The latter percentage varied in the males between 7·5 and 8·6, in the females between 9 and 10·9. That this sexual difference — as it appears in the above measurements — is fully constant, enabling us in every instance to distinguish between males and females, is hardly probable, for it coincides with a marked alteration of growth; but it would seem at least to show that the males retain the characters of youth longer than the females"[a].

The thick and tough skin completely envelops even the fins, but owing to the underlayer of lax connective

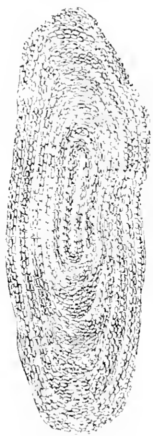

Fig. 276. Scale of *Anguilla vulgaris*. About 23 times the natural size.

tissue and fat is so loosely attached — as every kitchenmaid should know — that it can easily be stripped off entire. The copious slime that covers it has rendered the Eel's slipperiness proverbial; and the system of the lateral line is well developed. The lateral line itself, which is straight, lying about half-way up the sides, in front somewhat higher, so as to meet the temples, is made up of comparatively scattered pores, on the tail often indistinct, and not supported by special scales, but usually marked off by their light hue from the ground-coloration. The cephalic system of the lateral line shows a transverse row of pores across the top of the head behind the eyes, from which they are separated by a distance about equal to the length of the snout; and on each side runs a row, usually containing three distinct pores, straight forward from the transverse row, towards the superior margin of the eyes, but not extending half-way thither. More distinct are the pores on the snout, one row on the turbinal bones and the suborbital ring, another on each half of the mandible. The scales, which are entirely immersed in the skin, are thin, flexible, and of a prolongated elliptical shape, somewhat constricted at the middle of their length, which is about half the diameter of the eyes. On the sides of the body their arrangement is such that a certain number, usually 3—5, lie beside and contiguous to each other, obliquely across the longitudinal direction of the body, and on each side of this group lie others, the scales of which are set at about right angles to the former. Or each group may be longer, containing up to a score of scales, and forming a straight or curved row. Or the scales may be juxtaposited one by one, in the said zigzag arrangement. On the belly the scales are more scattered, and more nearly approach to the longitudinal direction of the body. The texture of the scales is highly characteristic. When slightly magnified, the entire surface seems to be composed of dense strings of lustrous beads, all parallel to the margin. When the scale is more powerfully magnified (fig. 276), this conformation dissolves into a honeycombed network, due to the union of the concentric striæ (ridges) round the elongated, central nucleus by radiating ridges of equal elevation.

The coloration of the Eel varies with age, the season of the year, the haunt of the fish, and partly too with its sex. The dorsal side is of a lighter or darker, greenish or grayish colour, the ventral yellow or white; the middle of the sides has a bronze lustre of varying intensity. The colour of the fins usually resembles that of the back, except in the case of the

[a] How futile it is to rely on the external sexual characters hitherto assigned in literature to the Eel, is most clearly shown by the conflicting results at which different writers have arrived. According to JACOBY (*Fischj. Comacchio*, Berlin 1880, p. 40) the males have pointed snouts. From his measurements (p. 41) it appears that the breadth of the snout at the nasal ducts — (I assume that "Breite der Schnauzenspitze zwischen den Nasaltuben" must be taken in this sense, for "between" the nasal tubes I have never found the distance so great) — measured in 8 males (319—480 mm. long) less, in 8 females (313—480 mm. long) more, than 12 % of the length of the head. According to LILLJEBORG (*Sv., Norg. Fisk.*, vol. III, p. 382) the males most commonly have blunt, "sometimes pointed" snouts.

anal fin, which in front shows the colour of the belly. The yellow tint of the belly is characteristic of the young and of the Eels that lead a somewhat stationary life among the seaweed on the coast, or in the mud and among the grass of the lakes. The white belly belongs to the migration uniform, the spawning-dress of the Eels[a]. The back is darkest, sometimes even black, in the migrating males. Among colour-varieties there have been observed light specimens, almost yellowish green on the back, and irregularly spotted fish, with light, clouded spots on the dorsal side or with "dorsal streaks of a golden yellow" (BENECKE). Albinos have also been found[b].

In the basin of the Atlantic the Eel is dispersed between the latitudes of the West Indies and of Norwegian Finmark, and from the United States eastwards over North Africa and throughout Europe, including the regions drained by the Baltic and the Mediterranean, but, strange to say, originally with the exception of the Black and Caspian Seas and their feeders[c]. FABRICIUS mentions it among the fishes of Southern Greenland, and even OLAFSEN[d] knew it from Iceland, where according to FABER, however, its length seldom exceeds $1^1/_2$ ft.; but from the Arctic seas and rivers it is else unknown. Within the basin of the Pacific it is found in Japan, China, Formosa, Borneo, and, according to GÜNTHER, New Zealand. The geographical range of the Eel is thus one of the most extensive; but the gaps — its absence, for instance, from the west coast of North America — are difficult to explain.

In Scandinavia the Eel becomes rarer and rarer inland and towards the north. Solitary specimens have indeed been found in the Fjords of Varanger and Tana; but into the innermost parts of Finland the Eel does not penetrate, and in Sweden, as well as in Norway, it seldom, if ever, ascends into the mountain-regions. On the Norwegian coast it is common, according to COLLETT, up to Lofoden, rarer on the coast of Finmark further north, and in Exaavand, a lake in Bjellerud (Province of Christiansand), it has been met with at a height of 1,600 feet (500 m.) above the sea-level[e]. The Eel occurs in every province of Sweden, but to the far north only on the seaboard. WIDEGREN described in 1860 the Eel-fishery of the lower Lulea Elf and the islands at its mouth. From the basin of the Angerman Elf TRYBOM was told that Eels were found in Lake Malgomaj, situated 356 m. above the level of the sea; and according to OLSSON the Eel ascends to the neighbourhood of Gäddede, on Qvarnberg Water, near the Norwegian frontier. In the basin of the Ljunga, according to OLSSON, it has been found on rare occasions in Herjeadalens Storsjö, 363 m. above the sea-level. In Southern Sweden, as in Denmark, the Eel is common in rivers, lakes, and meres, wherever it can find a congenial haunt. Throughout the basin of Lake Wener, however, it is said to have been wanting[g] previous to the construction of the Trollhätte Canal, when the Eel-fry made their way through the locks up the fall.

The Eel is tenacious of life and supple of body, adapting itself to the most confined abode and the most meagre circumstances; but in order to attain any considerable size it requires abundant food and ample space. It reminds us strongly of the snakes in its nocturnal habits and its fondness for hiding in holes or burrowing in the soft bottom. Like the viper it gathers in large bunches — "*lagger sig i vred*"[h] says the Swedish fisherman. To these serpent-like traits is allied its power of sustaining life for a long time out of the water: just as the common snake is partly an aquatic animal, the Eel can traverse considerable distances by land. Its serpentine, wriggling movements enable it to make rapid progress though the water, so as speedily to find a hiding-place; and its great power of muscle endows it with great endurance during its rovings in the sea; but it seems to rank among the sluggish fishes, and by nature belongs to the ground-swimmers. "Slippery as an Eel."

[a] Cf. F. H. T. LETH: *Iakttagelser over Aalene*. Dansk Fiskeritidende 1882, p. 393.

[b] FEDDERSEN, Dansk Fiskeritidende, 1891, p. 395.

[c] The Eel's original absence from the basin of the Danube — where it has been planted in recent times and seems to thrive, having voluntarily spread to the Black Sea and the lower courses of the Russian rivers — may perhaps be explained by a comparison with the equally singular presence in the Danube of the Huch (see SMITT, *Riksm. Salmonider*, p. 148). The Eel is wanting in Siberia, being compelled to enter salt water in order to breed, and incapable of enduring the cold of the Arctic Ocean, into which the Siberian rivers fall; and the same ancient configuration of the ocean as enabled the Siberian Huch to spread to the basin of the Danube may have cut off the advance of the Eel in this direction.

[d] *Reise igiennem Island* (1772), vol. I, p. 594.

[e] In the Swiss Alps, according to FATIO (*Faun. Vert. Suisse*, vol. V, p. 458), the Eel ascends to an elevation about twice as great.

[f] Nord. Aarsskr. Fisk., 1:ste Aarg. (1884), p. 306.

[g] See LLOYD, *Scand. Adv.*, vol. I, p. 143, and NILSS., *Skand. Faun. Fisk.*, p. 675, note.

[h] *Vred* is probably connected with *vrida*, to writhe, twist. — Tr.

is a proverbial expression; and this quality is of great service to the fish in every strait. Nor does the Eel forget to take advantage thereof, but slips through the tiniest openings. In order to widen the aperture, when this is too small to afford a passage for its head, it has recourse to the same method as that employed by a Fierasfer in gaining entrance to the body of an Holothuria (see above, p. 598, fig. 143). It first inserts the end of the tail. From a live-well or other receptacle, left without a lid, the Eel has often escaped tail first, lifting itself over the edge with this part of the body. The toughness of its skin is equalled by the obstinacy with which it keeps stationary in the same spot, unless impelled by hunger, the sexual instinct, or fear. It lies motionless among the dense water-plants of the lakes or river-banks, or among tufts of weed in the sea; hides under stones and in the crevices between them, or lies in the tunnel which it has burrowed in the mud or loose sand, its head and tail projecting at either end. Its caution is extremely great, and it avoids every suspicious object. An old tradition is current among the fishermen that if, on its migration in a river, the Eel comes to the unbarked trunk of a birch-tree placed across the channel, it halts; and by laying down such obstacles they force it to take the path leading into Eel-weirs or similar contrivances. LINNÆUS makes reference to this in his "coercetur trunco albo Betulæ." To changes in the weather it is very sensitive, and becomes greatly distressed and very restless in a thunderstorm, quitting its retreat, and falling an easy victim to the seine. In winter it burrows to a depth of several feet in the mud, and lies torpid, often in large companies, to escape the cold. But it may be frozen, though not too hard, and again thawed to life. Its tenacity of life is known to most by experience. Though skinned and chopped to pieces, it still moves. Its sufferings, before death finally releases it, must awake the pity of all. Ghastly is the description given by JACOBY[a] of the Eel-roasting carried on by the Italians at Comacchio. "A large establishment for the roasting of Eels is a sight during working-hours that none will forget. You see before you a living picture of hell, where the damned suffer all the torments that the pious imagination of mediaeval painters could conceive; and you are surprised at every moment by the perfect resemblance to the work of their pencils. In the background a huge door opens now and then, to let in the full flood of daylight. Through the door and over the murky water of the canal a rower guides his broad boat, mouthing execrations. He brings with him the souls of the damned, the Eels, which lie in writhing heaps at the bottom of the boat. The victims are now scooped up with nets and thrown into tubs. In front of each tub sits a fiend, armed with a sharp hatchet. He chops into three or four pieces the wriggling bodies of the large Eels, which vainly strive to escape. The small Eels are cast as they are, together with these pieces, into other tubs. The work is now taken up by other hands, with another diabolical duty to perform, that of spitting on huge skewers, up to two yards long, the pieces and the live Eels in coils, one after another. The spits, loaded with the still writhing pieces and the wriggling small Eels, are now taken to the fire. Eight or nine large furnaces, heated with great blocks of wood, spread a violent heat over a great portion of the dusky room. In each furnace, before and in the fire, hang seven or eight of these loaded spits. They are kept turning by women, who in face, age, and figure harmonize well with their infernal surroundings. Each gang of workers, men and women, chants its song, the flames roar, the smell of burning fat rises from the victims, and the picture of hell is almost complete." Man is here no more merciful than the beasts, which in the struggle for existence reck little of each other's sufferings. A different proof of the Eel's endurance was afforded us by the dissection of a porpoise that had been found dead in the Cattegat off the coast of Bohuslän on the 29th of April, 1878. In the abdominal cavity lay a dead Eel 465 mm. long. It had evidently been swallowed alive by the porpoise, but had retained strength and sense enough to gnaw its way through the wall of one of its devourer's stomachs into the abdominal cavity, thus inflicting death on the porpoise, though itself unable to escape from its prison[b]. In spite of these powers of endurance it is easy enough to make a wriggling Eel lie still. Only cut a slit across the hind part of the tail; and so great is the sensitiveness of this part that the Eel becomes motionless, probably with pain.

The Eel feeds principally by night, the time when it is most active in every way. Even in the daytime it may be enticed with a tempting bait, but, as a

[a] *Der Fischfang in der Lagune von Comacchio nebst einer Darstellung der Aalfrage*, Berlin 1880, p. 83.

[b] Cf. above, p. 621, DARWIN's anecdote of a *Diodon*.

rule, only when the water is turbid after a storm or in wet weather. It devours almost all animal food, live or dead, fresh or putrefied, that it can swallow. The small Eels content themselves with lower marine animals of every kind, small crustaceans (Gammarids), worms, and mollusks. Their elders begin with small fishes, such as Sticklebacks, Sand-eels, and Lampreys, and often gorge themselves with fish-roe. In fresh water they wage a ruthless war of extermination against the crayfish, which they most appreciate just after the old shell has been cast, and while the new one is still soft. They also attack one another; and instances are recorded of the victor in these combats being suffocated by its prey. The latter, the head of which was already swallowed, had bent its tail right back and forced it out through the gill-opening of its captor. Soon they do not shrink from assailing higher animals, such as frogs, young waterfowl, and water-rats. They even pursue the water-rats into their subaqueous holes, and Eels are frequently found that have turned these into their own hiding-places. But vegetable substances, such as grains of corn, demonstrably enter into their diet[a]; and FEDDERSEN relates[b] that at Copenhagen it was a popular diversion to feed the Eels in a pond in Örsted's Park with bits of bread. The voracity of the Eel thus renders it omnivorous.

In this connexion we may consider an observation repeated on many occasions, but as often explained away or even ridiculed: — the Eel, like the above-mentioned Climbing Perches (*Labyrinthici*), voluntarily travels in quest of food by land. "The Eel is said sometimes by night to crawl out of the water on the fields where it finds lentils, peas, or beans sown", wrote ALBERTUS MAGNUS in the 13th century. "This migration", wrote BOCK[d] in the 18th century, "explains the mysterious fact that in Prussia and Pomerania fish are caught on dry land and with the plough. On warm nights, when the Eels betake themselves to the peas, the peasants plough a few furrows along the water towards dawn, before the day has broken; and these are the nets in which the Eels are taken. For, though the Eel can drag itself along on the grass, its retreat is cut off by the upturned sods. The rustics consider it a sign of approaching storm when the Eel quits the water for dry land." The Royal Museum possesses in its collection of manuscripts a communication made to Prof. B. FRIES in 1836, and relating how the Dowager Countess B. M. HAMILTON in the early part of the century instituted the most cautious observations of some Eels and caused their capture during their land excursions on her estate. They wandered of a night from Lake Hedenlunda into a field, and ate pea-pods "with a smacking sound, like that made by sucking-pigs when they are eating. . . . . On investigation it was found that the pods were not gnawed in pieces or eaten up, but that the Eels only consumed the outer soft and juicy skin covering the young pods; and after this discovery the Eels, which were kept at Hedenlunda in a live-well, were fed with pea-pods." The communication further contains a description of the acuteness with which the Eel apprehends the slightest noise, even on land, and the celerity with which it then retreats to its proper ele-

Fig. 277. Intestinal worm (*Ascaris labiata*) of the Eel compared with a young Eel of the same size. After BENECKE.

ment. EKSTRÖM rejected all similar anecdotes as fables; NILSSON assumed that the Eel's object in these journeys was the quest of a food more suitable than peas, namely slugs (*Limax*). This opinion may be more reasonable, but credence can no longer be refused to the above-cited observations, for we have evidence from other sources of the Eel's taste for vegetable food.

The propagation of the Eel was a riddle for thousands of years, and has given rise to the most marvellous conjectures. According to ARISTOTLE[f] no one had found eggs in the Eel up to his time; but even then its intestinal canal had been observed to contain "hair-like or worm-like growths" (fig. 277), that were

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[a] See TRYBOM, Dansk Fiskeritidende, 1885, p. 411.

[b] Same periodical, 1885, p. 341; 1891, p. 397.

[c] Quoted by SIEBOLD, l. c., p. 314.

[d] *Wirtschaftl. Naturgeschichte von dem K*[illegible] Ost- [illegible] *Westp*[illegible] 1784, quoted by BENECKE, l. c., p. 175.

[e] *Skand. Fau. Fisk.*, p. 669.

[f] *Anim. Hist.*, lib. IV, cap. XI.

supposed to be young Eels, a mistake against which he cautions his readers, but which often crops up, even in modern times. He believed that Eels were born of worms generated in the sea by decaying weed and on the shores of fresh water by mud under the influence of heat[a]. According to PLINY[b] the Eels rub themselves against the rocks, and what they thus scrape off their bodies comes to life. According to RONDELET[c] even ATHENÆUS and OPPIAN (2nd and 3rd cent., A. D.) had seen Eels knot themselves together in bunches; and they believed that the slime the Eels thus pressed out of one another's bodies received animation. The old tale of the Eelpout (*Enchelyopus*, see above, p. 607) as "Eel mother" can be traced in literature back to ALBERTUS MAGNUS. With these conjectures the *Eel question* was dismissed throughout the Middle Ages; and the founder of modern ichthyology, ARTEDI, refrained from touching the point in his writings[d]. TISELIUS, a Swedish rector and a contemporary of his, had, however, published at Upsala in 1723 an "*Utförlig beskrifning öfver den stora Sjön och Götha Sjön Wätter*", where he relates (p. 113) that "in several Eels, close to the small of the back and the spine, has been seen a fine and handsome roe of a reddish appearance". This observation probably refers to the kidneys of the Eel, but perhaps to the true ovaries. The first discoverer of these may thus have been a Swede; but in scientific literature the Italian MONDINI[e] and the Danish naturalist O. F. MÜLLER[f] are generally mentioned as rivals for this honour. The ovaries were more thoroughly investigated by RATHKE[g] and HOHNBAUM-HORNSCHUCH[h]. The male organs of the Eels were not discovered until more recent times. RATHKE indeed speaks in several passages[i] of such organs, but whether he referred to the true testes, or had any knowledge of their structure, seems more than doubtful, for he so expressly states that they are without efferent duct. SYRSKI[j] was the first to publish more accurate information of these organs, and since then BROCH[k] and RYDER[l] have been the principal contributors to the elucidation of questions connected herewith.

The first observation from which we can derive a positive opinion as to the breeding of the Eel, is old enough, even in a literary sense. ARISTOTLE was quite aware that the Eel goes out to sea, but he expressly denied that these wanderings were due to sexual instinct, the Eel being destitute, in his opinion, both of semen and ova. From the middle of the 17th century, however, it has been known that the Eel breeds in the sea. We are told by FRANCISCUS REDI[m]: "Now there are other fishes that pass the greater part of their life in fresh water, but resort to the sea for the purpose of disburdening themselves of their seed. Thus I have arrived, by means of numerous and long continued observations, at the conclusion that year by year, as soon as the rainy season sets in about the month of August, especially on dark and cloudy nights, the Eels repair in great numbers from rivers and lakes to the sea, where they deposit their germs. The small Eels born of these swim up the mouths of the rivers into fresh water earlier or later, according as the weather is more or less severe, towards the end of January or just in the beginning of February, so that the migration is commonly over by the end of April. They do not arrive in one body, but in several detachments and at varying intervals. They come in such numbers that some fishermen whom I commis-

[a] There are several mediæval receipts for the breeding of Eels by laying two moist sods with the grassy sides together.

[b] *Hist. Mundi*, Lib. IX, cap. 50.

[c] *De Pisc. fluv.*, p. 199.

[d] LINNÆUS (*Syst. Nat.*, l. c.) based his opinion on FAHLBERG's communication to the Swedish Academy of Science in 1750 of the discovery of young in the intestine of Eels, a repetition of the old confusion with intestinal worms.

[e] *De Anguilla ovariis*, communicated to the Academy of Bologna in 1777, but not printed until 1783.

[f] *Underbrochne Bemuhungen bei den Intestinalwurmern*, Schr. Berl. Ges. Naturf. Freunde, vol. I, 1780, p. 204.

[g] *Beitr. Gesch. Thierw.*, 2:te Abth. (Schr. Naturf. Ges. Danzig, Heft. III), pp. 121, 161, 175; *Weibl. Geschlechtw. Aal.*, Arch. Naturg. 1838, p. 299; *Bemerk. hochtr. Aal*, Arch. Anat., Phys. 1850, p. 203.

[h] *De Anguill. sexu et gener.*, disp. Greifsw. 1842.

[i] *Beitr.*, l. c., pp. 183, 186, 196.

[j] *Über die Reproductions-Organe der Aale*, Sitsber. Akad. Wiss. Wien, LXIX, 1 (1874), p. 315.

[k] Mith. Zool. Stat. Neap., Bd. 2, p. 415.

[l] Bull. U. S. Fish. Comm., 1885, p. 1.

[m] FRANCISCI REDI, *Opusculorum pars tertia, sive de animalculis vivis quæ in corporibus animalium vivorum reperiuntur, observationes.* Ex Etrusci Latinas fecit PETRUS COSTE, Lugd. Batav. 1729, p. 99

sioned in 1667 to fish the River Arno at Pisa between the bridge nearest to the sea and the middle bridge, took within the space of five hours more than 3,000 pounds of Eels in seines alone. Another fisherman of the same river, only half a mile (5,000 paces) from the sea, caught just at daybreak more than 200 pounds of Eels which were so young and small that about 1,000 of them went to the pound — I mean a Tuscan pound, which contains 12 ounces. But not all the Eels are of the same size when they enter fresh water"; by far the greater number measure, according to his appended figures, about 35—55 mm., the remainder about 70—140 mm. On the same experience the great Eel-fishery of the lagoons off Comacchio, at the mouth of the Po, has been based since time immemorial. Here the extensive system of lagoons has been divided by means of dams and dikes into broads and canals, where the Eels can lead their fresh-water life. Every year, on the 2nd of February, all the sluices are opened, free ingress from the Adriatic being thus afforded to the ascending Elvers, which struggle up against the current, swollen as it is by the winter rains. By far the greater number of them are under 6—8 mm. in length, according to JACOBY. On fine days they keep to the bottom; at night and in cloudy weather they swim nearer to the surface. This *Eel-fare*, called by the Italians *montata* (the French *montée*), lasts three months. Towards the end of April the sluices are closed. They are again opened at the end of September, when the summer drought has so reduced the volume of the lagoons that the water of the Adriatic streams in. At this season the sexual instinct awakes in the old Eels — from 4 to 6, or, according to some, as much as 10 years of age — and they set out on their seaward migration. But their path is barred by the fisherman's devices; intricate systems of weirs guide them into large baskets, where the Eels first congregate, to be afterwards transferred to the broad boats which we have mentioned above. This fishery with all its contrivances depends on a knowledge of the migrations undertaken by the Eel, and was already old when TORQUATO TASSO, in his *La Gerusalemme Liberata*, compared TANCRED in the ambush to the Eels in this labyrinth.

In Sweden too, time out of mind, the fisherman has set Eel-nets (*lanor*) and constructed Eel-traps with the entrance opposed to the stream for the admittance of the descending Eels. In our rivers and lakes this downward migration begins in May, but does not become general until the dark nights set in, towards the close of August. "In the neighbourhood of Upsala", writes SUNDEVALL, "Baron CEDERSTRÖM was informed that before midsummer the Eels haunt the large beds of reeds and horsetail on the lower course of the Fyris. During July ("till St. Olaf's Day", the 29th), when these reed-beds are cut, they descend into the arm of Lake Mälar known as Ekoln, into which the Fyris falls. At the beginning of August great quantities of Eel are taken there on long-lines with 100 hooks. The Eels proceed down this bay to Sko Land, the south coast thereof, where the depth is greatest, measuring 20—30 fathoms. Here they are taken for a short time in the middle of August, after which they disappear". During its sojourn in fresh water the Eel retains its keen appetite; but less and less food is consumed as the sexual instinct asserts itself, and as the true migratory dress, the pale belly, is adopted. Frequently the migrating Eels knot themselves together in bunches, and large bundles, often a fathom in circumference, are seen lying still in the lakes or trundling down the streams. On reaching the sea the Eel proceeds on its way to the spawning grounds. Their situation has not yet been ascertained; but CALDERWOOD[a] mentions a female 29½ in. (749 mm.) long and "almost ready to spawn" that was taken on the 27th of December, 1892, about 12 miles south of the Eddystone, or 20 miles from the nearest point of land, Rame Head. That the Eel of Swedish waters spawns partly in the Baltic, seems probable, young Eels 7 or 8 cm. long having been found both in the Roslag (Upland) and in the Ljusne Elf[b]. But the main body of the Swedish migratory Eels roves along the Baltic coast and round Scania out through the Sound, perhaps too, in company with Russian and German Eels, through the Belts. That the Eel spawns in the Cattegat, is proved by the multitude of Eel-fry ½—1 dm. long so often to be observed in spring and summer all along the west coast of Sweden making their way into fresh water. In the north of the Sound, nearer to the Swedish than to the Danish coast, is a deep channel with more than 10, in places 20 fathoms of water, where Eel-fry occur in myriads during win-

[a] Ann., Mag. Nat. Hist., ser. 6, vol. XII (1893), p. 35.
[b] LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 392.

ter. "And here", says VILLUMSEN[a], "it may often be observed how the Cod in winter disgorge from their crammed stomachs extremely small and semi-transparent young Eels, only 5—8 cm. long. Food digests rapidly in the stomach of a Cod, and as the disgorged Eels are fresh and entire, we may safely conclude that they have been swallowed quite recently and thus on the spot. I have also seen them jump alive from the jaws of the Cod, which had probably seized them at the same moment as it took the fisherman's bait. The bottom in this part of the channel consists of mud mixed with clay, and must be tenanted by multitudes of Eel-fry, for sometimes every single Cod has secured a number of them. It cannot well be assumed that these frail creatures swim freely about at a time of year when the larger Eels eagerly take refuge in the security of the bottom. It is more probable that they lie concealed in the mud, but that the Cod knows how to rout them out from their hiding-places. This opinion is supported by the fact that the stomach of the Cod also contains other inhabitants of the mud, such as Ascidians, Holothurians, worms, etc."

"The Eel lays its eggs in the mud", writes DESMAREST[b], "after a kind of copulation. The eggs are bound together by a slimy mass like that which envelops the ova of the Perch, and form small clues or round balls. Each female, as we have ascertained by personal observation, annually lays several of these agglomerations. The fry are soon hatched, but remain for some days after exclusion within the said balls. When the fry have attained a length of 4—5 cm.[c], they liberate themselves from the bonds that confine them, and ascend the neighbouring rivers in dense and extremely numerous bodies".

Not all the Eel-fry, however, repair to the rivers at this age. A great number pass one or two years in the sea[d], and are 2—4 dm. long when they undertake the ascent. At Elfkarleby fry of this size make their way up the Dal Elf, where they are called *Alrimmor* or *Alrimmer*[e], without intermission from July till October, but mostly in September. These *Alrimmor* or Elvers are the *Civelles* of French rivers. When they have grown somewhat larger, and are found among the seaweed of the littoral regions or the grass of the lakes, they are known in Sweden as *Gräs-ål* or, on account of their watery flesh, *Blot-ål*, in Denmark as *Visse-ål*.

We have still to consider the question whether the Eel also breeds in fresh water. As we have seen, this is hardly probable. Eels occur, it is true, in tarns of great elevation and in isolated pieces of water which seem to be cut off from the sea by barriers impassable to a fish. But Eel-fry have an almost incredible capacity of penetrating or circumventing obstacles in their path, and their elders can also travel by land. Observations have been made, however, which are at least easiest of explanation on the assumption that the Eel propagates in fresh water as well as in salt[f]. TRYBOM states (l. c.) that "in 1864 1,000 young Eels were transplanted from Elfkarleby to Lake Hagel in Dalecarlia. The lake has no outlet, and no Eels had previously been found in its waters. In 1871 Eels weighing $1^1/_4$—$1^1/_2$ kilo. were taken there, in 1872 specimens that turned the scale at 1·7, 2, and even 3·4 kilo. In the summer of 1879 small Eels weighing only $^1/_5$ kilo. as well as larger ones were caught. Eel-fry have been planted in the lake on only one occasion". Only a few years ago it was supposed that male Eels occur in the sea alone, and do not ascend, at least not in any great number, into fresh water. It was consequently inconceivable that the Eel should multiply in fresh water. But the collections of the Royal Museum had contained ever since 1844 a male Eel 23 cm. long, taken by Lieutenant ROBSAHM at Trollhättan; and in 1880 HERMES[g] found 13 male Eels in the Elbe off Cumlosen, near Wittenberg, about 25 German miles from the mouth of the river. Recently (the middle of June, 1893) at Silkesborg Papermills and Holm Mill, in the Eel-traps

[a] Dansk. Fiskeritidende, 1892, p. 15.

[b] CHENU, *Encycl. d'Hist. Nat., Rept., Poiss.*, p. 328.

[c] But cf. JACOBY's statement, mentioned above, that most of the young Eels on their upward journey at Comacchio are only 6—8 mm. long.

[d] In the old outlet of the River Nissa, the so-called Svinbäck, open towards the sea, but now almost choked up, Eel-fry $^1/_2$—1 dm. long used to take up their summer quarters without evincing any migratory tendencies; and the boys of Halmstad amused themselves by wading in the shallow water to frighten these young Eels out of the mud and clay and catch them.

[e] SUNDEVALL, Stockh. L. Hush.-Sällsk. Handl. 1855, p. 92; TRYBOM, Landtbr. Akad. Handl., Tidskr. 1881, *Om s. k. Alrimmer* etc.

[f] See for example LEWIN's remarks in WITTMACK, Deutsch. Fisch. Ver. Circular, No. 1 (1875), p. 127.

[g] Bull. U. S. Fish. Comm. 1881, p. 98, and Mitth. Sect. Kust., Hochseef., Deutsch. Fisch. Ver., 1893, p. 113, not. 2.

of the Guden, which falls into Randers Fjord (the Cattegat), FEDDERSEN[a] found among descending Eels $2\frac{1}{2}$—4 dm. long numbers of males with yellow belly, amounting at the first-mentioned place to 80 per cent of the catch. In Lakes Hjul, Bras, and Avn, within the same river-basin, similar males were taken with Eel-seines. A month later (15th—17th July) the males in and near the Lakes of Silkesborg had begun to develop the white belly of the migratory dress, but judging by the take were fewer. He made similar observations at Maarup Mill, between Lakes Orum and Ove, on the other side of Liim Fjord, and in Westen-see (Province of Rendsburg, Holstein). It thus seemed probable at all these places that a descent of young Eels, especially males, takes place in summer, before the general descent of older females commences. The males, like the females, consequently spend a portion of their life in fresh water; but the assumption that the Eel spawns in fresh water, side by side with its normal breeding-season in the sea, first requires authoritative confirmation.

Not all the Eel-fry, as we have seen, ascend into fresh water during the first year of their existence; nor do all females of a size that indicates maturity undertake migrations. In the lagoons of Comacchio the fishermen have long been aware of this, and call the large Eels that do not migrate *Pasciuti*[b]. Near the same locality these forms are also found in the sea, off the coast; and JACOBY described them as broad-snouted, small-eyed, yellow-bellied, high-finned, and with glassy ovaries, destitute of fat and containing transparent eggs with little, if any, granulation. He explains them too as sterile females; but whether this sterility is permanent or temporary, still remains an open question, for many broad-nosed Eels have ovaries of normal development. In Sweden they are known on account of their voracity as *sluk-ål* (ravenous Eel), the Danish *klæpal*. They do not rove in shoals, but lead a more solitary life; yet are often caught, for they freely take a hook, the best bait being Roach. JACOBY extols their delicious flesh, "which melts in the mouth". KRÖYER describes their flesh as hard, dry, and lean, and their skin as hard and tough. The difference may easily be due to the recency or remoteness of the spawning-season.

In recent times ichthyologists have been most inclined to the belief that after spawning the Eel dies[c]. This opinion may be correct, for it is partly true of the Salmonoids, and applies to the Lampreys, from which the Eels do not differ widely in the structure of the generative organs. On one or two occasions dead Eels, spent, as it is stated, have been found on the seashore, and a skipper is said to have sailed some distance in the North Sea among dead Eels, floating at the surface. Large Eels have never been found migrating in any number to fresh water. But this is no adequate solution of the point, for that a re-ascent may take place, though it is seldom observed, appears from ROBIN'S[d] discovery of female Eels, with the stomach full of marine animals — Annelids (*Eunice sanguinea*) and shellfish (*Doris*) — which they had brought far up the Adour, 40 kilom. from the sea. The so-called *blötalar* and *slukalar* in the sea must also be taken into consideration. They are demonstrably not always sterile, nor has it yet been proved that the larger among them have never spawned.

The Eel is greedily preyed on by mammals, such as otters, seals, and dolphins, by piscivorous birds, and by larger fishes; but its most destructive enemy is undoubtedly man. To a good digestion its flesh is one of the most excellent foods, whether boiled or fried — less indigestible in the latter form — fresh or salted, smoked or marinaded. The young are made in many places into *Eel-cake* (cf. above, p. 973). The tough skin of the Eel has been most generally employed as material for flail-thongs.

The great Eel-fisheries have contributed in a high degree to our knowledge of the Eel's habits, for the method of setting his tackle which the fisherman has learnt from the experience of ages best indicates how the Eel comes and goes. When the Eel descends the rivers, large or small *lanor*, a kind of seine with fine meshes in the bosom, are stretched across the channel, or Eel-traps (*ålhus*) are constructed in the slopes of the streams. These are timbered like log-houses, but on the lower side chinks are left between the logs, wide enough to allow of the passage of the water, but too narrow for the Eel to slip through. On the side facing the current a hole is made, in which is inserted a

[a] Dansk Fiskeritidende 1893, p. 333.

[b] "Pasturers".

[c] See JACOBY, l. c., p. 55.

[d] Comptes Rendus, Fevr. 21, 1881, p. 382

trough or wooden pump-barrel, blackened lest it should frighten the Eel, and with the inner end raised high enough above the level of the water in and below the trap to cut off the Eel's retreat. When the trough is closed, the water runs out of the trap, and the Eels are fished up. On the same principle *ålkistor* are con-

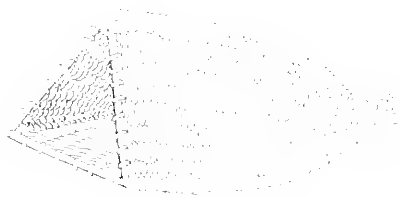

Fig. 278. Eel-basket.

structed beside mills and other waterworks; but their lower end is generally closed with a fine iron grating. Into Eel-trunks (*brädsumpar*), which are placed in a strong current, the Eel is guided by two converging rows of freshly peeled, white stakes or unbarked birch-trunks. Wherever the Eel is known to have its haunts in fresh water, among the reeds and in calm inlets, Eel-boxes (*ål-lådor*) are sunk, lined with woolly sheep-skin, the wool facing inwards, and pierced with round holes 3 or 4 cm. wide. At these holes the sheepskin is slit up crosswise, and the strips are left hanging

Fig. 279. Eel-spear.

there. The Eel-box is baited with pieces of meat or the like wrapped in fresh pea-haulm, and the box is then left in a fathom or two of water for a week or so, when it is examined, and moved to another locality, if the catch is too poor. In the same way Eel-baskets

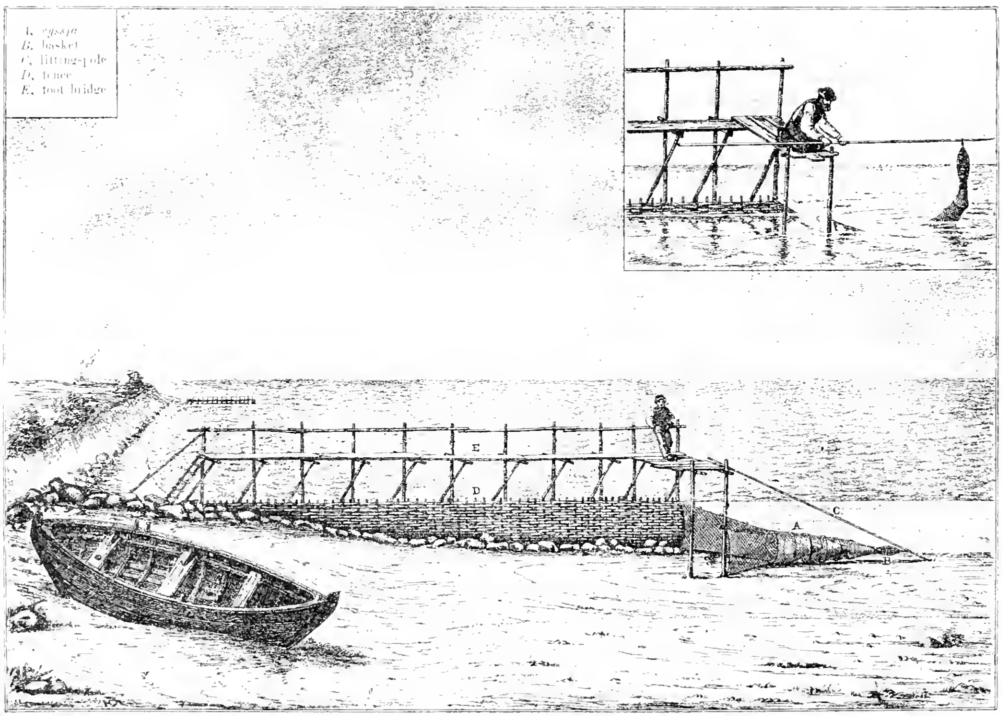

Fig. 280. Danish Eel-weir. After DRECHSEL.

(*alkupor*, fig. 278) are set, constructed on the same principle as *mjärdar* (see above, p. 32), but triangular, woven with osiers or thin deal splinters, and with a round wooden plug to stop the opening at the narrow end. With the setting of Eel-lines all our readers are, no doubt, familiar. They may be baited with fish, if possible alive, shrimps, or worms. Eels may also be taken with an ordinary hand-line, baited with worms or fish-offal — pyloric appendages are best — but the bait must lie on the bottom. With the Eel spear (*ljuster*, fig. 279) much Eel is caught, both in winter and summer. Where the Eel lies hidden in the mud, or among the grass or weed, air-bubbles rise to the surface. In winter these bubbles stop under the ice, and show the fisherman where to strike: in summer he watches for them in smooth inlets, or where the current is not strong, and there the Eel lies of a morning, with its head turned towards the sun. The fisherman thus knows where to plunge his spear so as to transfix the Eel, even without seeing it. In many places, as in the island-belt of Blekinge[a], the Eel-spearer strikes blindly in the bottom (*harkning, hattning*, or *pattning*), doing more harm than the catch can repay. In Germany and Denmark much use is made of the so-called *al-rad* (Eel-seine), either the *drif-rad* (drift-seine, Germ. *Zeesen*), a net for bottom-fishing, plied from a sailing-boat, and with a double bag as in the trawl, or the *handrad* (*pulsrad, bott-rad, ankar-rad*, or *sumre-rad*), manipulated from a rowboat, and with a simple bag. Large or small seines (*strandvadar*) are also drawn from the shore. Or the fishermen wade out with an *alglip*, a square scoop-net, which one of them holds on the bottom, while the other splashes in front of him, to drive the Eels into the net. But the most valuable Eel-fisheries depend on the migrations of the Eel in the sea. In Denmark Eel-weirs (*algardar*) have been constructed from prehistoric times. These are rows of stakes, or fences woven with brush (fig. 280), running straight out from the beach, and with an *al-ryssja* (*hommor*) at the outer end. Or there, as on the Swedish coast, only *hommor* are used, set singly or in a row, one outside the other (fig. 281). These constructions have conferred names on the mi-

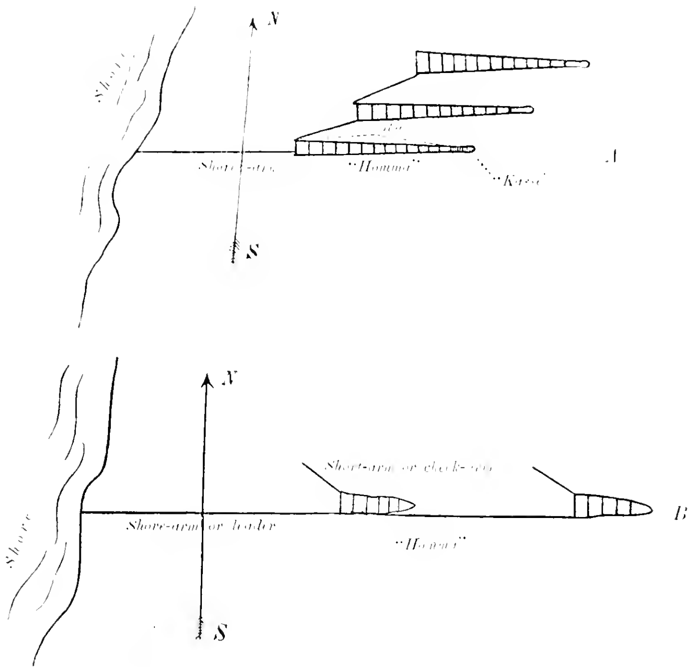

Fig. 281. Different methods of setting *alhommor*. *A*. from the Province of Calmar; *B*. from Blekinge and Eastern Scania. After LUNDBERG.

[a] See *Förslag till ny fiskeristadga*, Stockh. 1883, p. 94.

grating Eels, *gard-al* in Denmark, *hom-al* in Sweden. The *hommor*[a] are one-armed or two-armed, furnished in the latter case with a long arm and a short one, the former (the leader or *lang-arm*) to guide the Eel into the *homma* itself (*hatt*), the latter (the check-arm or *gin-arm*) to head off the fish and prevent them from passing the opening. At the outer end of the *homma* an Eel-basket (*kasse* or *tina*) is set, out of which the Eel cannot creep back. The whole engine is firmly anchored to the bottom with large stones, and the basket is secured in a sled-shaped wooden frame. When the Eel, on its migration along the east coast of Sweden, comes from the north and north-east, along the south coast from the east, and in the Sound from the south, the *hommor* must be placed with the opening on that side of the leader from which the Eel approaches. The same rule applies, of course, to the position of the *al-ryssja* at the outer end of the Eel-weirs, where the weir may be lengthened by setting more *ryssjor* outside. The season lasts through the closing months of the year, dark and stormy nights and land-winds being most favourable to the fishery. Most of the Eels taken on the east coast of Sweden are sold alive to Germans who sail in their well-boats (*qvasar*) along the coast, buying up the supply.

The value of the Eel-fisheries in Scania and Blekinge, according to LUNDBERG[b], was in the years

1882	£8.240.
1883	£11.604.
1884	£15.691.
1885	£14.846.

the price fetched in Scania being about 1s. 1d., in Blekinge about $10\frac{1}{2}$d. per kilo. The statistics of the Eel-fisheries in other parts of Sweden are extremely defective; but we probably do not exaggerate in assuming that the Eel affords our country an average annual income of between £16,500 and £22,000. In Denmark the Eel-fishery is still more productive, and its combined annual value in the two countries certainly exceeds £55,000.

GENUS CONGER.

No scales in the skin. One row of jaw-teeth larger than the rest and transversely compressed at the base, but more or less sharpened at the tip in the longitudinal direction of the jaws. Vomerine teeth set in a card containing several rows.

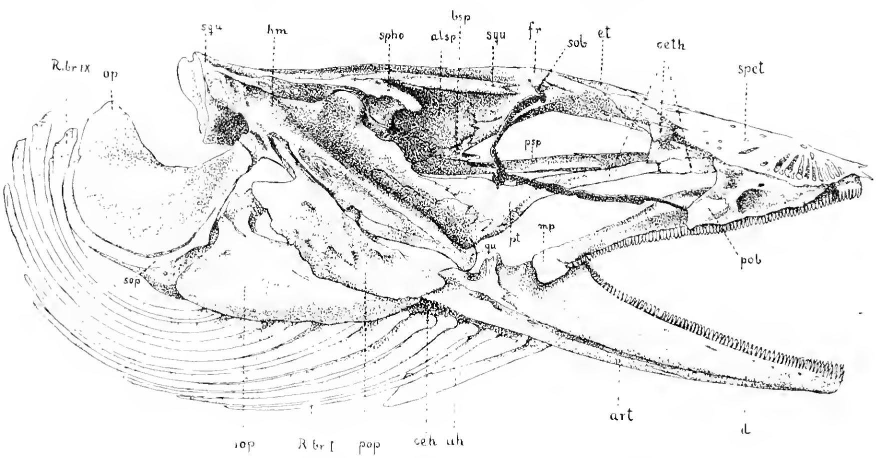

Fig. 282. Bones of the head in a Conger (*Conger niger*).

alsp, alisphenoid; *art*, articular part of the lower jaw; *bsp*, basisphenoid; *ceh*, ceratohyoid; *ceth*, cartilaginous parts of the ethmoids; *d*, dental part of the lower jaw; *et*, ethmoid; *fr*, frontal; *hm*, hyomandibular; *iop*, interoperculum; *mp*, maxillary (maxillo-palatine); *op*, operculum; *pob*, preorbital (first suborbital); *pop*, preoperculum; *psp*, parasphenoid; *pt*, entopterygoid; *qu*, quadrate; R. br. I—IX, first—ninth branchiostegal rays; *sob*, hindmost suborbital bone; *sop*, suboperculum; *spet*, supraethmoidal (nasal); *spho*, postfrontal (sphenotic); *squ*, squamosal; *uh*, urohyoid.

[a] A minute description of this fishery may be found in LUNDBERG, *Om ålfisket med s. k. hommor vid svenska Östersjökusten samt Öresund*, Landtbr. Akad. Handl. och Tidskr. 1881.

[b] *Meddelanden rörande Sveriges Fiskerier*, Part. II (1888).

The genus of the Congers, which as defined above, after KAUP[a], contains a few (3 or 4) ascertained species, in the essential form of the body and fins resembles the preceding genus, only that the dorsal fin commences further forward. The character afforded by the form and distribution of the teeth (fig. 282) distinguishes it not only from the preceding genus, but also from three other genera[b] belonging to the family of the Eels. The most important skeletal differences from *Anguilla* are remarked above. Here we shall merely add that the nasal (supraethmoidal, *spet*) bones covering each nasal cavity are more developed in *Conger*, being indeed thin, but broad, and broken up anteriorly into a grating, with the openings set transversely or, at the extreme front, directed forwards.

The generic name had a specific signification in LINNÆUS, and ought indeed to have retained this capacity; but CUVIER[c] raised it to its present rank, which it has uniformly preserved in the system. Now that it has been proved (see above) that the formerly recognised genus *Leptocephalus*, which has occupied a place in the system since 1763, consists of larvæ and degenerate forms, belonging in great part to the species of the common Conger, it may well be asked whether the Cuvierian generic name ought not to be replaced by the Gronovian. But at present, so long as there are *Leptocephalus* forms which cannot be referred with certainty to any definite species, the alteration might easily cause confusion[d]. Furthermore, *Conger* has been known as a generic name ever since the time of ARISTOTLE[e], and in the works of BELON[f], RONDELET[g], and WILLUGHBY[h].

THE CONGER (SW. HAFSÅLEN).

CONGER NIGER.

Plate XLV, fig. 2.

Distance between the dorsal fin and the tip of the snout about 1/5[i] of the length of the body, or at most about 1/2[j] of that between the anal fin and the same point. Length of the snout 1/4 or more of that of the head, which measures 2/3—3/4 of the distance between the dorsal fin and the tip of the snout. Length of the pectoral fins about 1/4—1/3 of the last-mentioned distance.

R. br. 9[k]—10; *D.* ca 275—300; *A.* ca 205—225; *C.* 10; *P.* 17[l]; *Vert.* 153—156[m].

Syn. *Muræna* supremo margine pinnæ dorsalis nigro, ART., *Ichthyol.*, *Gen.*, p. 24; *Syn.*, p. 40.

Muræna Conger, LIN., *Syst. Nat.*, ed. X, tom. I, p. 245; BL., *Naturg. Ausl. Fisch.*, pt. II, p. 37, tab. CLV; AHL (*Ophichthus*), *Mur.*, *Oph.* (disp. Ups. 1789), p. 11; MITCH. (*Anguilla*), Lit., Phil. Trans. N. York, vol. I, p. 360; PALL. (*Muræna*), *Zool. Ross. Asiat.*, tom. III, p. 72; NILSS., *Prodr. Ichthyol. Scand.*, p. 64; KR. (*Anguilla*), *Danm. Fisk.*, vol. III, p. 603; NILSS. (*Muræna*), *Skand. Fna, Fisk.*, p. 680; BR.-GOODE (*Leptocephalus*), *Fisher., Fisher. Industr. U. S.*, sect. I, p. 656, tab. 240.

Muræna myrus, BRÜNN., *Ichthyol. Massil.*, p. 12 (false determ.).

Echelus Macropterus, RAF., *Caratt. Alc. N. Gen.*, p. 64 (+ *E. Grumcus*, p. 65), tab. XVII, figg. 2 et 3.

Muræna nigra, RISSO, *Ichthyol. Nice*, p. 93 (+ *Mur. conger*, p. 92); JORD., GILL (*Conger niger*), Bull. U. S. Nat. Mus., No. 16, p. 362; COLL., N. Mag. Naturv., Bd. 29 (1884), p. 113.

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[a] *Cat. Apod. Fish., Brit. Mus.*, p. 111. The characters were first pointed out, however, by RICHARDSON in *Ichthyol. Ereb., Terror*, p. 107.

[b] *Ophisoma*, SWAINSON (*Congromuræna*, KAUP, GTHR), *Uroconger*, KR. and *Poecilocongér*, GTHR.

[c] *Regn. Anim.*, ed. 1, tome II, p. 231.

[d] JORD., GILL., Bull. U. S. Nat. Mus., No. 16, p. 362, note.

[e] Γόγγρος, *De Anim. Hist.*, lib. I, cap. V; lib. II, capp. XIII, XV, XVII; lib. III, cap. X; lib. VI, cap. XVII; lib. VIII, capp. XIII, XV; lib. IX, cap. II.

[f] *Nat., Divers. Poiss.*, p. 159.

[g] *De Pisc.*, lib. XIV, cap. I, p. 394.

[h] *Hist. Pisc.*, lib. 4, cap. V, p. 111.

[i] 19—20 %; in old specimens, according to KRØYER, up to 23 %.

[j] 46—52 %.

[k] Sometimes 8, according to BLEEKER.

[l] „ 15, „ „ „ , and 19, according to DAY.

[m] 154—164, according to DAY.

Conger vulgaris (*Congre commun*), Cuv., *Règn. Anim.*, éd. 1, tom. II, p. 231; Yarr., *Hist. Brit. Fish.*, ed. 1, vol. II, p. 304; Schleg. in Sieb., *Faun. Japon.*, *Pisc.*, p. 259; Bleek., *Atl. Ichth. Ind. Or.*, tom. IV, p. 26, tab. CXLIX (*Mur.* V), fig. 2; Gthr., *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 38; Coll., Forh. Vid. Selsk. Chnia 1874, Tillægsh., p. 199; 1879, No. 1, p. 99; Dareste, Arch. Zool. Expér., tom. IV, p. 227; Winth., Naturh. Tidskr. Kbhvn. ser. 3, vol. XII, p. 51; Mor., *Hist. Nat. Poiss. Fr.*, tom. III, p. 565 (+var. *nigra*, p. 566); Malm, *Göt. Faun.*, p. 559, tab. X; Mob., Heinck., *Fisch. Ostsee*, p. 148; Day, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 250, tab. CXLII, fig. 2; Storm, Vid. Selsk. Skr., Trondhj., 1883, p. 41; Lillj., *Sv.*, *Norg. Fau.*, *Fisk.*, vol. III, p. 410; Car., *Prodr. Faun. Medit.*, vol. II, p. 541.

Congrus leucophaeus, Richards., *Ichth. Voy. Ereb. Terr.*, p. 108.

Conger occidentalis, Dek., *N. York Fau.*, pt. IV, *Fish.*, p. 311, tab. LIII, fig. 172.

Conger Linnei, Malm, *Göt. Boh. Fau.*, p. 591.

Formae larvales et degeneratae:

Leptocephalus, Gronov., *Zoophyl.*, fasc. I (1763), p. 135, No. 410, tab. XIII, fig. 3; *Morris*, Penn., *Brit. Zool.*, ed. 1776, vol. III, p. 139, tab. XXV, No. 67.

Leptocephalus Morrisii, Gm., *Syst. Nat. Lin.*, ed. XIII, tom. I, p. 1150; Yarr., *Brit. Fish.*, ed. 2, vol. II, p. 311; Kp., *Cat. Apod. Fish.*, *Brit. Mus.*, p. 147; Couch, *Hist. Fish. Brit. Isl.*, vol. IV, p. 318, tab. CCXXXVIII, fig. 2; Gthr., *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 139; Mor., *Hist. Nat. Poiss. Fr.*, tom. III, p. 567.

Helmictis punctatus, Raf., *Ind. Ittiol. Sic.*, p. 62, tab. II, fig. 3; Kp. (*Leptocephalus*), l. c., p. 148, tab. XVII, fig. 8 — sec. Mor.

Leptocephalus Spallanzanii, Risso, *Eur. Mér.*, tom. III, p. 205; Kp., l. c., tab. XVII, fig. 7 — sec. Gthr.

Leptocephalus Gussonii, Cocco, Isis 1831, p. 1340 — sec. Kp. et Gthr.

Leptocephalus candidissimus, Costa, *Faun. Reg. Nap.*, *Pesc.*, Malacott., Apod., tab. XX — sec. Kp., (?) sec. Gthr.

Leptocephalus inaequalis, Facciola, Atti. Soc. Tosc. Sc. Nat., vol. VI, fasc. 1; Natural. Sicil., Anno XII (1893), p. 194.

Obs. Dareste proposed (l. c.) to unite with this species, or at least to regard as a variety thereof, the East Indian and East African *Conger marginatus*, Val., Gthr. = *Conger Noordzieki*, Bleek., and judging from the variability of the preceding species, there would seem to be good reasons for this opinion. But apart from the more elongated (shallower) form of the body, the higher dorsal fin, and the black-spotted pectoral fins, characters of *Conger marginatus* that Bleeker in particular laid stress upon, we find a remarkable difference in the shorter trunk of the last-mentioned species — the beginning of the anal fin being seperated from the tip of the snout by a distance of about 36 % of the length of the body — and in the commencement of the dorsal fin being still more advanced — the length of the head measuring about 79 or 80 % of the distance between the dorsal fin and the tip of the snout. In these respects the species is consequently still farther removed from the preceding genus than *Conger niger*.

The Conger, in Sweden known as the *Hafsal* (Sea-Eel) or sometimes, in Bohuslän, as the *Konger-al*, so closely resembles the Common Eel in the form of the body that no long description is necessary. The most prominent differences from the preceding species are the greater extension in a forward direction of the dorsal fin, the more pointed tail, the longer snout, and the larger, more oval eyes. As a rule too the Conger is distinguished by its far more considerable size. In Scandinavian waters it is, we may almost say, rare to find Congers so small that they might be mistaken for Common Eels, though Kroyer mentions a specimen 34 cm. long. The maximum length which can be assigned with certainty to the Conger is about $2^1/_2$ m. Day mentions a specimen of this length and weighing 58 kilo. The largest specimen Collett had heard of from the Norwegian coast was taken at Farsund in September, 1883, measured nearly 23 dm., and weighed 25 kilo. The greatest depth of the body in small Congers is about 5 %, in large ones about 10 or 11 %, of the length of the body, except in the case of females with belly monstrously distended by the tumid ovaries.

The length of the head commonly varies between about $13^1/_2$ and $15^1/_2$ % (sometimes as much as 17 %) of that of the body. Its form is the same as in the preceding species, with the above-mentioned exception that the snout is longer, and the tip of the snout usually projects beyond that of the lower jaw, though this is by no means constant, both jaws being sometimes of equal length. The eyes are oval, sometimes so distinctly that the vertical diameter is only $^3/_4$ or even $^2/_3$ of the horizontal, sometimes, in old specimens, less perceptibly. During the growth of the Conger from a length of $3^1/_2$ to one of 16 dm. the longitudinal diameter of the eyes varies between 19 and 11 % of the length of the head. The length of the snout varies between 25 ($25^1/_2$, according to Kroyer) and 28 %, and the postorbital length is about $^2/_3$ (66—64 %), of the length of the head. The interorbital width increases in these Congers from about 15 to 24 % of the length of the head, the longitudinal diameter of the eyes, which in young Congers is greater than this width, being in the old only about half thereof, and their vertical diameter decreasing during these alterations of growth from about $^{1}/_{5}$ to $^2/_5$ or even approaching $^1/_3$ of the same. The posterior nostril on each side is a longitudinal slit in front of the anterior upper corner of the eye, in young specimens measuring only about $^1/_{12}$ of the longitudinal diameter of the eyes, in old up to about $^1/_4$ of the same and separated from the eye by a distance about equal to its own length. The anterior nostrils are set here too one on each side of the tip of the snout, and are tubular, but comparatively shorter than in the preceding species. The mouth is similar to that of the common Eel, but the gape is comparatively larger, and the lips are still broader, especially in front, on the sides behind the tips of the snout and lower jaw, where the outer folds may be expanded almost like wings. Into the base of the outer fold on the upper jaw projects the lower posterior corner of the preorbital bone, which is furnished on the outer side with a large, round hollow, including a muciferous cavity belonging to the cephalic system of the lateral line. The length of the upper jaw from the tip of the snout is about 37 or 38 %, the length of the lower jaw about 48—52 %, of the length of the head. In front, both on the under surface of the rostro-ethmoidal tip (of the intermaxillaries, according to PETERS' theory) and on the vomer, in the anterior part of the upper jaw and on the tip of the lower, subulate teeth are set in a card containing several rows, the two first-mentioned groups being often, not always, separated by a toothless space at the above-mentioned constriction. On the jaws these pointed teeth are continued backwards in a row double in front, single behind, farthest back on the inside of the above-mentioned great median row of compressed teeth, for a short distance on its outside. The tongue is free, narrowing abruptly to a point. The branchial arches (fig. 283) are here too without gill-rakers, and the cardiform pharyngeal teeth resemble those of the common Eel. The structure of the opercular apparatus we have mentioned above. To the gill-openings essentially the same remarks apply as in the case of the common Eel.

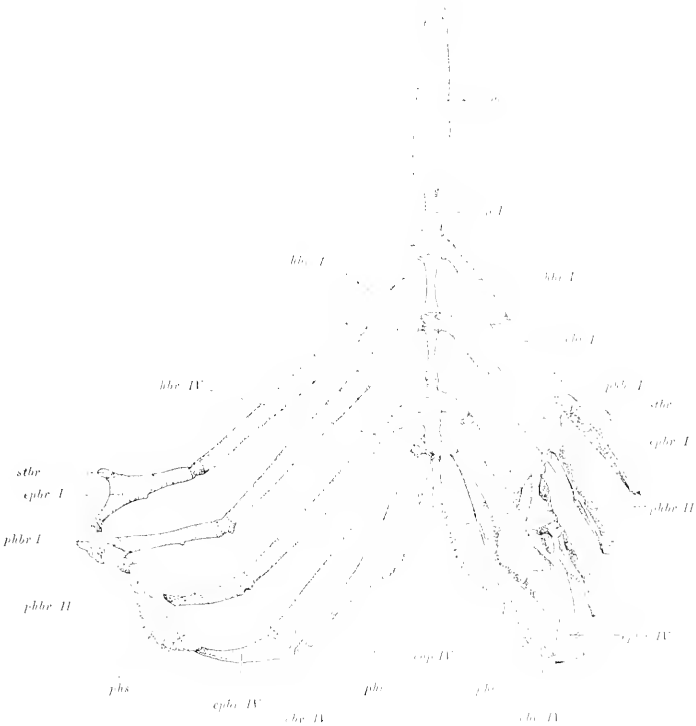

Fig. 283. Branchial arches of a Conger (*Conger niger*) seen from above. Natural size. Halves of the right arches in a natural position, those of the left arches bent outwards, so that the under surface of their upper parts is visible.

glh, glossohyoid (true lingual) bone; *cop I—IV*, first—fourth copulæ; *hbr I—IV*, first—fourth hypobranchials; *cbr I—IV*, first—fourth ceratobranchials; *epbr I—IV*, first—fourth epibranchials; *phbr I* and *II*, first and second pharyngobranchials; *stbr*, stylobranchials; *phs*, upper, *phi*, lower pharyngeals.

The dorsal and anal fins differ from those of the common Eel in having their longest rays somewhat further forward, the gradual backward shortening of the rays being thus more extended, whence the more pointed form of the tail. The length of the head is always perceptibly less than the distance from the beginning of the dorsal fin to that of the anal, usually only 60—70 % thereof; but in Congers with an excessively long head this percentage may rise to 85.

The pectoral fins are oval or obliquely pointed above, the upper rays being longest, and extending to about a line with the beginning of the dorsal fin, somewhat beyond or somewhat short of the same. Their length is about 6 % — in KRØYER's youngest specimen only 4 % — of that of the body, or about 10—15 % of the distance between the anal fin and the tip of the snout.

In the scaleless skin the depressed, straight lateral line with its light (white or yellowish white) pores is distinct throughout the length of the body.

The coloration of the dorsal side and the tip of the tail is gray, with a more or less pronounced tinge of chocolate-brown, lighter or darker, sometimes even black, the ventral side is white, with a dash of violet behind. The base of the dorsal fin is of the same colour as the back, but towards the top the fin becomes ash-gray or violet, to a greater and greater extent behind, and the extreme margin is black. This black tint also appears on the posterior part of the margin of the anal fin, the rest of this fin being grayish blue or violet, growing paler in front. The pectoral fins are black at the upper margin, ash-gray or violet with a white or yellowish white rim on the outside, dark, sometimes quite black, on the inner (posterior) surface. The top of the head in colour resembles the back; the lips and its under surface are of the same hue as the belly, the former, however, with a more or less distinct tinge of flesh colour; the cheeks have a more or less powerful metallic lustre. The iris is sometimes silvery, punctated with black, sometimes of a metallic lustre. In old Congers the inside of the mouth and the branchial cavities are principally black; in the young the mouth and tongue at least are white.

The Conger, as the Swedish name conveys, is distinctly a salt-water fish, and has a wide geographical range, extending almost round the globe. It is known from the east coasts both of North and South America, from St. Helena and the west coast of Europe, the Mediterranean, India, Japan, New South Wales, and Tasmania. On the west coast of America it has never been found. Its true home hardly extends into Scandinavian waters, though it can by no means be regarded as rare on the west coast of Sweden, and sometimes strays even into the Baltic. STORM received specimens from the outer parts of Trondhjem Fjord; but farther north it has never been taken. On the shelving west coast of Jutland it seems to be rarer than in Norway; but several specimens are known from the Skager Rack, the Cattegat, and the Sound. ESMARK received a *Leptocephalus* caught, it was stated, in Christiania Fjord, and perhaps a proof that the Conger may spawn not far from Scandinavia, though these larval forms rove considerable distances in the ocean. In 1877 MALM estimated that at most between 20 and 30 specimens had been secured during the preceding 30 years on the Swedish coast. NILSSON received a specimen nearly 15 dm. long from Halmstad, and another (in the winter of 1853), 24 dm. long, from Landskrona. The latter, according to LILLJEBORG, had been left by the waves on a sandbank; and a female 16 dm. long was found under similar circumstances off Raa (near Helsingborg) at the beginning of March, 1883, and forwarded by Dr. TRYBOM to the Royal Museum. MÖBIUS and HEINCKE mention two specimens from Eckernförde Bay, the one 2 m. long and $34^1/_2$ kilo. in weight, the other weighing 45 kilo., one from Travemünde Bay, measuring 17 dm. and weighing $14^3/_4$ kilo., and one from Kiel Harbour, 16 dm. in length and over 15 kilo. in weight. According to MELA the Conger has even penetrated into the Gulf of Finland, to the Nyland coast. It is plentiful on the English and French coasts and, above all, in the Mediterranean. In the Black Sea it is rare off the Crimea, but is often seen in Constantinople.

The true haunts of the Conger lie in 20—50 fathoms of water, but it ascends between the tide-marks, and has been found at low water on dry land. It shares the preference of the common Eel for a nocturnal life, and in the daytime shows the same proclivity for hiding among weeds and stones, in crevices and in the sand. Off the mouths of rivers it lies in wait for the migratory fishes on their upward and downward journeys. It has great powers of endurance and a robust appetite. Its dentition shows that it is one of the most formidable predatory fishes. With the pointed, though smaller, front teeth it seizes its prey, and with the sharp edges formed by the close-set, larger jaw-teeth it mangles the victim. Its strength may be gathered from the fact that it has been seen to tear asunder lines as thick as a man's finger. It does great damage to fishing-tackle, and lays the fisherman's take under heavy contribution. It bites holes in the nets and drags out the fish. It creeps into lobster-pots, makes short work of the catch, and if the material of the pot is flexible, bores its way out, tail first, through one of the chinks. Like the common Eel, it is sensitive to changes in the weather. Immediately before a gale it is restless, and many Congers are cast ashore in stormy weather. It seems to suffer especially from cold. In winter it is often found half-dead at the surface, with air-bladder strongly distended. The cold apparently deprives it of command over the distension of this organ.

The rapacity of the Conger often embroils it with other pirates of the deep, and it falls a victim to porpoises, dolphins, Sharks, and large Rays. In the Mediterranean one of its bitterest enemies is its own relative, the large Muraena, and the combats of these antagonists were famed even among the ancients. Against the Muraena its ordinary stratagems, such as suddenly taking refuge in holes, or firmly coiling its tail round stones or in crevices, are of no avail; and as a proof of its tenacity of life the old story relates that the Muraena bites off its tail, but that it survives the wound.

The diet of the Conger comprises all kinds of fish — principally belonging to the Clupeoid and Gadoid families, and especially Rocklings — lobsters, crabs, and cuttles; and it shows no mercy to its own species. The Conger is consequently taken in numbers on the hook, with a bait of Herring or other fish; but the bait should, if possible, be fresh. Yet it does not disdain decomposing flesh, and it has been found concealed within the dead bodies of large animals.

The spawning-season occurs in winter. BUCKLAND estimated[a] the number of eggs in a female at over fifteen million, perhaps a liberal computation; but DAY mentions a female, weighing nearly 7 kilo., that had died in the Southport Aquarium, and the ovaries of which weighed rather more than 3 kilo., containing over six million eggs. In fecundity the Conger is thus by no means inferior to the common Eel. The actual spawning has never been observed; but the young have been diligently studied in recent times, especially by the Italian FACCIOLA[b]. He distinguishes between six different *Leptocephalus* forms belonging to this species, more or less distinct transition forms which compose an unbroken series from the most degenerate larvae, *Leptocephalus inaequalis*, or from the longer known *Leptocephalus Morrisii*, to the easily recognisable fry of *Conger niger*. The first-mentioned larvae are sharp-nosed, transparent, slender, but deep behind the middle of the body, are furnished with comparatively large, subulate jaw-teeth, and have the beginning of the dorsal fin situated in the posterior third of the length of the body, the vent in the hindmost fifth thereof. *Leptocephalus Morrisii* is blunt-nosed, with prominent tip of the snout, terete, though transparent, and of more uniform depth, has lost all the jaw-teeth or the greater number thereof, and has the beginning of the dorsal fin situated at a distance from the tip of the snout measuring about 28 % of the length of the body, the vent at a distance from the same point measuring about 38 % of the said length. The ascertained fry of *Conger niger* are brown on the back, and at first show two longitudinal bands of chestnut-brown. As we have already remarked, however, the average size of the last-mentioned, least degenerate forms may be less than that of *Leptocephalus inaequalis*.

The subsequent growth of the Conger is apparently very rapid. JACKSON, the manager of the Southport Aquarium, added to the collections a number of Congers weighing 2—3 lbs. (0·9—1·36 kilo.), which he assumed to be about a year old. Five years afterwards (in 1880) one of these specimens died, and was sent to BUCKLAND. It measured 6 ft. 5 in. (1,956 mm.) and weighed 90 lbs. (40·8 kilo.).

In aquaria the Conger is easily kept alive, but its ravenous hunger renders it a dangerous comrade to its fellow-captives. "We find these congers," wrote JACKSON, "are the most voracious creatures we keep; they attack and devour even dogfish, and these of a size that one would think beyond their powers of swallowing. We have quite given up keeping the piked dogfish with them, and even the topers must be big ones, or down they go. The only safe things are our big sturgeons, monk-fish, skate, and the huge turbot we have reared from little ones (these latter continue to grow). Con-

[a] *Nat. Hist. Brit. Fish.*, p. 387.
[b] *Il Naturalista Siciliano*, Anno XII, 1893, p. 194.

gers swallow their prey head first, as a rule, but when committing an act of cannibalism they swallow their small brother often, if not always, tail first. If the youngster is a bit too big, you may often see him three parts swallowed, and when the big one is quite exhausted the other will wriggle out none the worse, except that it is scratched by the big one's teeth. We have had this happen so often with the same fish that at last it has got as ragged and full of scratches as it could hold; some day, however, one of the big ones has given a mighty gulp, and once let its jaws close over the head of the little one, and we see it no more". In the fisherman's boat the Conger struggles violently to escape; it bites at everything within its reach, and with the aid of its prehensile tail casts itself overboard, unless stunned in time. Even when cut off from the body, the head of the Conger has been known to inflict a dangerous bite.

In Scandinavian waters the Conger, on account of its small numbers, cannot repay any special fishery. Where it is more plentiful, large quantities are taken on hand-lines and long-lines; but its flesh is inferior and full of bones. It is eaten boiled, or the flesh is dried and ground to a powder, which is used as an ingredient in soups. The tough skin may be employed in the same manner as that of the common Eel.

PISCES CHONDROSTEI

(STURGEON-FISHES).

Fishes with endoskeleton principally cartilaginous, but with dermal ossifications representing several of the internal bones of the Teleosts, with shoulder-girdle suspended from the head, with maxillary and palatine arches free from the skull or united therewith merely by a mobile connexion, with branchial cavity, which is situated under the skull and common to the free branchial arches, more or less entirely covered by the opercula, with fully heterocercal caudal fin, and with paired fins unilaterally rayed. Nostrils lateral, set just in front of the orbits.

We have briefly mentioned above (p. 1) the most important anatomical points wherein the Teleosts differ from other piscine orders, and we have now to examine the relations obtaining between those typical fishes which in general organization are by no means inferior to the Teleosts, but which never attain so high a degree of skeletal differentiation or ossification as the latter, and have therefore borne the general name of cartilaginous fishes. As a rule, though with important exceptions, we find that in these forms the ossification deficient in the endoskeleton is compensated in the dermal system, which is strengthened or protected with hard, thick (Ganoid) scales, spiny plates, or scutes. In Artedi[a] they were included, together with the *Cyclostomata*, in a single order, *Chondropterygii*, which was retained under the name of a series by Cuvier[b], in contradistinction to the "true fishes" (Teleosts). Agassiz divided this order into two: the *Ganoidei*[c], among which he further ranged, on account of their hard dermal growths, several Teleosts (the Glanomorphs, Plectognates, and Lophobranchs), and the *Placoidei*[d], among which he placed the Cyclostome fishes too. Bonaparte[e] introduced the first reform, and removed the *Cyclostomata* to a separate subclass, *Marsipobranchii*, as opposed to the subclass of the Chimaeras, Sharks, and Rays, *Elasmobranchii*, and Müller[f] eliminated from the order of the Ganoids the said Teleosts. The delimitation of the Ganoids from the Teleosts, however, was no longer based exclusively either on the enamelled scales of the former or on the less advanced calcification (ossification) of their skeleton, but mainly on the characters adduced above (p. 1) and derived from the more intimate fusion (chiasma) of the optic nerves after their emergence from the brain, and the prolongation of the heart, at the transition to the common branchial artery, into a muscular *conus arteriosus*, furnished internally with several rows of valves. Thus defined the Ganoids still comprised, in addition to the *Chondrostei*, the multitude of fishes, possessing more complete jaw-bones, but now for the most part extinct, in which the piscine type has evolved by manifold processes a wealth of forms rivalling that of the Teleosts, but of which

[a] *Gen. Pisc.*, p. 64.
[b] *Regn. Anim.*, ed. 1, tom. II, p. 111; ed. 2, tom. II, p. 128.
[c] *Rech. Poiss. Foss.*, tom. II.
[d] „ „ „ tom. III.
[e] *Selachiorum tabula analytica*, Romae 1839.
[f] Abh. Akad. Wiss. Berl. 1844, p. 147.

only two types survive, inhabitants of the tropical regions of Africa (the Bichir, *Polypterus*) and America (the Bony Pikes, *Lepidosteus*). LÜTKEN[a] restricted the scope of the Ganoids to the last-mentioned division (MÜLLER's *Holostei*), but ranged them as well as the Sturgeon-fishes (MÜLLER's *Chondrostei*) in the category of distinct subdivisions among the Teleostean Physostoms.

The free gill-arches alone, with the branchial lamellæ projecting beyond their free, outer (convex) margin, are enough to distinguish the Sturgeon-fishes from the true cartilaginous fishes and approximate them to the Teleosts, with which they are also allied by several other points in their organization, e. g. the covering of the head with membrane-bones that distinctly represent the several component bones of the Teleosteous cranium, and the structure of the generative organs. Their inclusion within the order of the Teleosts is indeed forbidden not only by the above-mentioned characters (*chiasma* and *conus*), but also by the structure of the extremities, wherein the Sturgeon-fishes have preserved a great portion of the primordial cartilaginous radialia, as well as by the undivided chondrocranium and the very partially transformed notochord. But LÜTKEN is, beyond doubt, fully justified in his opinion that the Sturgeon-fishes have far more in common with the Teleosts than with the true cartilaginous fishes. DÖDERLEIN[b] too combined them together with the Teleosts and the true Ganoids into an order, *Teleostomi*, characterized by the completely ossified skeleton or at least by membrane-bones on the head and shoulder-girdle, by the free (joined to the cranium by articulations, sutures, or ligaments) hyomandibular and palatoquadrate arches[c], and by the unarmoured pectoral fins[d]. Among the Teleostoms they are distinguished by their fully heterocercal caudal fin, with the tip of the spinal column extending quite or nearly to the end of the upper caudal lobe, and by their unilaterally rayed[e] paired fins. In DÖDERLEIN they rank, with these characters, as a sub-order (*Heterocerci*). In the Scandinavian fauna, which contains neither Lung-fishes (*Dipnoi*) nor Ganoids, it may suffice to have drawn attention to the relation of the Sturgeon-fishes to the Teleosts and the true cartilaginous fishes, which is adequately expressed by MÜLLER's interpretation of them as a distinct order.

FAM. ACIPENSERIDÆ.

Body fusiform, with five rows of large osseous bucklers. Four barbels in a transverse row on the under surface of the snout, in front of the protrusile mouth. No branchiostegal rays.

In modern times the Chondrosteous order contains only two families, one of which, the American and Chinese *Polyodontidæ*, with almost or quite naked body and without barbels, is principally distinguished by its comparatively large mouth, open even laterally (on the sides of the head), and with upper jaw incapable of protrusion, the anterior extremity of the palatine arch being firmly united by ligaments to the under surface of the skull. Another important difference is that the *Polyodontidæ* are without pseudobranchiæ, those of the Sturgeons being exceedingly well developed, even functional as gills, with at least superiorly free branchial lamellæ, on the inside of the opercula.

On opening the pharyngeal and branchial cavities of a Sturgeon, the most striking difference from all the Teleosts meets us in the roof of the palate. This (fig. 284, *mx—mpt*) is a continuous, convex disk, with free margins both in front and behind, and capable, together with the toothless jaws and fleshy, tumid lips, of protraction forwards and downwards and of retraction. On each side of the deep fold that hangs, covered with the thick mucous membrane of the pharynx, between the free hind margin of the palatine roof and the under surface of the skull (parasphenoid bone) or posterior, fixed palatine roof with its continuation, the roof of the pharynx, we find an aperture. This hole

[a] *Om Ganoidernas Begrundsning og Inddeling*, Vid. Meddel. Naturh. For. Kbhvn. 1868, sep.
[b] STEINMANN and DÖDERLEIN, *Elemente der Paläontologie*, pp. 540 and 556.
[c] As opposed to the Lung-fishes.
[d] As opposed to the primeval and extinct *Placodermi* (*Pterichthys*, *Cephalaspis*, etc.).
[e] Not *lobate*, or but slightly so, in contrast to the strongly lobate fins of the so-called *Crossopterygii*.

leads into a canal which runs upwards, skirting the anterior margin of the great upper suspensorium (hyomandibular, *hm*) common to the whole apparatus of the palate and jaws, and opens (fig. 286, *spir*) on the top of the head, a little behind the eye, at the outer margin of the osseous plate covering the squamosal part (*squ*) of the skull, and foreshadowing the squamosal bone. The upper opening is called the spiracle, and the canal, which as well as the former is entirely absent in the fishes we have hitherto considered, but which in all higher animals, man included, has its homologue in the external and internal auditory meatus and the tympanum, is here furnished in its lower (inner) part, just above the internal aperture, with a row of branchial lamellae, not respiratory, however, for they are supplied with arterial blood. The entire to the suboperculum and interoperculum. In the Sterlet these lamellae are for the most part free; in the common Sturgeon they coalesce throughout the greater part of their external margin with the operculum, only their tops being free. In one of the Ganoids (*Lepidosteus*) MÜLLER[a] has shown that the upper part of this row of gill-laminae loses its functional importance as a respiratory organ, and it is thus fully homologous with the pseudobranchiae of the Teleosts. Behind the pharyngeal cavity the branchial cavity of the Sturgeon shows the same structure as that of the Teleosts, four gill-arches, each with two rows of branchial lamellae and short, scattered gill-rakers; and the fifth arch (fig. 284, *hbr* + *cbr*$_5$), the lower pharyngeal of the Teleosts, furnished with one row of gill-rakers, is here, too, destitute of branchial lamellae, and has no gill-slit behind it, being

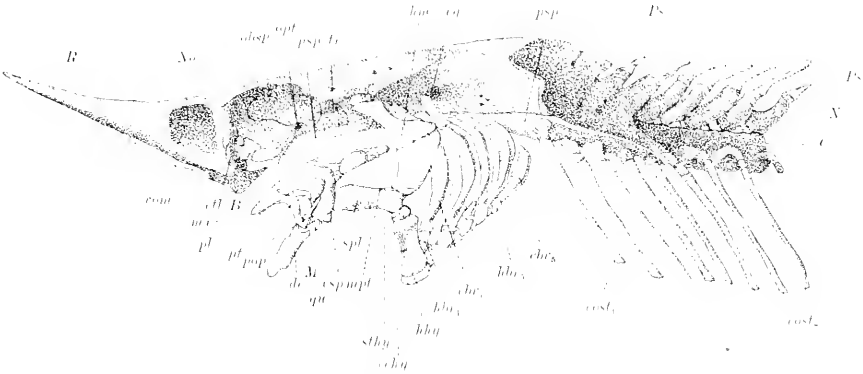

Fig. 284. Forepart of the endoskeleton in a Sturgeon. Partly after J. MÜLLER and PARKER.

B, basal angle; *C*, notochord; *cbr*$_1$—*cbr*$_5$, first—fifth ceratobranchial cartilages; *chy*, ceratohyoid; *cost*$_1$—*cost*$_8$, first—eighth ribs; *csp*, spiracular cartilage (according to PARKER); *de*, dental part of mandible; *etl*, lateral ethmoid; *hbr*$_1$—*hbr*$_5$, first—fifth hypobranchial cartilages; *hhy*, hypohyoid; *hm*, hyomandibular cartilage, with the upper part covered by a parostotic disk; *M*, articular part of the mandible (hind part of the Meckelian cartilage); *mx*, maxillary; *mpt*, metapterygoid cartilage; *N*, neural arches; *Na*, nasal cavity; *obsp*, orbitosphenoid; *opt*, foramen of the optic nerve; *pl*, palatine; *pop*, preoperculum (according to PARKER); *Ps*, neural spines; *psp*, parasphenoid; *pt*, pterygoid; *qu*, quadrate cartilage; *R*, rostral cartilage; *spl*, symplecticum; *sthy*, stylohyoid; *tr*, foramen of the *nervus trigeminus*; *vg*, foramen of the *nervus vagus*; *vom*, vomer.

canal is analogous to a gill-slit between the palato-mandibular and hyoid arches, the latter of which furnishes with its upper parts (the hyomandibular, fig. 284, *hm*, and symplecticum, *spl*) a suspensory apparatus to the former as well. The gill-slit next behind (between the hyoid arch and the first branchial arch proper) has its branchial lamellae set in a large, but single, arcuate row on the inside of the operculum, throughout the hind margin thereof, as well as on the inside of the plates situated below the operculum and corresponding firmly coalescent with the hind wall of the branchial cavity or anterior side of the scapular arch.

In an adult state the mouth of the Sturgeons is entirely toothless; but their larvae have teeth, in form and distribution not unlike those of the Sharks, in their corneous structure resembling those of the Lampreys, both in the upper and lower jaws and on the ceratobranchial bone (*cbr*$_1$) of the first branchial arch proper. These teeth are developed soon after the palato-mandibular arch, originally continuous and arcuate, has brok-

[a] Abh. Akad. Wiss. Berlin 1844, p. 133, taf. II, fig. 4 and taf. V, fig. 6.

en up into two parts, an upper, which has medially grown together from the sides to form the framework of the palatine roof and an analogue to the quadrate bone (fig. 284, *qu*), and a lower (the Meckelian cartilage), which forms the framework of the lower jaw (*de* + *M*). At the age of three months these teeth disappear. Meanwhile the palato-quadrate cartilage has differentiated into two firmly coalescent, but distinguishable parts, the posterior (*mpt*) answering to the metapterygoid of the Teleosts, the anterior corresponding principally to their pterygoid proper and quadrate (*qu*), but also acquiring at its anterior margin special ossifications, homologous with the palatines (*pl*) and the ento-

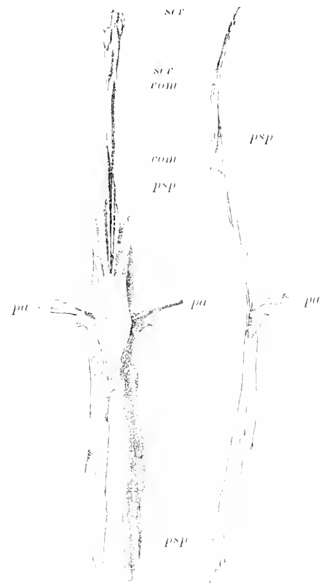

Fig. 285. Ossifications on the under surface of the skull in *Acipenser sturio*. $^1/_4$ of the natural size. *psp*, parasphenoid; *pa*, its ascending sphenoid process; *vom*, vomer; *scr*, vomerine scutes.

pterygoids (*pt*). There further appears on each side of the anterior margin of the palatine arch a freer bone, the maxillary (*mx*), which extends from the anterior tip of the palatine disk (pterygoid bones) to its lateral extremity (the knob by means of which the quadrate bone articulates with the mandible), leaving between itself and the palatine disk a fissure, through which the levators of the lower jaw find a passage. On the outside of the above-mentioned juncture between the maxillary and the quadrate lies a triangular ossification (*pop*), most pointed above, which has been interpreted by PARKER as representing a preoperculum; and on the outside of the Meckelian cartilage (*M*) is developed the dental part (*de*) of the lower jaw.

In the skull itself there appear ossifications the largest of which (*psp*) answers to the parasphenoid of the Teleosts, and extends from the nasal region not only under the skull, but also, divided into two lateral plates (fig. 285), under that part of the spinal column which has not been completely divided into separate vertebræ, but in the form of a cartilaginous mass, continuous below, composes a backward prolongation of the cranial cartilage. This parasphenoid is covered underneath, throughout the greater part of its length, by the hard mucous membrane alone; but between the nasal and orbital regions (in the ethmoidal region) it pierces the downward projection (fig. 284, *B*, the so-called *basal angle*, which may also be observed in the Sharks) of the chondrocranium. Within this it meets and wedges itself into the vomer (*vom* in figs. 284 and 285) in front of it, which advances under the rostral cartilage (fig. 284, *R*), and is continued in its turn by several vomerine scutes (fig. 285, *scr*), evidently belonging to the skin. In the ethmoidal region (the lower anterior part of each orbit) the lateral ethmoids (fig. 284, *etl*) are developed; above the foramen of each optic nerve (in the arched roof of the orbit) appears an orbitosphenoid bone (fig. 284, *obsp*), behind this a smaller osseous disk, corresponding to the alisphenoid, and behind the orbit, round the orifice for the *nervus trigeminus* (*tr*), an osseous disk answering to the petrosal. But all these bones, according to PARKER[a], are superficial growths external to the cartilage (*parostoses*), foreshadowing the cartilage-bones (ectostoses and entostoses) present at the same points in the Teleosts and the higher vertebrates. Similar foreshadowers appear in the form of osseous scutes (scale-growths) in the skin on the top of the head and outside the shoulder-girdle. At the middle of the occiput, but firmly united to the first dorsal scute, lies a trefoiled (posteriorly broad, with a narrower lobe projecting in front) osseous plate, evidently answering to the supra-occipital (here called the *supraoccipital scute*, fig. 286, *ocs*) of the Teleosts. Further forward lie two larger scutes, usually the largest on the whole head, whose

[a] Philos. Trans. Roy. Soc. London, vol. 173 (1882), p. 175.

place is occupied in the skull of the Teleosts (see, for instance, the cranium of the Eel, p. 1014, fig. 268, *B*, *par*) by the parietals (*parietal scutes*, fig. 286, *par*). Their hind extremities are parted by the said projecting lobe of the supraoccipital scute: they are sometimes contiguous throughout the rest of their length (fig. 286, *B*), and in other cases their anterior ends are separated (fig. 286, *A*) by an osseous plate (*et*) fitting in between them from in front. Before them and partly on the sides of their anterior extremities lie a pair of plates (*frontal scutes*, *fr*), often but slightly inferior to them smaller plates. All these variations may be observed in the same species, e. g. in the common Sturgeon. The inconstancy of form depends upon the comparatively lax connexion between these scutes and the skeleton, the looseness increasing towards the snout, which is generally covered with numerous, more irregular, smaller plates, except on the sides, which are armoured in adult specimens of the common Sturgeon with large scutes in a definite row. Outside each parietal plate lies a *squamosal scute* (by others called the temporal scute, *squ*), and in front of this, above the orbit, on the outside of

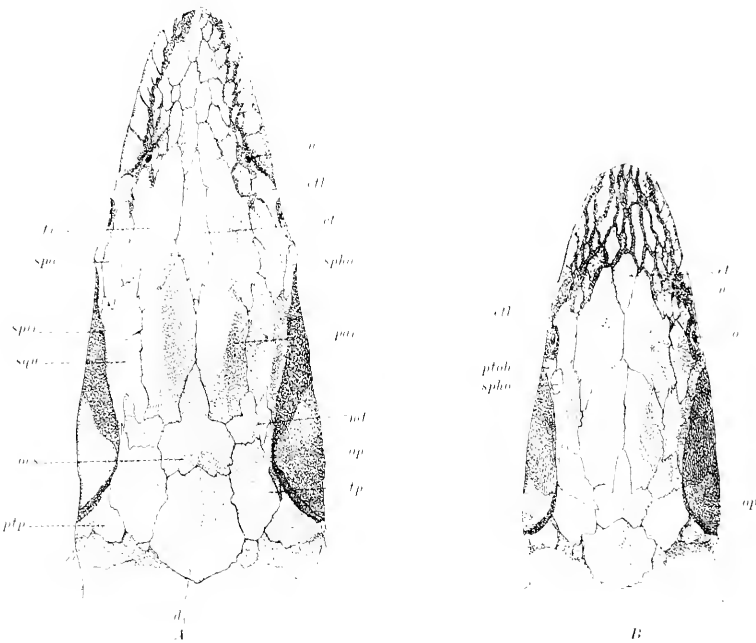

Fig. 286. Upper surface of the head in the Sturgeon (*Acipenser sturio*). $^1/_4$ of the natural size. Two figures showing variations in this species; both specimens taken at Christianstad.

d_1, first dorsal scute; *et*, ethmoidal scute; *etl*, ectethmoidal scute; *fr*, frontal scute; *mt*, mastoid scute; *n*, anterior nostril; *o*, eye; *ocs*, occipital scute; *par*, parietal scute; *ptob*, postorbital scute; *ptp*, posttemporal scute; *spho*, sphenotic scute; *spo*, supraorbital scute; *spir*, spiracle; *squ*, squamosal scute; *tp*, temporal scute; *op*, operculum.

in size. These correspond in situation to the frontal bones of the Teleosteous skull, and are sometimes closely applied to each other, but usually separated at least in front (fig. 286, *B*), sometimes throughout their length (fig. 286, *A*), either by an elongated *ethmoidal scute* (*et*), which may even extend, as mentioned above, between the anterior extremities of the parietal scutes, or by several (up to 5 or more and sometimes two-rowed) each frontal plate, a curved row of three scutes, the posterior representing a postfrontal bone (*sphenotic scute*, *spho*), the anterior a prefrontal bone (*ectethmoidal scute*, *etl*), and the middle one a supraorbital bone (*supraorbital scute*, *spo*). The lower end of the sphenotic scute touches the top of an angular plate, the form of which calls to mind the preoperculum of the Teleosts, but which here composes the posterior and inferior limits of the orbit, and is hence known as the *postorbital scute* (*ptob*). Behind each squamosal plate we sometimes find two plates, sometimes only one[a], touching the outer sides of the parietal, occipital, and first dorsal scutes. Where the plates are two in number, the anterior is evidently homologous with the mastoid of the Teleosts (*mastoid scute*, *mt*), and the posterior, which has received the name of the *temporal scute* (*tp*), is the uppermost plate in the curved row covering the scapular arch of each side. It rests on (covers) a backward prolongation of the mastoid angle of the chondrocranium, just as the first dorsal scute is placed on a similar process springing from the supraoccipital part of the chondrocranium. We have already mentioned (p. 635) PARKER'S comparative investigations wherein he traced the homologues of the human clavicle in different vertebrates from the very stage where they are mere dermal growths even in its cloven form, with the posttemporal bone of the Teleosts. It stands out, however with equal distinctness as the first plate in the upper lateral row of body bucklers, and forms the superior part of the hind limit of the branchial cavity, but lies as a tegumentary bone on two cartilages, one of which (the upper) is the top of the above-mentioned process issuing from the mastoid part of the head, while the other (fig. 287, *ssc*) is the uppermost, segmented part of the shoulder-girdle proper, a part which has disappeared in the Teleosts, where the dermal plate has also been transformed into a portion of the endoskeleton. The median part of the hind limit of the branchial cavity consists chiefly, sometimes entirely, of a large plate, the *clavicular scute* (*cl*), answering to the clavicle of the Teleosts. Often, however, there is inserted, close behind the upper part of this plate, a smaller one, the *supra-*

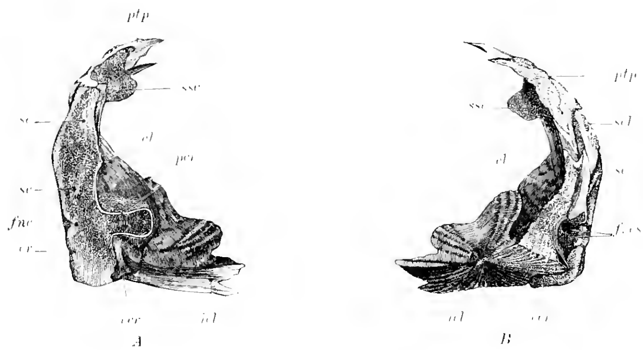

Fig. 287. Left scapular scutes and cartilages of a Sturgeon (*Acipenser sturio*). $^1/_2$ of the natural size. *A*, seen from within; *B*, from without. After PARKER.

The cartilaginous parts of the shoulder apparatus are: *ssc*, *pars suprascapularis*[b]; *sc*, *pars scapularis*; *cr*, *pars coracoidea*; *ccr*, *pars epicoracoidea*; *pcr*, *pars præcoracoidea*; *fnc*, *fenestra coracoidea*; *f. cs*, *fenestra coraco-scapularis*. The scales (plates) transformed into tegumentary bones for the shoulder-girdle are: *ptp*, posttemporal scute; *cl*, clavicular scute; *icl*, interclavicular scute; *scl*, supraclavicular scute.

(fish-scales); and it was principally from the Sturgeon that he traced his comparisons. On the outer and posterior sides of the temporal scute, or in the same relative position to the mastoid scute, when this is confluent with the former, lies a vertical plate, more or less deeply forked above, on which PARKER conferred the name of the *posttemporal scute* (figs. 286 and 287, *ptp*), and which is evidently homologous, *clavicular* (*scl*), corresponding to the supraclavicle of the Teleosts. The lower part of the clavicular scute curves inwards, over the ventral side, but the greater part of the external scapular arch on each side consists at this point of the *interclavicular scute* (*icl*), the homologue of the interclavicle remarked above among the characters of the Hemibranchs. The inner parts of these plates are perfect bones, and as in the Teleosts,

[a] This variation too may be observed within the limits of the same species, for example in the common Sturgeon.

[b] Above the suprascapular part, below the top of the posttemporal plate (*ptp*), lies the tip of the prolongated mastoid cartilage, not shown in the figure.

in a manner that reminds us especially of the Trunk-fishes (see above, p. 619), both the clavicle and the interclavicle are continued inwards by an entire osseous disk, forming the posterior wall of the branchial cavity. Within (above) the anterior extremities of the interclavicles, where these bones meet in the median line of the belly, we find, situated under the *conus arteriosus*, and forming, as it were, a special protection for the same, a flat, heart-shaped bone. Its original dermal structure is indicated merely by a small, terete protuberance, even externally visible, and it is apparently to be regarded from a morphological point of view as

Fig. 288. Left pectoral fin of a male Sturgeon (*Acipenser sturio*) 1,845 mm. long and taken at Luleå on July 18th, 1893. $^1/_2$ of the natural size. Seen from above.

R, radiale of the first (composite) ray, answering to GEGENBAUR'S *mesopterygium*; *1—4*, the four true radialia, the last of which (*4*) answers to GEGENBAUR'S *metapterygium*.

representing the sternum of the higher vertebrates (*sternal scute*).

The internal parts of the shoulder-girdle—omitting the already mentioned suprascapular part (*ssc*)—form a continuous mass of cartilage; but in adult Sturgeons this mass is seen to consist of three several parts, the same as we have seen above in Glanomorphs, Cyprinomorphs, and Thrissomorphs, namely an upper part, answering to the scapula (*sc*), a lower part, answering to the coracoid bone (*cr*), and an inner anterior part, corresponding to the precoracoid (*pcr*). At the line where the scapula and coracoid meet (at *f. cs*), the pectoral fin is articulated, in the same manner as normally meets us among the Teleosts; but the articulary surface of the large first ray (spinous ray) glides partly on a projection of the clavicle, an articulation that calls to mind the pectoral fin of the Sheatfish. In the basal structure of the fin we find (fig. 288) the same four radialia (brachial bones, *1—4*) as in the Teleosts, increasing in length backwards (downwards). But these are cartilaginous and divided into two joints (an inner and an outer row, cf. above, on the Herring, p. 951); and at the hind inferior margin of the fin there are several

Fig. 289. Left ventral fin and pelvic bone of the same Sturgeon as in the preceding figure. $^1/_2$ of the natural size. Seen from above.
for, foramen obturatorium (?); *mtp*, metapterygium; *pil*, processus iliacus (?); *pp*, processus pubicus (?); *1—7*, radialia.

supplementary radialia, the inner ones branching off, however, from the outermost (hindmost) radiale, called by GEGENBAUR the *metapterygium*. A similar, but still greater superfluity of cartilaginous radialia appears in the basal parts of the ventral fins (fig. 289). The number of radialia is greater in the Sterlet than in the Sturgeon (fig. 289, *1—7*), being in the former at least 9, in the latter 7; but in the former the first three, in the latter the first four radialia (basalia) articulate at the proximal (inner) end with a common cartilage, answering to the pelvic bone of the Teleosts[a]; whereas the others (the posterior six) articulate in the Sterlet, according to VON RAUTENFELD, each with a separate cartilage, parallel to the pelvic bone, but evidently of the same nature as the radiale, from which it has been separated by constriction. Similarly a small piece of cartilage is cut off from the distal (outer) end of most of the first-mentioned radialia, so that three rows of these bones are formed, the innermost row containing the pelvic bone and, behind this, the inner radialia. In the Sturgeon, on the other hand (fig. 289), the posterior (3) radialia are distinctly inclined at angles to each other, and so arranged that only one of the innermost parts (*mtpt*), common to them all, articulates with the pelvic bone, and with the top of this part are jointed two cartilages, one belonging to the fifth radiale, the other forming a common base for the last two (6th and 7th) radialia. All the radialia thus lie on one side of an imaginary axis, drawn through the inner margin of the pelvic bone, and continued outwards by the hindmost (innermost) radiale. The pelvic bone is now[b] interpreted as being formed by the coalescence of the inner parts of the anterior radialia; and at the inner end of each pelvic bone we find in adult Sturgeons[c] a constriction setting off the part (*pp*) which, according to WIEDERSHEIM, is the true rudiment of the pelvis of the Selachians and the higher vertebrates. The difference in the number of the radialia in the Sterlet and Sturgeon is the expression of a continued reduction, which has finally brought about their disappearance in by far the greater number of the Teleosts. On the other hand, the similarity in structure of the original basal parts of the pectoral and ventral fins, their composition of articulated radialia, covered at the distal ends by the bases of the true (secondary) fin-rays, is the expression of the common origin of these fins. They have been produced by the differentiation of a fold running along each side of the belly, now persistent only in the Lancelet, in the same manner as the dorsal and anal fins have originated from differentiations in the region of the embryonic vertical fin. The one-sided arrangement of the radialia — set more or less distinctly at angles to a more developed basal part, which is originally situated at the hind margin of the fin — is best explained by a comparison with the transformation of the caudal fin from diphycercy to heterocercy. Fishes[d] in general began by making their caudal fin — their earliest organ of locomotion — heterocercal, for the attainment of a more highly developed musculature, concentrated on one side, to steer and accelerate their movements. The same alteration was extended to the other vertical fins, dorsal and anal, the anterior margin and its basal parts being strengthened and developed into organs for cutting and stemming the water or into weapons of offence and defence, while the posterior parts grew more mobile with more numerous divisions, but with the outer (distal) joints arranged in series on one side of the more or less confluent basal portions (GEGENBAUR'S *metapterygium*). Having once been established among the vertebrates, this manner of development spread to the lateral fins, to the fore and hind limbs of the highest vertebrates. These too became unilateral.

Among the remaining skeletal peculiarities most characteristic of the Sturgeon-fishes is the persistency of the notochord with only slight alteration, without undergoing such coarctations or constrictions as attend the development of perfect vertebræ. It is enveloped, however, by a comparatively thick sheath (perichord, fig. 290, *Cs* and *Ec*), in and upon which there develop cartilages representing both neurapophyses (*N*) and hæmapophyses (*H*), as well as upper spinous processes (*Ps*), which parts, however, remain separate. Between the apophyses lie strengthening disks (*intercalaria*, *Ic*), and the hæmapophyses are prolongated into transverse processes, bearing cartilaginous ribs, and also grow inwards (*Fo*) under the notochord, where they surround in the caudal region both the aorta and the caudal veins, in the abdominal region only the former. Above the spinal cord, which is enclosed on each side by the apophyses, runs another similar canal, formed by holes through each vertebra, and containing an elastic, longitudinal, tendinous band (*El*).

[a] Cf., however, our remarks (above, p. 635) on the pelvic bones of the Hemibranchs, which bones are evidently dermal growths of the nature of interspinal plates. The normal pelvic bones of the Teleosts, on the other hand — as appears from their form — are homologous with interhaemal bones (supporting bones of the anal and caudal fins), and we now see that the pelvic bones of the Sturgeons are intermuscular growths, and have the same origin as the supporting bones of the vertical fins, ontogenically being confluent constrictions of the supporting cartilages of the ventral fins.

[b] Cf. WIEDERSHEIM, *Das Gliedmassenskelet der Wirbelthiere*, Jena 1892, p. 70; *Grundriss Vergl. Anat. Wirbelth.*, Jena 1893, p. 184.

[c] As in *Polyodon* and *Scaphirhynchops*, see WIEDERSHEIM, l. c.

[d] SMITT, *Ur de högre djurens utvecklingshistoria* (lectures for 1873), Stockholm 1876, p. 230.

Of the system of the lateral line (dermal sense-organs) we find in young Sturgeons pores in the plates of the lateral line and in the temporal and mastoid plates, as well as a connecting canal (a junction common in the Teleosts too between the two supratemporal canals, cf. *spt* in fig. 104, p. 368) across the occiput, between the mastoid and supraoccipital plates. On each side of the head the main canal runs forward under the squamosal plate, to branch at the upper posterior corner of the eye downwards to the sphenotic and postorbital plates, and forwards, under the inner margin of the supraorbital and ectethmoidal plates, in the dermal bridge between the nostrils. The system is most distinct, however, on the snout, especially on the under surface thereof, where the four filaments of touch (barbels) of the Sturgeon are also situated. Here we find partly small, simple pores (ordinary lateral line pores), partly agglomerations of these, forming wheel-shaped figures that cover large muciferous cavities. These cavities (the *Schleimsäcke* or *Nervensäcke* and *Gallertröhren* of Leydig, the *tubes muqueux à ampoules* of Duméril) occur in the common Sturgeon, being most distinct in young specimens, 1) below the eyes and on the upper surface of the snout in a row along each margin, forward from the nasal cavity, 2) on the under surface of the snout, sometimes throughout its extent. The small, simple pores are set on the under surface of the snout in a single or double row, curving inwards from the lower posterior angle of each suborbital plate, and thus answering to the suborbital branch of the Teleosts, but running forwards, outside the outermost barbel, and discernible in young specimens to the very tip of the snout.

The variations in the form and arrangement of the body bucklers belong to the description of the several species; but common to all the Sturgeon-fishes and most of the Ganoids are the so-called *fulcra*, imbricated splints, resembling spinous rays, at the anterior margins of the vertical fins. The posterior fulcra of the several fins, however, more and more assume the form of true fin-rays, and thus clearly show a transition between these growths. The fins of the Sturgeon-fishes are furnished, like those of the Teleosts, with secondary, partially ossified and sagittally (in the longitudinal direction of the body) divided rays, originally all simple and articulated. But with age these rays become more and more confluent and, in the anterior part of the fins, hardened, as in most of the Physostoms, so that the foremost rays are spine-like, though with distinct vestiges of the original articulations.

In the internal structure of the Sturgeon-fishes we have already remarked the most essential respect wherein the heart differs from that of the Teleosts. In a male Sturgeon measuring 1,845 mm. from the tip of the snout to the end of the upper caudal lobe, the length of the abdominal cavity is about 700 mm. The thick-walled œsophagus runs in this specimen for a distance of about 9 cm. close under the spinal column, and is internally furnished here anteriorly with 5, posteriorly with 8 series of hamate or (behind) valvular flaps, exchanged furthest back for shallow, flat folds of the mucous membrane. Where these folds terminate, the mucous membrane of the stomach, which is somewhat wider, but has thinner walls, commences, and about 4 cm. further back opens the short, but wide, pneumatic duct of the large and thick-walled air-bladder.

Fig. 290. Transverse section of the anterior part of the spinal column in *Acipenser ruthenus*. After Wiedersheim.

Ps, upper spinous process; *El*, elastic tendinous band; *N*, neurapophysis; *Sl*, fibrillar tissue (belonging to the skeletogenous layer); *M*, medulla; *P*, inner membrane (*pia*) of the myelon; *Ic*, intercalare; *C*, notochord; *Cs*, inner chordal sheath; *Ec*, outer (elastic) chordal sheath; *H*, haemapophysis; *Z*, basal part of a haemal arch; *Fo*, cross-pieces projecting mediad (inwards), and ventrally (inferiorly) covering the main trunk of the arterial system (aorta, *Ao*).

The stomach now assumes a more intestine-like form, and runs upwards to the left, to a distance of about 23 cm. from the diaphragm, where it turns forwards to the right and downwards, to a point (fig. 291, *c*) distant about 3 cm. from the diaphragm, where it again bends back and is thickened. At each crook its inner surface is furnished with thick, terete folds of the mucous membrane, 8 at the former bend, 6 at the latter; but between these points the inside is smooth, and the last-mentioned folds are continued on the inner surface of the pylorus (*pyl*), which is directed backwards, has very thick walls, and is bounded from the retral duodenum (*duod*) by a strong, annular valve. Just behind this valve the upper wall of the intestine is pierced with a large hole (*app*), wide enough for the insertion of a finger, and two somewhat smaller holes, outlets of the large pancreas (*pcr*), which is flesh-coloured with yellowish brown spots, and has been formed by the coalescence of the caecal pyloric appendages[a], being therefore coursed by numerous, tubular passages (*cap*). This gland is of a flattened elliptical shape, about 12 cm. long, 8 cm. broad, and $2^1/_2$ cm. thick, with sharpened edges. It is situated in the circle formed by the above-mentioned gyrations of the intestiniform stomach; and in the present case it occupies rather more than two-thirds of this circle. The duodenum (*duod*) runs back to a distance of 37 cm. depressions on the inside. A similar, though somewhat finer network appears on the mucous membrane lining the rectum (*isp*), which is about 50 cm. long.[b] Here we find an apparatus peculiar to the Sturgeon-fishes, Ganoids, Lung-fishes, and Selachians. The valve is continued by a spiral, in the present case with eight coils, which extends almost to the termination of the rectum. The spiral consists of a thick raised margin (*sp*), which shows the same depressions as the network of the mucous membrane, though more sparsely, and which runs along the inside of the upper rectal wall, being continuous therewith; but at eight points it detaches itself from the roof, and is attached instead by a backward membranous spiral (*msp*) to the rest of the intestinal wall. About $2^1/_2$ cm. before the vent the central cord of the spiral terminates in a tubercular swelling (*tub*),

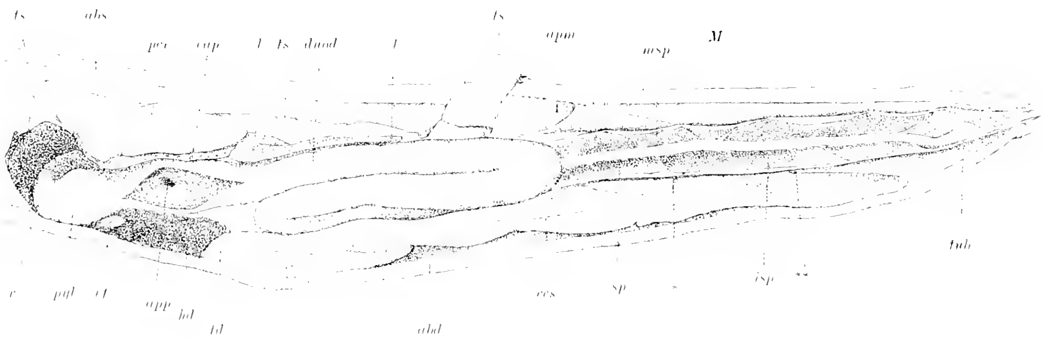

Fig. 291. Viscera of a male Sturgeon (*Acipenser sturio*) 1,845 mm. long, taken at Luleå on July 18th, 1893. About $^3/_{10}$ nat. size. Seen obliquely from below.

abd, right (*abs*, left) wall of the abdominal cavity opened and folded back; *apm*, inner mouth of the left Müllerian duct (*M*); *app*, largest of the pancreatic orifices visible in the opened beginning of the duodenum (*duod*); *cap*, section of one of the pancreatic canals; *duod*, duodenum; *h*, front part of the liver; *hd*, right lobe of the liver; *isp*, spiral intestine, opened; *l*, spleen; *M*, left Müllerian duct; *msp*, spiral membrane, the lateral membrane of the spiral valve; *pcr*, pancreas, sectioned and with one (the ventral) half somewhat raised to show the canals (*cap*) within it; *pyl*, pylorus; *sp*, *spira*, central cord of the spinal valve; *td*, right, *ts*, left testis, with the posterior half of the latter cut loose and laid back behind the left wall of the abdominal cavity; *tub*, tubercular swelling of the *spira*; *r*, termination of the procurvated stomach; *res*, dotted line indicating the outlines of the posterior part of the air-bladder, otherwise concealed; *vf*, gall-bladder; * * *, mesorchial thickening of the right testis.

from the diaphragm, where it abruptly bends forward to a point distant about 20 cm. from the same, and turns back with equal abruptness, soon passing into the straight (spiral) intestine, from which it is divided by an annular valve. Throughout the course of the duodenum the mucous membrane forms a uniform network of and the extreme end of the rectum has five longitudinal ridges with rather sharp margins on its inside. The liver (*h*—*hd*) of the present specimen is of a bluish black colour[c]. The left lobe is about 21 cm long, the right lobe (*hd*) $17^1/_2$ cm. The gall-bladder (*vf*), about 36 mm. long and 23 mm. broad, lies embedded in

[a] Cf. their structure in the Tunny, see above, p. 99.

[b] We here adopt RATHKE's division of the intestinal canal. According to others (see, for instance, WIEDERSHEIM, *Grundr. Vergl. Anat. Wirbelth.*, p. 412), the greater part of what we here call the rectum, so far as the spiral valve extends, should be regarded as a part of the middle intestine.

[c] According to KRØYER it is of a ruddy yellowish brown.

the lateral anterior margin of the right lobe; and the gall-duct (*ductus choledochus communis*) opens on the right side of the above-mentioned pancreatic orifices. The spleen (*l*), about 13½ cm. long and 3½ cm. broad, is pointed behind and forked, being divided from in front, throughout the greater part of its length, into two anteriorly pointed lobes, the lower of which lies under and to the left of the above-mentioned first crook of the stomach, behind and projecting a little way over the pancreas, while the other lobe is laid to the right of the mesenterial fold joining the stomach to the intestine. The testes (*ts* and *td*) of the present specimen, which was taken in the middle of July, are very tumid, and had nearly attained their annual ripeness. They extend throughout the greater part of the length of the abdominal cavity, the left being, however, longer than the right. Throughout their length they are divided into irregular lobes by transverse incisions and shallower constrictions. The length of the left testis (*ts*) is 55 cm., its greatest breadth 7½ cm., and its greatest thickness 4 cm. The corresponding dimensions of the right testis (*td*) are respectively 49 cm., 6 cm., and 3 cm. So oblique is the relative position of each testis to the other that the hind extremity of the left only extends to a point distant 11 cm. from the anal aperture, a distance which in the case of the right testis is reduced to 7 cm.[a] Their outside (facing the wall of the abdominal cavity) is convex, their inside flatter; the former is covered with an extremely thin membrane, the latter with a thicker continuation of the mesorchium, the peritoneal membrane that holds each testis suspended partly (in front) from the wall of the abdominal cavity, partly (further back) from the air-bladder, partly (behind the air-bladder, which terminates about 19½ cm. in front of the vent) from the kidneys. Posteriorly the mesorchium is thickened (*—**), on the left testis for a distance of about 10 cm., on the right for about 8 cm. Behind this thickening the testes are free from their suspensory membrane, the left only for a very little way, the right for a distance of 6½ cm. On the inside, in front near the middle of the breadth or even near the lower, free margin of the testicle, behind near its upper (suspensory) margin, runs a wide efferent duct (*vas deferens*), the radices of which ramify in all parts of this side. The efferent duct is skirted by a sharp-edged, rather thin, adipose band, with free margin and in some places 1 cm. broad, at other points narrower or even merging into the mesorchium. Air blown into the efferent duct spreads partly into its ramifications, partly, in the hind portion of the testis, into large lacunae between the testicular membrane and the stroma. Mercury injected into the duct penetrates through canals in the thickened part (*—**) of the mesorchium into the kidneys. It is thus evident that the sperma may find egress in this direction and through the ureter; but another passage seems also to be afforded. Both male and female Sturgeon-fishes possess peritoneal funnels, not unlike those we have seen above in female Salmonoids, especially in the Smelt and Capelin. But here these funnels are developed into independent ducts (*M*), distinct from the true organs of generation, densely ciliated, and opening behind into the ureter. They are thus fully homologous with the so-called *Müllerian ducts* (oviducts) of the Ganoids, Lung-fishes, Selachians, and the higher vertebrates. In the males of most vertebrates they are more and more reduced, the testes being furnished instead with deferent canals through the pronephros; but in the Sturgeon-fishes this transformation has not advanced so far, the males having as large, as open, and apparently quite as functional Müllerian ducts as the females. In the above-mentioned male Sturgeon the inner (abdominal) aperture (*apm*) of the left Müllerian duct lies about 31½ cm., that of the right 32½ cm., in front of the anus; and the former duct measures 15 cm. to its posterior aperture, which opens into the ureter. Frequently, at least in male and female Sturgeons not yet in spawning condition, the last-mentioned aperture is closed; but to judge by the perfect development of the Müllerian ducts in our specimen, it would seem quite probable that they may be functional in breeding fish of both sexes, even if the sperma of the males may also find its way into the ureter by another mode of passage.

On each side of the anus the Sturgeon-fishes are commonly furnished with a so-called *abdominal pore*, an aperture by means of which the abdominal cavity communicates with the surrounding water. It is often wanting, however, as in the specimen just described. Its function is somewhat doubtful, though probably

[a] In another Sturgeon the relations were reversed: the left testis extended further, even in a backward direction, than the right.

Cf. Jungersen, *Bidr. Kundsk. Kønsorg. Udv.*, Disp. Kbhvn 1889, p. 101.

Cf. Weber, Morphol. Jahrb., Bd XII (1886), p. 366.

that of a respiratory organ. It is a relic of the segmental organs found in lower animals, and recurs in the Selachians and Ganoids, as well as in the Salmonoids, Enchelymorphs, and Mormyroids among the Teleosts.

The family of the Sturgeon-fishes contains only two, not very dissimilar genera, *Scaphirhynchops* and *Acipenser*. The former, of which only one species is known, with spatulate snout, long but shallow (depressed) peduncle of the tail, with the upper lobe of the caudal fin prolongated into a filamentous appendage, and further characterized by the absence of spiracles, belongs exclusively to the southern regions of North America.

Genus ACIPENSER.

Peduncle of the tail terete (not depressed) and at least twice as deep as the lateral caudal plates, which do not meet from each side of the body.

The Sturgeons have met with the same variety of systematic treatment as the Salmons, and probably from the same cause. They are anadromous fishes, breeding in fresh water—a few, it is true, permanent inhabitants thereof—but else living in the sea. Their geographical range is about the same as that of the Salmons, extensive enough to offer a great variety of physical environments. They also show an inconstancy of form fully comparable with that of the Salmons, and the methods of their classification have been equally diversified. In 1870 DÜMERIL described[a] 81 species of this genus, among them 62 from America. In the same year GÜNTHER adopted in his *Catalogue* only 19 species, 9 American. JORDAN and GILBERT[b] (1883) recognised only 5 species in America, 2 from the Pacific coast, 3 from the Atlantic; but the specific rank even of these may be called in question.

The characters hitherto employed in the definition of the species are subject to considerable variations. It has long been known that the large body bucklers of young Sturgeons are set closer together, and have a longer, more pointed, and usually more hooked, central spine, than those of older specimens. Their number was indeed recognised by GÜNTHER as a valid character, but varies in the common West European and American Sturgeon, for example, between 11 and 13 in the dorsal row and between 26 and 34 in the upper lateral row. According to JORDAN and GILBERT these variations extend between 11 and 14 in the dorsal row and between 27 and 36 in the upper lateral rows, according to KROYER between 10 and 14 in the former and between 26 and 31 in the latter. FATIO[c] counted 15 plates in the dorsal row. Of the small plates in the skin between the large bucklers GÜNTHER remarks, in the case of the common Sturgeon, that in very young examples (which thus would be referred to the genus *Huso* of DÜMERIL) the skin is provided with very small rough points; in older ones these ossifications are broader, rough, substellate, and more (as in the genus *Acipenser* of DÜMERIL) or less (as in *Antaceus* of DÜMERIL) regularly arranged in oblique series[d]. According to MILNER'S observations[e] of the American fresh-water Sturgeon, the large bucklers increase in size until the fish has attained a length of about 63 or 64 cm., but afterwards diminish, partly owing to the detrition of the spines, partly by resorption of their margins, and both at the dorsal line and the ventral margins they partially drop off, or at least become indistinct. Simultaneously with this process may be observed a shortening of the snout; and the far greater relative length of the snout and its more pointed form in young Sturgeons give the head an appearance quite different from that of older specimens.

The external sexual characters are not marked, and but little has been observed on this head. In the *Sevruga* (*Sherg*, *Acipenser stellatus*) of the Black Sea and its feeders, which species is characterized by a very long and slender snout, the females, according to HECKEL

[a] *Nouv. suites à Buffon, Hist. Nat. Poiss.*, tome II, pp. 87 cett.

[b] Bull. U. S. Nat. Mus., No. 16, pp. 85, cett.

[c] *Fne Vert. Suisse*, vol. V, part. II, p. 491.

[d] The same observation had already been made by NILSSON (*Skand. Fna, Fisk.*, p. 702), though he did not expressly point out its systematic significance.

[e] U. S. Comm. Fish and Fisher., Rep., part. II (1872 and 1873), p. 70.

and KNER[a], have a shorter snout, a weaker spine in the pectoral fins, smaller dorsal and lateral scutes, with longer hooks than in the males. Of the *Sterlet* (*Ac. ruthenus*), however, the same writers[b] remark that the females have a longer, thinner, and more upturned snout and a flatter forehead. In the common Sturgeon (*Ac. sturio*) we have found no perceptible external difference between the sexes, save that the ventral fins of the males are not removed so far back during growth as those of the females, the length of the pectoral fins even in old (more than 1 m. long) males being at least $^{1}/_{5}$ of the distance between the ventral fins and the tip of the snout. The males thus seem to represent the characters of the early stages of growth. Of the *Hausen* too HECKEL and KNER[c] state that the females attain the greatest size. The materials within our reach as well as the recorded observations, however, leave much to be desired in our knowledge of the external differences of sex.

The form of the Sturgeons is also influenced by their environments. "Some forty years ago", wrote GRIMM[d] in 1883, "the sterled penetrated through the canals into the North Dvina, and finding the conditions favourable to its existence (for ex. cold water, which is so necessary for it) it not only settled down and multiplied, but acquired some peculiarities in its exterior (a short, blunt snout and an arched back) and also a fine flavour, for which in Petersburg it is prized more than the Volga sterled. I must remark that even in the system of the Volga the sterled is much finer in the north (for instance in the river Sheksna) than in the southern parts, and the further south one goes, the less tasty the sterled becomes". Among the Sturgeons, as among the Salmons, certain forms[e] are sometimes found landlocked in fresh water and unavoidably debarred from exchanging at regular intervals, in obedience to the natural instinct of the genus, fresh-water life for a marine existence. It is only to be expected that such forms should suffer alteration.

The actual number of species within the genus it is thus impossible as yet to state with certainty. In Europe 7 or 8 species are supposed to occur, most of them belonging to Russia and the Danubian countries. In Scandinavian waters only one species of the genus is found, the common Sturgeon of Western Europe. King FREDERICK I. of Sweden attempted to plant the Russian Sterlet in Edsviken (near Stockholm) off Ulriksdal, an experiment which at first seemed to promise success, but eventually proved a complete failure.

The Sturgeons have been highly esteemed from time immemorial for their flesh, their roe, and the gelatine extracted from their air-bladder. Gregarious and at certain seasons extremely sluggish, they are an easy catch; and at other times, when they are more active, their great timidity drives them blindly into the fisherman's snares. Some of them are among the colossi of the piscine world: the Hansen, for instance, is stated to have attained a weight of more than 1,500 kilo., and specimens weighing 550 kilo. are still taken from time to time. A single fish of the latter weight commands at Astrachan a price of about £22[f]. The Sturgeon-fishery is consequently of great importance and, especially in Russia, a productive source of food and income. According to DANILOVSKI[g] the annual take of Sturgeons in European Russia may be approximately valued at eight million roubles (£1,250,000). Of this sum about five millions are represented by the flesh, about two millions and a quarter by caviare, about 600,000 roubles by isinglass, and about 100,000 roubles by *vjeziga*, the notochord (*chorda dorsalis*), which is principally employed in the preparation of stock for soups and as an ingredient in pies[h].

Acipenser[i] is classical Latin, and was introduced into ichthyology, as a generic name, by ARTEDI. In PLINY the Sturgeon is called *Attilus* and *Mario.*[k] Among the

[a] *Susswasserf. Östr. Mon.*, p. 345.
[b] l. c., p. 339.
[c] l. c., p. 569.
[d] *Fish., Hunt. in Russ. Wat.*, p. 24.
[e] E. g. *Acipenser rubicundus* in America.
[f] GRIMM, l. c., p. 32.
[g] See GRIMM, l. c., p. 26.
[h] For a description of the Sturgeon-fishery in Russia, see BREHM, *Thierleben, Gr. Ausg.*, 1879, Abth. III, Bd. 2, p. 358.
[i] GESNER supposed that the word had arisen by letter-changes from the Greek ὀξύρρυγχος.
Hist. Anim., lib. IX, cap. XIII.
[k] l. c., lib. IV, cap. XV.

Greeks the genus bore the names of *Ellops*[a], *Antacaeus*[b], and several others, the application of which is, however, disputed. In mediaeval times the name of *Sturio* was coined from the Teutonic *Stoer*, which according to WORMIUS[c] is the same as the Scandinavian *stor* (great), but according to GESNER[d] should be derived from the Teutonic *storen* (to root, stir up the bottom), a reference to the method practised by the Sturgeons in procuring their food.

THE STURGEON (SW. STÖREN).

ACIPENSER STURIO.

Plate XLVI, fig. 1.

Dorsal bucklers mesocentric (with the boss uppermost in the middle, and sloping forwards and backwards). Number of plates in the upper lateral row as a rule less than 37[e]. *Length of the snout about* $^1/_2$ *(53*[f]*—42 %) of that of the head, which occupies about 27—20 % of that of the body. Width of the mouth, which, when protruded, is square with rounded angles, at most about* $^2/_3$ *of the breadth of the snout at the barbels. Barbels terete, simple (not fimbriated*[g]*), and shorter than the distance between them and the anterior margin of the mouth. Base of the dorsal fin less than* $^1/_{12}$ *of the length of the body. Length of the pectorals less than* $^1/_4$ *of the distance between the ventrals and the tip of the snout.*

R. br. 0; *D.* 30—40(44); *A.* 23—26(30); *P.* 36—40(42); *V.* 26—27(30); *C.* $\frac{26\text{—}29 \text{ super.}}{80\text{—}100 \text{ infer.}}$

Syn. *Acipenser sive Sturio*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 9.

Sturio, WILLUGHB., *Hist. Pisc.*, p. 329, tab. P. 7, fig. 3.

Acipenser corpore tuberculis spinosis aspero, ART., *Ichthyol.*, *Gen.*, p. 65; Synon., p. 91; LIN., *Fna Suec.*, ed. I, p. 101; *It. Scan.*, p. 187.

Haae-Storje (Sturio), STRÖM, *Sondm. Beskr.*, pt. I, p. 286.

Styrja, OLAFS., *Reise Isl.*, pt. II, p. 711.

Acipenser europaeus, LIN., *Mus. Ad. Frid.*, p. 54, tab. XXVIII, fig. 2.

Acipenser Sturio, LIN., Syst. Nat., ed. X, tom. I, p. 237; MÜLL., *Zool. Dan. Prodr.*, p. 39; BL., *Fisch. Deutschl.*, pt. III, p. 89, tab. LXXXVIII; RETZ., *Fna Suec. Lin.*, p. 309; EKSTR., Vet. Akad. Handl. 1831, p. 104; NILSS., *Prodr. Ichthyol. Scand.*, p. 109; BDT, RATZEB., *Medic. Zool.*, vol. II, pp. 17 et 352, tab. III, fig. 1 et M—S; PARN., Mem. Wern. Nat. Hist Soc., vol. VII, p. 403; BONAP., *Fna Ital.*, *Pesc.* (tom. III, 2), tab. 129, fig. 1; YARR., *Hist. Brit. Fish.*, vol II, p. 475 et Suppl. (RICHARDS.) II, p. 7; KR., *Danm. Fisk.*, vol. III, 2, p. 747; NILSS., *Skand. Fna, Fisk.*, p. 699; HECKL, KN., *Susswasserf. Östr. Mon.*, p. 362; MGRN, *Finl. Fiskfna* (disp. Helsingf. 1863), p. 70; MALM, Gbgs Vet. Vitt Samh. Handl., Ny Tidsf., H. VIII (1863), p. 102; STEIND., Stzber. Akad. Wiss. Wien, Math. Naturw. Cl., LIII, I (1866), p. 204; v. BEMM. in HERKL., *Bouwst. Fna Nederl.*, tom. III, p. 318; LINDSTR., *Gotl. Fisk.*, Gotl. L. Hush. Sällsk. Årsber. 1866, p. 24 (sep.); DÜM., *Hist. Poiss.* (N. Su. a Buff.), tom. II, p. 184; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 342; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 205; 1879, No. 1, p. 102; N. Mag. Naturv. Chrnia, Bd 29 (1884), p. 115; MALM, *Gbgs. Boh. Fna*, p. 604; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 55; FEDDERS., ibid., p. 93; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 471; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 191; ID. in M. v. D. BORNE, *Handb. Fischz., Fischer.*, p. 181; DODERL., *Man. Ittiol. Medit.*, pt. II, fasc. I, p. 6; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 85; MELA, *Vert. Fenn.*, p. 362, tab. X; MÖB., HEKE, *Fisch. Osts.*, p. 149; DAY, *Fish. Gt. Brit., Irel.* vol. II, p. 280, tab. CL; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 488.

Acipenser Lichtensteinii, BL., SCHN., *Syst. Ichthyol.*, p. 348, tab. 69; BDT, RATZEB., l. c., pp. 21 et 352, tab. II, fig. 1.

Acipenser oxyrhynchus, MITCH., Trans. Lit., Phil. Soc. N. York, vol. I, p. 462 (+ ? *Acip. sturio*, p. 461 = *Acip. brevirostrum*, LESUEUR, Trans. Am. Phil. Soc., vol. I, p. 390); DEK., *N. York Fna*, pt. IV, p. 346, tab. LVIII, fig. 189; STOR., Mem. Am. Acad. Arts, Sc., vol. VIII, p. 431, tab. XXXV, fig. 4; DÜM., l. c., p. 106.

Acipenser latirostris, PARN., l. c., p. 405, tab. XXXIX.

Acipenser huso, THOMPS., Ann. Mag. Nat. Hist., vol. XX, 1847, p. 172; SUNDEV., Öfvers. Vet. Akad. Förh. 1853, p. 228. Nec LINNÉ.

Acipenser Thompsonii, BALL, Proc. Irish Acad., No. 25, p. 21; THOMPS., *Nat. Hist. Irel*, vol. IV, p. 245.

Acipenser hospitus, KR., l. c., p. 780.

Acipenser sturioides, MALM, Gbgs Samh. Handl., l. c., p. 108; *Gbgs. Boh. Fna*, p. 605.

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[a] Ἔλλοψ, ARISTOT., *Zool.*, lib. II, capp. 13 et 15.

[b] HERODOT., *Hist.*, lib. IV, cap. 53.

[c] Cf. CHARLETON, *Onomast. Zoic.*, p. 152.

[d] *De Aquat.*, p. 932.

[e] The specimen described by RICHARDSON, (in YARR., *Brit. Fish.*, ed. 2, Suppl. II, p. 21) from the Free Kirk College of Edinburgh, with 38 plates in the upper lateral row on the right side and 40 on the left, has been shown by GÜNTHER to belong to the American species *Acipenser rubicundus*, which may thus be assumed to have strayed into European waters. But DAY (*Fish. Gt. Brit., Irel.*, vol. II, p. 279) questions the Scottish origin of the specimen. MALM counted in a Swedish specimen 38 plates in the said row.

[f] In a young specimen — probably an exceptional case — 57 %, according to KRÖYER.

[g] In old Sturgeons, however, the barbels are sometimes broader, compressed, and more or less distinctly fimbriated.

The ordinary size of the Scandinavian Sturgeon is about $1^1/_2$—2 m. In the island-belt of Södermanland, according to EKSTRÖM, small specimens 3—6 dm. long are commonest. The young Sturgeon, 18 cm. long, figured by LINNÆUS, is still preserved in the Royal Museum; but whether it was taken in Scandinavia, is uncertain. Among the specimens measured by KRØYER the three smallest are 16—32 cm. long; but he does not state whether they are Scandinavian. MALM's smallest specimen was 39 cm. in length. On the other hand, rather large specimens, measuring up to 3 m., are more frequently found; and LINDSTRÖM records the find in Gothland of a dead, stranded Sturgeon which was stated to have been 14 Sw. feet (415 cm.) long. According to an old statement in SCHONEVELDE, the Elbe Sturgeon has been known to attain a length of 18 feet ($5^2/_3$ m.)[a].

The body of the Sturgeon is of an elongated fusiform shape or, when the fish is spent, clavate, thickest at the occiput. It tapers forward in a highly characteristic manner, due to the pyramidical form of the snout, and also deviates behind from the ordinary piscine type in its oblique, prolongated, and heterocercal caudal fin. The greatest depth of the body, which is usually deepest just behind the occiput, is about $^1/_7$—$^1/_{10}$ of its length, and the greatest thickness about $^1/_{10}$—$^1/_9$ of the same. The least depth, just in front of the caudal fin, is only about 3 % of the length, but increases with age (during the growth of the Sturgeon from a length of 16 cm. to one of 185 cm.) from 11 to 16 % of the length of the head, or from 23 to 28 % of the length of the pectoral fins. The fusiform shape of the body is considerably modified, however, especially during youth and in lean specimens, by the large shield-rows, which render it pentagonal in section. The shield-rows belong to the dorsal line, the lateral line, and the side margins of the belly; but on the under surface of the tail, between the vent and the anal fin, the ventral rows coalesce, at least partially, into one, which is again divided, however, behind the anal fin; and on the back of the tail, behind the dorsal fin, the shield-row of the dorsal line commonly, but often irregularly, breaks up into two rows, which may also be pre-indicated in front of the dorsal fin by one or two pairs of plates, smaller than the rest, being fitted in before its fulcrum. In shape and relative position the bucklers show considerable variations, individual, it is true, appearing even in specimens of equal size, but evidently also expressing the alterations of growth. In young Sturgeons they are more densely set and deeper, with sharper and more pointed, recurved spine, which is furnished with small spines on its sloping hind margin. With age the spines are obliterated, the plates become shallower (flatter), and separate more and more from each other in the several rows. Yet it applies to these alterations of growth, as to so many others, that they appear more distinctly in one individual than in another, and have consequently occasioned the designation of the same species by a plurality of names. As a rule the spines are most persistent on the posterior body bucklers. The plates of the dorsal line are most curved, showing in young Sturgeons an acute-angled transverse section; the plates of the lateral lines are least curved, especially in the anterior parts thereof; the plates of the ventral line, even during youth, are most remote from each other. The surface of the scutes is scabrous and both radially and concentrically striated with cavities and ridges, calling to mind the scale-texture we have seen above in the Eels[b]. In the dorsal and lateral lines the anterior scutes are shorter (comparatively broader) than the posterior. The form of the plates further varies from the rhomb, which preponderates in the ventral lines and the anterior part of the dorsal line, or hexagon (rhombs with truncated anterior and posterior angles), which appears in the rest of the dorsal line, to the semicircle or triangle, as shown in the lateral lines. The foremost (properly the only) fulcrum supporting the anterior margin of the vertical fins is linguiform in the dorsal and anal fins, with the narrower end directed up the fin-margin; at the upper and lower margins of the caudal fin the tongue is prolongated to a lanceolate form. The inconstancy in the number of plates in the dorsal line before the dorsal fin and in the lateral lines has been mentioned above. Behind the dorsal fin 4 pairs are set, as a rule, in front of the caudal fulcrum; but on each side of the posterior part of the dorsal fin the small dermal plates are usually enlarged with age, so that a more or less regular row of 2 or 3 plates, smallest in front, appears on each side at this point, forming a forward continuation of the

[a] BELON (*Nat., Div. Poiss.*, p. 89) also mentions a specimen 18 feet long. A Sturgeon of this size was said to have been presented at Montargis to King FRANCIS I.

[b] I. e. of a texture that distinctly calls to mind the plates of the body.

dorsocaudal row. The plates of the ventral lines vary in each row within the preabdominal region, as a rule, between 10 and 12; but KRØYER once found only 8, and LILLJEBORG adduces as many as 14. Behind the vent there generally lie 2 or 3 pairs in front of the anal fulcrum, or the posterior of these pairs coalesces into one plate. Behind the anal fin are set 3—5 (in exceptional cases only 2) pairs of distinct plates in front of the lower caudal fulcrum; but to the posterior part of the anal fin the same remarks apply as to the corresponding part of the dorsal. In the preceding pages we have also considered the transformation of the remaining dermal covering from small scattered spines and their more or less distinct agglomerations, simultaneously with their adoption of a blunter, more tuberculate form, into the diamond-shaped dermal scutes, arranged in oblique transverse rows, with small rows of tubercles between them, that are especially prominent on the dorsal sides above the lateral lines. On the fins and their rays the small, sharp spines are persistent; but on the upper part of the caudal fin, on each side of the continuation of the spinal column within this fin, elongated, diamond-shaped, and smooth bony plates are developed, arranged in oblique rows running from below and in front upwards and backwards.

The hind part of the head is rather terete, constricted above at the gill-openings and eyes, with more or less depressed interorbital space. A striking difference from the head of the Teleosts is that the opercula do not entirely cover the gill-openings, the gills of the Sturgeon being consequently laid bare to some extent behind. In front the head is depressed and of varying length, tapering in a pyramidical form, with the superior surface of the snout more convex than the inferior and the other two sides narrowing sometimes to an edge. In young Sturgeons the relative length of the snout, as we have mentioned above, is considerably greater than in old, varying with age from about 14 % at least to about $8^3/_4$ % of the length of the body, or from 53 % (according to KRØYER sometimes 57 %) to 42 % of that of the head, so that the entire length of the head is also comparatively less in the latter. The postorbital length of the head, on the other hand, relatively remains almost unaltered during growth, being about $^1/_{10}$[a] of the length of the body. The eyes are small and somewhat oval. Their longitudinal diameter, which shows relative diminution during the growth of the fish, varies between 10 and 7 % of the length of the head, between 19 and 14 % of the length of the snout, or between 37 and 22 % of the interorbital width[b]. The interorbital space, which is convex, but medially more or less depressed, grows narrower in proportion to the general growth, varying between about $7^1/_2$ and $6^1/_2$ % of the length of the body, but wider in proportion to the length of the head, varying between about 27 and 33 % thereof. In front of the eyes lie the large nostrils — comparatively larger, however, in young Sturgeons than in old — the posterior in each pair being the larger, an obliquely or even a transversely set ellipse, the length of which is sometimes greater than the diameter of the eyes, and situated low down; the anterior more extended in the longitudinal direction of the body, and set nearer to the level of the forehead. They are separated by a thin (in old specimens rather broad) dermal ridge. The shortening of the snout during the growth of the fish is accomplished at the expense of its anterior part (the rostral cartilage), the distance from the anterior nostril to the tip of the snout being sometimes reduced with age from 47 to 28 % of the length of the head.

The under surface of the head, like that of the belly, is rather plane. Behind the perpendicular from the centre of the eyes is situated the comparatively small mouth[c]. Owing to its structure, which we have described above, it may be protruded (in a downward direction), so as to form a square tube, rounded, however, at the corners (fig. 292). The toothless jaw-margins are rounded. The lips are tumid, on the upper jaw rather uniformly, but with a median indentation, at the corners of the mouth in a bulging form, on the lower jaw in the form of two fleshy folds, which are closely applied to each other from the sides, but distinct, the jaw itself being medially naked. Half-way between the tip of the snout and the mouth — sometimes, in young Sturgeons, distinctly nearer to the latter, sometimes, in old, nearer to the former[d] — hangs the transverse series of barbels characteristic of the Sturgeons. These are 4

[a] Varying, according to our measurements, between about $10^1/_2$ and $9^1/_2$ %.

[b] For the vertical diameter of the eyes the corresponding percentages are respectively 8 and $5^1/_2$, 16 and 12, 30 and 16.

[c] One of the most reliable distinctions from the *Hausen* (*Acipenser huso*) and the *Ossétr* (*Tok*, *Ac. Güldenstädtii*), which have a broader mouth.

[d] The distance between the barbels and the tip of the snout measures 64—44 % of that between the mouth and the same point.

in number and of fairly equal length, sometimes extending, when laid back, rather near, but never quite to the anterior margin of the mouth, seldom indeed to the hollow in the ethmoidal cartilage for the reception of the latter. In the median line of the under surface of the snout there lies in front a series of tuberculated bony plates in the skin, paired or, at the very beginning, set in several irregular rows. These rows terminate behind, between the middle barbels, in a plate which does not belong exclusively, however, to the skin, but is merely the prominent, though sometimes concealed, head of the vomer (fig. 285, p. 1046), whose hind extremity, as we have described above, is embedded in the cranial cartilage and meets the parasphenoid bone. Thus we have here a most excellent anatomical example of the morphological transition from dermo-ossifications to parts of the endoskeleton.

The plate-armour of the head we considered above, when we selected the Sturgeon as our type of the general conformation of these parts within the family. There remains only the opercular apparatus, which externally resembles that of the Teleosts, but is characterized by the absence of rays in the thick branchiostegal membrane. The gill-openings extend right across the sides of the body, the branchiostegal membranes being united below to the isthmus in a line with the upper angles of the gill-openings, and separated from each other by a distance hardly greater in young Sturgeons than the diameter of the eyes, but which widens in older specimens until it is at least half of that between the upper angles of the gill-openings. Each branchiostegal membrane contains three bones, in a row one below another. The uppermost is the operculum, which is naked throughout the greater part of its extent, and shows the same radial striation and thimble-like granulation of the surface as the dermal scutes. In form it resembles a sector of a circle, somewhat greater than a quadrant, and with the inferior radius incurvated. At the anterior part of its lower angle, and united by a firm suture to its inner surface, is inserted the more elongated suboperculum, which lies across the body, and in old Sturgeons is mostly covered by the skin, but on the outside has a high ridge, above sending out through the skin a few granulated spines. The ridge is continued on the lowest bone, explained as an interoperculum, which has a more quadrilateral form, but is irregularly incised, with radially disposed ridges on the outer surface.

The dorsal fin lies far back, farther in old Sturgeons than in young. The distance between its beginning and the tip of the snout increases with age from about 62 to 69 % of the length of the body. Its last ray is so small in old Sturgeons that its trapezoidal form approaches to the triangular. The upper posterior margin is concave. The length of the base varies between 6 and 8 % of the length of the body, and the height is about the same, somewhat greater or less. The first three or four rays in old Sturgeons are very short, thick, and hard, resembling fulcra. As a rule, the first seven or eight rays are simple, gradually increasing in length, and the ninth or tenth ray is the longest in the fin. The anal fin is opposed to the posterior part of the dorsal, and resembles the latter fin, but has a shorter base — varying between about 3 and 4½ % of the length of the body — and consequently a more pointed form. The form and covering of the caudal fin we have already noticed. The upper lobe (the very tip of the tail), which

Fig. 292. Head of the Sturgeon, with mouth protruded like a proboscis. After Benecke.

in adult specimens (more than 2 dm. in length) has all its upper rays, except the outermost 3—5, transformed into hard fulcra, is nearly twice as long as the lower.

The pectoral fins are set low, almost in the plane of the belly, and horizontally. They are obliquely pointed in form (fig. 288, p. 1049), with rounded inner posterior angle. Their length varies between about 12 and 11 % of that of the body, or between about 22 and 18½ % of the distance between the ventral fins and the tip of the snout, affording an easy distinction between the present species and the Sterlet, which has perceptibly longer pectoral fins. The first ray is considerably stronger than the rest; but distinct traces in its structure mark it as the result of a coalescence of several (8—10) simple and articulated rays. The ventral fins are inserted behind the middle of the body, at a distance from the tip of the snout measuring about 51—59 % of the length of the body. Their form (fig. 289) is less pointed and more trapezoidal than that of the pectorals. Their length during youth is about 55 %[a], in old specimens about 63—65 % of that of the pectoral fins. At the base of the anterior margin are set two short and thick supporting rays, similar to fulcra, and the following 6 or 7 simple rays gradually increase in length out to the tip of the fin. Both in form and structure the ventral fins are thus not unlike the vertical. The preabdominal length measures about 33—37 %, the postabdominal about 12 %, of the length of the body. The latter (the distance between the anterior margins of the ventral and anal fins) is, however, not fully entitled to the above name, for the vent lies rather far in front of the beginning of the anal fin, the distance between them being 5—7 % of the length of the body.

The coloration of the Sturgeon is simple, its salient features calling to mind that of the Codfishes[b]. The dorsal side is of a reddish or bluish gray, gradually paling down the sides of the body, though a distinct boundary-line, about half-way between the plates of the lateral lines and those of the ventral margins, divides this colour from that of the belly, which has a bluish tinge above, sometimes with a silvery lustre, and below is pure white. Above the ventral fins, however, runs a broad stripe, in an obliquely forward direction, joining the bases of these fins to the dorsal coloration. In young Sturgeons KRØYER found, "between the plate-rows of the dorsal and lateral lines, blackish spots, giving this part a chequered appearance". The outer parts of the fins are of a more or less pronounced ash-gray, becoming paler towards their bases. The pectoral fins are darkest, but share, as well as the dorsal and caudal, in the coloration of the back; the ventral and anal fins are palest. The iris is of a brassy yellow; the black pupil has a dash of green.

The Sturgeon is a salt-water fish with the migratory instinct of the Salmons, an anadromous form that ascends from the Atlantic into the rivers of North America and Europe in order to spawn. From the Atlantic its range extends into the Baltic and the Mediterranean including the Adriatic Sea. Whether it penetrates into the Black Sea[c], is doubtful. Neither HECKEL and KNER nor NORDMANN found it there[d]. In the Baltic, on the other hand, it makes its way to the head of the Gulf of Bothnia, according to a statement by WIDEGREN[e], even up the Tornea Elf. Now and then it is met with off all parts of the east coast of Sweden as well as on the Finnish coast, and occasionally it ascends into the Swedish lakes[f]; but it is common in the Baltic proper only to the south and in the German rivers falling into those waters[g]. It is common in all Danish waters, says WINTHER; but as the Danes do not ply any special Sturgeon-fishery, it is not seen very often. The case is the same throughout the west coast of Sweden, especially off Mount Kullen and in Laholm Bay; and in the Göta Elf it has been found at Lilla Edet, 33 miles above Gothenburg (NILSSON). In Norway too the same observation has been made: the Sturgeon is not taken anywhere in numbers, but solitary specimens are frequently met with throughout the coast-line, both in the sea and the river-mouths, even east of the North Cape (COLLETT and STORM). Off Iceland it is rare. It is common enough in the rivers running from the east into the North Sea. In Great Britain and Ireland it is not much commoner than in Sweden; but into the French rivers with a westward course, especially into the Garonne, the Sturgeon ascends more frequently and in greater numbers (MOREAU). Its most constant habitat lies, however, in the Mediterranean and Adriatic as well as the rivers flowing into these seas. On the east coast of North America its range extends from Cape Cod to Florida. A fresh-water form, considered to be a distinct species[h], inhabits the Mississippi Valley, the Great Lakes with their feeders, and the basin of the Albany River. On one occasion this American Sturgeon is supposed to have extended its wanderings into Scotch waters, and GÜNTHER[i] was of opinion that the young Sturgeon from Bohuslän, described by MALM under the name of *Acipenser sturioides*, should be referred to this species. So wavering are the specific distinctions within the genus;

[a] Sometimes 50, according to KRØYER.

[b] The name of ὀνίσκος was thus applied by the ancient Greeks both to Codfishes and the Sturgeon.

[c] GRIMM, l. c., states that it occurs there.

[d] In the Black Sea and the Danube lives a species very nearly allied to the Sturgeon, the *Osseter* (*Toks. Acipenser Guldenstadtii*), which has a broader mouth. Cf. below, as to the difference between the American fresh-water Sturgeon and the present Sturgeon

[e] Landtbr. Akad. Handl., 18:de delen (1858), p. 181.

[f] According to LILLJEBORG a specimen has been found in Lake Limmar (Roslagen, just south of Norrtelje).

[g] In the Baltic Provinces of Russia the Sturgeon is rare, according to SEIDLITZ, *Fauna Baltica*, p. 89.

[h] *Acipenser rubicundus* = *Ac. maculosus*. According to MILNER it has a broader mouth than our Sturgeon. No other distinction of any significance seems to be given between them.

[i] *Cat. Brit. Mus., Fish.*, vol VIII, p. 339, note

and the suspicion readily suggests itself that the American fresh-water Sturgeon is a landlocked form of the common Sturgeon, and stands in the same relation to the latter as *Salmo trutta* to *S. salar*.

Of the life and habits of the Sturgeon we possess but scanty information. Most of its existence is passed at the bottom, where it is beyond the reach of all curiosity. To judge by its behaviour in aquaria, it is a sluggish, though petulant creature; and it usually glides at a gentle pace over the bottom, shooting out and drawing in its mouth; but of a sudden, awaking, as it were, from its drowsy laziness, it darts through the water with the speed of an arrow. It is extremely tenacious of life, and in a cool place may be kept alive out of the water for twenty-four hours or even longer. "It seems a spiritless fish", says PENNANT[a], "making no manner of resistance when entangled, but is drawn out of the water like a lifeless lump". By the assertion of its great muscular strength, however, it sometimes gives formidable proof that it is by no means insensible to danger and sufferings, and a blow dealt by the tail of a large Sturgeon is enough to fracture an arm or a leg. Besides it is far from always so indifferent to its fate as to abandon itself to the toils without more ado. The fishermen frequently complain that it breaks loose from their nets. When the Sturgeons are found in rivers which they have ascended in order to spawn, and when they are distressed by the pressure of the tumid generative organs, they are sluggish from natural causes; but "in the sea, where they are sometimes stated to be sterile, they are evidently not ripe for the time being, being in a certain sense virgin, and consequently far more active. Herr DECKER has communicated a proverb current among the Sturgeon-fishermen of the North Sea, which runs, *Leaping Sturgeons and dancing girls are hard to hold fast*"[b]. The Sturgeon also resembles the Salmons in its habit, when migrating, of now and then flinging itself entirely out of the water.

The Sturgeon feeds in the manner just described on the worms of the bottom, crustaceans (*Amphipoda*), and mollusks, but also, like several Cyprinoids, on the decomposing animal substances to be found in the mud. The stomach of a male which was taken at Dalarö on the 18th of July, 1890, and which is represented in our figure (Plate XLVI, fig. 1), was filled at the anterior crook with a score or two of Isopods (*Idothea entomon*). That the diet of the Sturgeon consists principally of Herring, Mackerel, Cod, and Salmon, the last of which it chases up the rivers, is a statement which originated with LACÉPÈDE[c], and was dictated by his conception of the Sturgeon as distinctly a predatory fish, using its barbels as a lure to entice its prey. The Sturgeon, no doubt, does not disdain a fish or two, when it can procure a meal of this kind — its larger congener, the Hausen, is notorious for its pursuit of small fishes, especially a variety of Bleak, in the Russian rivers — but so far as we know, it contents itself with victims of insignificant size, such as Sand-Eels, whose manner of life renders them a suitable prey. We also know[d] that it is sometimes taken on Haddock-lines or Cod-lines, the bait of which must thus have attractions for it. From the last-mentioned circumstance we may also conclude that its haunts in the sea extend from the littoral zone down to a depth of some twenty-five fathoms; but how deep it can descend, is unknown to us.

The spawning-season of the Sturgeon occurs in spring and early summer, from April to the end of July. Like the Salmons, it then repairs to running water, preferring rivers with wide mouths, deltaic streams, or estuaries where the salinity of the water gradually diminishes up the channel. That it spawns in Sweden, admits of no question, though no special locality where the operation takes place is known. In the middle of July we once received from Luleå a ripe male, the internal organs of which are described above, and at the same time of year we obtained a spent male from Dalarö. In the island-belt of Södermanland EKSTRÖM secured fry 3—4 dm. long, "during autumn, in the deeper watercourses". Under ordinary circumstances the Sturgeon does not ascend so far up the rivers as the Salmon. Its timidity too probably leads it to avoid the Swedish rivers where timber is rafted. That it should spawn at the mouths of the Swedish rivers or even in the Gulf of Bothnia, on the shores of the island-belt, is by no means incredible. MILNER describes how its nearly related congener, if not a member of the same species, the fresh-water Sturgeon of America,

[a] *Brit. Zool.* (1776), vol. III, p. 110.

[b] HENKING, Deutsch. Fisch. Ver., Mitth. Sect. Küst., Hochseefisch., 1893, p. 21.

[c] *Hist. Nat. Poiss.*, (1798), tome I, p. 418.

[d] KRÖYER, l. c., p. 775.

congregates near the shores and at the mouths of the rivers, and how the fish may be seen in the evening leaping from the surface, throwing their bulky forms entirely out of the water. "At Pier Cove, Mich., on the 11th of June, 1871, schools of sturgeons were at the edge of the shore in a few feet of water, and men from the vicinity were in the habit of wading out and drawing them ashore with gaff-hooks. Mr. PORTMAN, of Benton Harbor, has seen the sturgeon at this season lying in numbers on a shallow clay ledge at the edge of a stream, several of them lying flat on their backs, with their bellies upward, rolling and splashing in shallow water, with apparent enjoyment"[a]. With regard to the spawning of our European Sturgeon, to the best of my knowledge, no personal observations have yet been recorded.

The eggs are at first yellow. As they approach ripeness, this colour turns to black. Eggs of both colours are often found interspersed in the same female. The diameter of the ova rises to about 2 mm., and their number in a single gravid fish runs to several millions. They are said to be hatched six days after deposition; and the fry soon afterwards set out on their journey to the sea, whence the young Sturgeons do not return until capable of taking part in the operations of reproduction.

The Sturgeon-fishery is naturally pursued on the most extensive scale in the countries where the fish annually ascend the rivers (for instance the Po) in large shoals. But the value of the Sturgeon is greatest just before the roe begins to ripen; and off the river-mouths of Northern Europe important sea-fisheries are carried on for Sturgeon in this condition, especially in the German Haffs and on the west coast of Germany. The tackle employed consists of coarse-meshed nets, with a mesh 14—18 cm. square, and with or without sinkers. The net is always loosely attached to the head-line, so that in certain parts the meshes run free along this rope, the Sturgeon thus entangling itself in the net more and more at every struggle. Besides Sturgeons the catch often includes seals and dolphins, Salmon and other large fishes. The captive Sturgeons are generally handled with no great tenderness. A rope is passed in through the mouth and out at one of the gill-openings. Another rope is made fast round the tail. The fish is then towed at the end of these lines beside the rowboat, and tethered, on the fisherman's return, to a stake or an anchor. The Sturgeon's tenacity of life often exposes it to considerable sufferings before it finds a purchaser.

The purposes to which the Sturgeon is applied in domestic economy, and the value set upon it, vary widely in different localities. The flesh, in many places where its excellent qualities are appreciated, has been and still is highly esteemed. There is an old saying which declares that a skilful cook can convert the flesh of the Sturgeon into ham, beefsteak, roast lamb, or feathered game. The ancient Romans decked the Sturgeon with flowers, and the dainty fish appeared at table to the strains of music. At present the Sturgeon is eaten less commonly fresh than smoked. The carcase is cut up, and the strips of flesh are cured in the said manner. Most generally known and prized, however, is the roe, which is usually sold in Sweden under the name of *Elbe caviare*[b]. To be fit for consumption, especially if it is to be kept any length of time, the roe should be not quite ripe. The ovaries are opened, and the roe is stirred in a sieve, through which it is carefully pressed, so as to rid it of the ovarian membranes and blood-vessels. This caviare requires no further preparation but salting, though it is often compressed in small bags, especially for transportation to other markets, in which form it is, of course, drier, but is preferred by many palates. *Vjeziga* (the notochord), which finds a great demand in Russia, is not prepared from the Sturgeon in Sweden.

The Sturgeon also yields — though on a far less important scale than the Hausen — an excellent fish-glue for industrial purposes. This gelatine properly consists of nothing but the innermost membrane of the air-bladder, washed and dried, in leaves which are cut to a convenient size. In this condition, its purest form, it is both tasteless and without smell, and may be used not only as a glue, but also as the best isinglass for soups and jellies, as a vehicle in the administration of medicines, and in the fining of wines. In the usual process of preparation, however, several other parts of the air-bladder are not removed, and the purity of the isinglass thus suffers. A coarser glue may be extracted from the skin of the Sturgeon, and the offal may be boiled down into oil.

[a] Cf. DEAN, *Note on the Spawning Condition of the Sturgeon*, Zool. Anzeig., XVI Jahrg., No. 436 (27 Dec. 1893), p. 473.

[b] The caviare principally imported from Russia into Sweden is the coarse-grained roe of the Hausen. The finer-grained, more valuable caviare of the Sterlet is scarce in the latter country.

PISCES ELASMOBRANCHII.

Fishes with cartilaginous endoskeleton (without dermoskeleton), with the shoulder-girdle detached from and suspended behind the head, with the maxillary (and mandibular) bones represented merely by loose cartilages at the sides of the palate and lower jaw, with the branchial arches entirely or partly united to the skin (gill-slits externally open or covered by a common dermal fold), and with diphycercal or heterocercal caudal fin. Fin-rays primary. Nostrils as a rule ventral[a]. Air-bladder none.

These fishes were removed from ARTEDI'S *Chondropterygii*[b] by BONAPARTE into a separate order, most clearly distinguished by the structure of the gills both from the preceding orders, which have borne the common name of *Tectobranchii*[c], as having the branchial cavity covered by a true opercular apparatus, belonging to the skeleton, and from the lower fishes, the *Cyclostomi* and *Leptocardii*, which are without true branchial arches. The union between these arches and the skin is accomplished in the Elasmobranchs by the extension of a membrane, supported by cartilaginous rods, between the latter and each of the former. With this membrane too the several branchial lamellæ coalesce throughout their length. In some Elasmobranchs, in the suborder of the Chimæras, however, the said membrane extends only in part, above and below, quite to the skin, a common branchial cavity being thus produced on each side of the body. This cavity is furnished, as in the preceding fishes, with a single aperture, and the rest of it is covered by a dermal flap, extended on cartilaginous rods, which are homologous with the branchiostegal rays of the Teleosts, and by a thin disk of cartilage (fig. 294, *op*), representing the operculum of the preceding fishes, but evidently formed here, as in the other suborder, by the mutual confluence of the upper (posterior) cartilaginous rods at the upper (anterior) end. Analogous cartilaginous rods also appear, as we have mentioned, in the membrane originating from each of the branchial arches, and supplying attachments for the branchial lamellæ. In the rest of the Elasmobranchs, the suborder of the Sharks and Rays, which is far superior in variety of form, the last-mentioned membrane, supported by its cartilaginous rods (figs. 298 and 300, *rbr* and *hr*), is united throughout its extent, both from the hyoid and the branchial arches, either obliquely or in a straight outward direction, to the skin, which opens at the interstices into external gill-slits, numbering 7—5 in the surviving forms of this suborder.

The scapular and pelvic arches are far more developed in the Elasmobranchs than in the preceding fishes; and starting from the Elasmobranchs, morpho-

[a] An exception is made by ancient (primitive) forms, such as *Chlamydoselache anguineus*, a Japanese fish remarkable in many other respects on account of its primitive characters, and described by GARMAN, Bull. Mus. Comp. Zool. Harv. Coll., vol. XII, No. 1, and GÜNTHER, *Deep Sea Fish.*, Chall. Exped., p. 2, pl. LXIV, LXV.

[b] See above, p. 1043.

[c] HASSE, *Beitr. allgem. Stammesgesch. Wirbelth.*, Jena 1883, p. 12

logists have succeeded in explaining the equivalent parts of the preceding fishes, where these are more and more simplified by reduction, as well as the corresponding structure of the higher vertebrates. In some Elasmobranchs (the Rays, fig. 293) the shoulder-girdle forms a closed, flattened ring around the anterior end of the abdominal cavity and the spinal column behind the last branchial arch, being suspended over the confluent neural spines of the anterior part of the spinal column. The upper part of this ring consists of the two simple suprascapular disks, one on each side of articular condyles (for the pectoral fin), set in an horizontal row. The scapular part lies above the coracoid; but both of them form a continuous cartilaginous disk, and are also of a piece with the lower median part of the ring. The last-mentioned part has been interpreted by PARKER as an equivalent of the epicoracoid bone of the higher vertebrates, where this bone is distinct even in the lowest mammals. In most of the Elasmobranchs (the Sharks and Chimaeras, fig. 294), however, the suprascapular cartilages (*ssc*) are parted from each other and suspended from the membranous investment

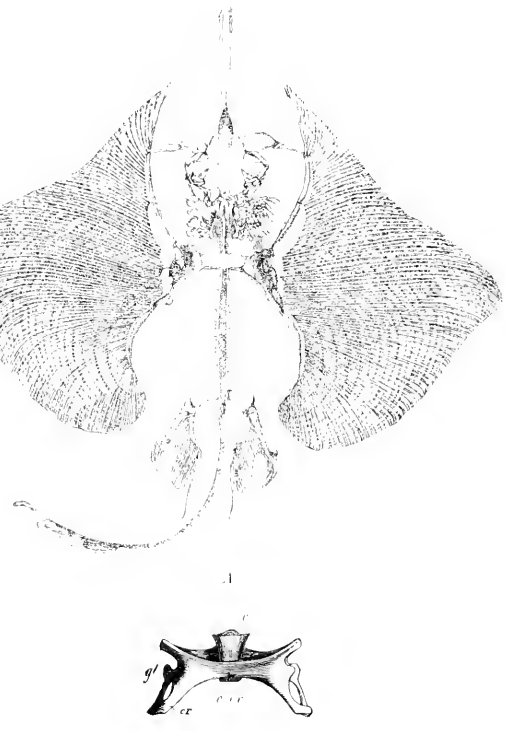

Fig. 293. Skeleton and shoulder-girdle of the Rays.

A: Skeleton of a Skate (*Raja nidrosiensis*), ♂, seen from the dorsal side. $^{1}/_{10}$. Trondhjem Fjord, March 17, 1891. Conservator STORM. *B*: Shoulder-girdle of a Thornback (*Raja clavata*), seen from the ventral side. $^{1}/_{3}$. After PARKER. *c*, part of the spinal column; *gl*, the first of the three lateral processes furnished with articular surfaces for the pectoral fin; *cr*, coracoid part; *c. cr*, ventral side of the shoulder-girdle (epicoracoid part).

the spinal column. The sides thereof are formed by the much more expanded scapular and coracoid parts, which are pierced with large foramina (for the passage of nerves and blood-vessels) and furnished with three (*aponeurosis*) of the dorsal muscles only by a prolongation of their own investing membrane (*perichondrium*), the whole girdle too being more simple and not unlike the pelvic girdle. The cartilage of the latter (figs. 293, *A* and 295) never forms a closed arch, but only a ventrally situated half-arch on each side, the two halves being usually confluent in the median line of the belly, but in the Chimaeras united only by a mobile symphysis. The main part of the pelvic girdle — originally produced by the inward growth and coalescence of the inner (proximal) parts of the primary ventral radialia — answers to the *ossa pubis* and *ossa ischii* of the higher vertebrates, but in most cases there appears on each side a process ascending from the end of the pelvic disk, especially well developed in the Rays, and representing an *os ilii*. In the Chimaeras this process runs so far up, more in a straight line with the pelvic disk, as to unite by means of ligaments the pelvic girdle and the aponeurosis of the lateral muscles, in the same manner as the suprascapular cartilage suspends the shoulder-girdle in these fishes and in the Sharks. A closer morphological connexion in respect to the structure of the shoulder-girdle and pelvis exists, as we see, between the Elasmobranchs and the higher vertebrates than between the former and the Teleosts.

The structure of the fins points to a similar conclusion. In this respect, it is true, the Elasmobranchs approach nearer to the common parent-forms, where all the fins were more or less differentiated sections of originally continuous dermal folds — unpaired along the dorsal and interior caudal margins, but double (paired) on the ventral side, as having been divided to surround

Fig. 294. Anterior part of the skeleton in a *Chimaera monstrosa*, ♂. 2/3 nat. size.

b, saddle-like disk formed by the coalescence of the neurapophyses of the first abdominal vertebrae; *bhy*, basihyoid; *cc*, anterior aperture of the ethmoidal canal; *ch*, notochord; *chy*, ceratohyoid; *cp*, precorbital canal, passage of the *ramus ophthalmicus superior nervi trigemini* to the ethmoidal canal; *da*, anterior dental plate of the upper jaw; *di*, dental plate of the lower jaw; *dp*, posterior dental plate of the upper jaw; *fa*, foramen for a branch of the facial nerve; *fb*, fibrils of the anterior dorsal and the pectoral fins; *h*, rudimentary haemapophyses; *hm*, hyomandibular; *ihtd*, spine (ichthyodorulite) of the anterior dorsal fin; *in*, interneurals; *lf*, fronto-nasal cartilage (prehensile organ of the male); *lmi*, labial cartilage of the lower jaw; *lms*, labial cartilage of the upper jaw; *ln*$_1$, first labial cartilage of the nasal capsule; *ln*$_2$, second labial cartilage of the nasal capsule; *lr*$_1$, first rostro-nasal cartilage; *lr*$_2$, second rostro-nasal cartilage; *mb*, posterior, fibril-less membrane of the first dorsal fin; *mp*, *mesopterygium*; *mt*$_1$, first part of the *metapterygium*; *mt*$_2$, second part of the *metapterygium*; *N*, nasal capsule; *na*, neurapophyses; *occ*, occipital condyles; *on*, orbitonasal canal, passage of the *ramus ophthalmicus profundus nervi trigemini* to the ethmoidal canal; *opt*, optic foramen; *pp*, *propterygium*; *qpg*, palatoquadrate; *R*, undivided radial (interspinal) cartilage of the first dorsal fin; *rb*, foramen for the *ramus buccalis nervi trigemini*; *s*, Solgerian (spiracular) cartilage; *sc*, scapular cartilage; *sp*, tegumentary cartilage of the spinal canal (*processus spinosi superiores*); *ssc*, suprascapular cartilage; *sy*, *symplecticum*; *tr*, foramen for the trigeminal and facial nerves; *trs*, foramen for the *ramus ophthalmicus nervi trigemini*; *1–6*, first (proximal) to sixth (distal) series of the pectoral radialia.

the vent and advance along each side of the belly"[a]. Yet this structure has undergone great development, retaining meanwhile the axial parts of the paired fins to such an extent that morphological comparison may have recourse to the Elasmobranchs in quest of starting-points for the interpretation of the arms and legs of the higher vertebrates. From embryology BALFOUR[b] and WIEDERSHEIM[c] learnt — as THACHER[d] and MIVART[e] had previously discovered by researches in comparative anatomy — that the primordial parts in the skeleton of the paired fins are the basal portions of the cartilaginous rays (primary radialia), which grow inwards to form the groundwork of the shoulder-girdle and the pelvis, and in their outward collocation, radiating unilaterally from a basal part, are split in a transverse direction and multiplied within the fin itself. That the primordial arrangement, however, here as in the diphycercal caudal fin, was bilateral, with rays on each side of an axial part, appears from such forms as *Pleuracanthus*, a primitive Shark of the Permian fauna, or *Ceratodus*, a still surviving Lung-fish[f]. The axial parts which have been retained in the paired fins of the living Elasmobranchs have been named by GEGENBAUR the *anterior*, *middle*, and *posterior pterygial parts* (*pro-*, *meso-*, and *metapterygium*). In some forms, as in the Rays, the Notidanoids, and some other Sharks, all these parts share in the articulations of the pectoral fins, in others only two of them or even only one, as the propterygium and a part of the metapterygium in *Chimæra* (fig. 294, *pp* and mt_1), and the metapterygium in *Scymnus*. The last-mentioned peculiarity may also be observed in the ventral fins. In the Chondrosteans and Teleosts we have seen how these parts gradually disappear during the development of the normal piscine type. In the ventral fins of all male Elasmobranchs, on the other hand, the metapterygium is prolongated into free appendages (fig. 295, *ptpd*), which may serve as organs of motion, but are properly copulatory organs. The male Chimeras are furnished with another appendage, possessing the same function, a mobile, sickle-

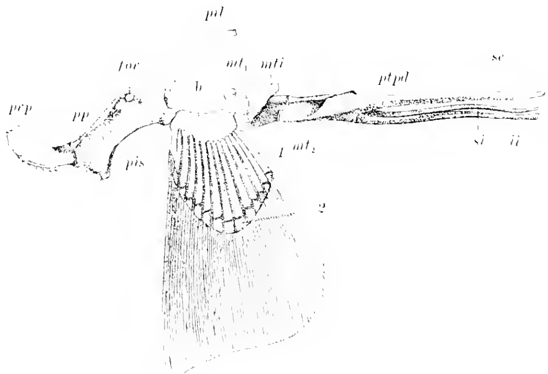

Fig. 295. Left side of the pelvic girdle and left ventral fin of a *Chimæra monstrosa*. ♂. $^2/_3$ nat. size.

b, undivided basal cartilage of the ventral fin, answering to the propterygium and mesopterygium; *for*, obturator foramen, at the side of which appear two fenestræ, closed with membrane, in the pelvic cartilage; *pil*, iliac part; *pis*, ischiadic part; *pp*, pubic part; *prp*, præpubic part, serrated cartilage or anterior copulatory organ of the male; *ptpd*, *pterygopodium* of the male, metapterygoid structure, consisting of: *mti*, inner metapterygoid cartilage; mt_1 and mt_2, inner (proximal) and outer (distal) metapterygoid parts, the latter divided into three branches, the outer superior (*se*), the inner superior (*si*) and the inner inferior (*ii*).

[a] Cf. SMITT: *Ur de högre djurens utvecklingshistoria*, pp. 240 and 241.

[b] *Comparative Embryology*, vol. II, pp. 492, cett.

[c] *Das Gliedmassenskelet der Wirbelthiere*, Jena 1892.

[d] *Median and paired fins*, Trans. Connect. Acad., vol. III (1877).

[e] *On the Fins of Elasmobranchii*, Trans. Zool. Soc. Lond., vol. X.

[f] Appending a reference to the structure of the paired fins in *Ceratodus*, I expressed in 1873 the above-cited opinion, which WIEDERSHEIM (l. c., p. 13) calls "Die THACHER-MIVART-BALFOUR-HASWELL-DOHRN'sche *Lehre*".

shaped disk of cartilage (fig. 295, *prp*) on each side of the pelvis, armed with sharp teeth at the outer (lower) margin, and analogous in position to the praepubis of the Batrachians and Reptiles.

The fin-rays of most of the Elasmobranchs are cartilaginous, distal sections (joints) of the radialia; but in the membrane of the outer parts of the fins — sometimes, as in the dorsal fins of the Rays, also between the tops of the true rays — are set fibrillar or corneous rays (figs. 294—297, *fb*), such as we have seen above in the embryonic fins of the Teleosts or in the so-called adipose fin. In the Sharks and Chimaeras similar rays support the greater part of the fins (outside the radialia). Well-marked calcifications indeed appear, under the form of fin-rays almost exactly resembling in their exterior the spinous rays we have seen among the preceding fishes. Such rays are set in many Elasmobranchs before the unpaired fins (fig. 294, *iktd*); and in some Rays they arm the tail with mobile weapons of offence and defence. In palaeontology they bear the name of *ichthyodorulites*. AGASSIZ has shown[a], that both as regards their attachment, which is without true articulation, and their texture, which exactly corresponds to the dentinal structure of dermal spines (placoid scales) and jaw-teeth, these spines are widely different from the spinous rays of the Teleosts. They are mere dermal growths; but inasmuch as they immediately overlay and cover with their bases the anterior margin of the supporting cartilages of the fins — e. g. the spines of the dorsal fin in the Sharks and Chimaeras — they should also be interpreted as most nearly representing skeletal tegumentary bones, although they are without true ossification.

The skeleton of the Elasmobranchs is characterized by this very want of endoskeletal and tegumentary bone. Calcifications of great extent appear it is true, in old specimens, under the form af a thin coat outside or just within the surface of the skeletal cartilage, and in several Sharks the intercellular mass of the vertebral cartilages is radially or (at the centre of the vertebra) concentrically calcified. But there is no true ossification. The structure of the spinal column, composed of very numerous vertebrae, displays the most sweeping alterations and the most radical divergencies. In the Chimaeras the notochord (fig. 294, *ch*) remains almost unaltered throughout the life of the fish; but around it slender calcific rings develop, several, five or even more, to each vertebra, whose area may be defined as the space between the origins of two pairs of roots belonging to the medullary nerves. In the Sharks and Rays, on the other hand, the notochord is more or less constricted (fig. 296, *c*), or even snipped off entirely at each vertebra (fig. 297, *c*), by the formation of the hollow double cones, contiguous at the tops, of which the body of the vertebra is composed. The neural arches of each vertebra are usually broken up into two or more pairs of triangular disks, the true neurapophyses (figs. 294, 296, and 297, *na*) applying their base to the body of the vertebra, and the other disks, the so-called upper intercalaria or intercruralia (*in*), wedging the apex of their triangle in a downward direction between the neurapophyses. The spinal canal is sometimes (fig. 294, *sp* and fig. 297, partly between *le*) closed above by the development of unpaired terminal parts, answering to the upper spinous processes of more developed vertebrae, and where the vertical fins appear, vertical disks of cartilage sometimes afford high supports to these fins and their radialia — sometimes produced by the coalescence of the spinous processes, as in the Chimaeras (fig. 294, *b*), sometimes corresponding to the interspinal or interneural bones of the Teleosts. In other cases this closure is accomplished by the intercalaria (fig. 296 and fig. 297, partly between *le*). Or the covering may consist simply of a fibrous membrane. The neural arches sometimes (e. g. in the Rays) grow downwards along the sides of the vertebrae or even to their ventral side; but as a rule haemal arches (figs. 296 and 297, *ha*), lower intercalaria (*ih*), and lower terminal parts (spinous processes) are developed in a downward direction, their extent and alterations being similar to those we have just remarked in the corresponding parts of the neural canal. In the anterior part of the body, behind the head, both the vertebrae and their apophyses often coalesce into a continuous mass of cartilage, pierced only by the spinal cord and the spinal nerves; and in this part ribs are wanting or replaced by a continuous fibrous membrane, whereas costal cartilages are present further back. Such is the case in the Rays. In the Sharks, on the other hand, the vertebrae are more regularly differentiated throughout the spinal column; and ribs, though sometimes wanting, are more frequently present throughout the abdominal region. The *Holocephali* (fig. 294) show

[a] *Poiss. Foss.*, tom. III, pp. 1 and 212

a coalescence of the anterior part of the spinal column similar to that just mentioned, and are without ribs. The ribs of the Elasmobranchs, however, differ essentially from those of the Teleosts in being more deeply embedded in the musculature (flesh), so that they are not immediately applied to the peritoneum, but in this respect more nearly answer to the scleral bones of the Teleosts and the ribs of the higher vertebrates.

The skull forms a continuous capsule of cartilage, with no other limits between the separate parts than those indicated by the situation of the organs of sense and by the orifices of the cranial nerves. With their aid we can distinguish (*1*) an occipital region, around their postorbital (*ptob*) and preorbital (*prob*) processes, (*4*) an ethmoidal region, around the nasal capsules (*N*) with the internasal cartilage, and lastly (*5*) a rostral region, with the confluent tops of the primordial trabeculæ (the basitrabecular tip, *R*) and the supporting cartilage (*h*) of the strongly developed rostral system of the lateral line.

The occipital region is the shortest. In the most primitive forms the anterior end of the notochord extends into the basioccipital part[a], and the foremost neurapophyses enter into the cerebral capsule. In the Sharks the articulation between the head and the first vertebra is commonly very little more developed than

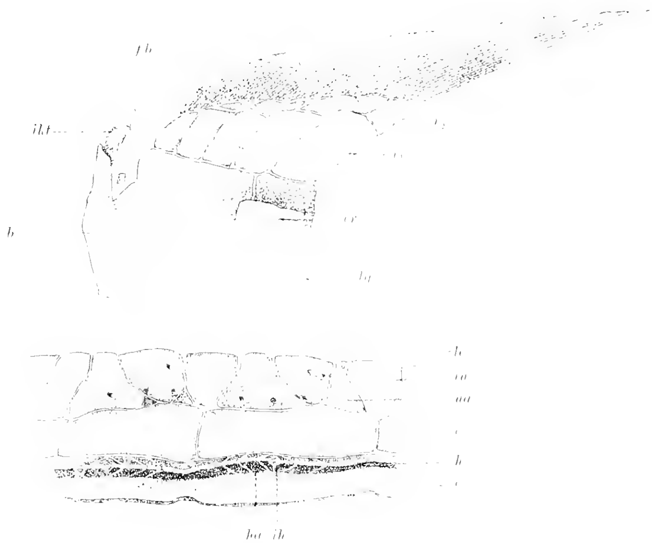

Fig. 296. First dorsal fin with its skeletal parts and the subjacent part of the spinal column in a Cyclospondyle (HASSE), a Greenland Shark (*Acanthorhinus carcharias*), 230 cm. long, from the North Sea. $^1/_2$ of the natural size.

b, basal disk of the dorsal fin; *ikt*, rudimentary dorsal spine, hidden under the skin; *fb*, dorsal fin with its bunches of fibrils; r_1 and r_2, first (proximal) and second (distal) rows of radialia; *cr*, lateral ridge of the basal disk, a projecting crest for the attachment of muscles; *lg*, vertical ligament of the dorsal fin; *le*, elastic ligament of the spinal column; *in*, interneural cartilages (*intercalaria neuralia*); *na*, neurapophyses; *v*, vertebræ, superficially constricted and each containing in the space between the constrictions a division of the spinal cord; dispondylic, each vertebra answering to two neurapophyses; *h*, hæmal ridge, divided into hæmapophyses (*ha*) and interhæmal cartilages (*ih*, *intercalaria hæmalia*).

the foramen magnum (figs. 298 and 299, *fom*), and limited in front by the *nervus vagus* foramen (*vag*), (*2*) a temporal or labyrinthine region, bounded in front by the true trigeminal foramen (figs. 294 and 300, *tr*), (*3*) a frontal (orbital) region, surrounding the orbits with in the Teleosts; but in the Rays (fig. 300) and the Chimæras (fig. 294), as well as in some Sharks (fig. 298, *C* and fig. 299), this articulation is accomplished by true condyles (*occ*), in the same manner as in the higher vertebrates. In the Chimæras, these condyles,

[a] See, for example, *Chlamydoselache* in GARMAN (Bull. Mus. Comp. Zool. Harv. Coll., vol. XII, No. 1), pl. VII, fig. B.

low but broad, medially convex and laterally concave, are set one on each side of the foramen magnum, and a corresponding condyle, medially concave and laterally convex, is set on the front side of the confluent vertebral mass at the beginning of the spinal column (fig. 291, *b*).

The temporal region surrounds the parts of the labyrinth, and frequently shows traces (elevations), even on the surface, of the position within the cartilage of the labyrinthine canals (fig. 298, *asc*, *psc*, and

On the outside of the lateral cranial walls there lie in this region the more or less marked articular cavities of the hyomandibular cartilage (*hm*). Through the temporal region pass the foramina for the *nervus glossopharyngeus* (fig. 298, *C*, *gp*), *n. facialis* (fig. 300, *fa*), and, at the boundary between it and the orbital region, for the *n. trigeminus* (*tr*).

The orbital region is furnished on each side in the most primitive forms with a posterior articular cavity for the palatine cartilage of the upper jaw (pa-

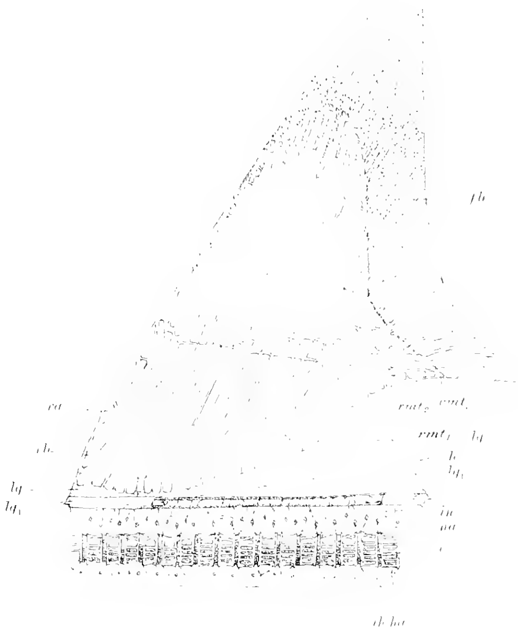

Fig. 297. First dorsal fin with its skeletal parts and the subjacent part of the spinal column in an Asterospondyle (HASSE), a Porbeagle (*Isurus cornubicus*), 213 cm. long, from the North Sea — $^1/_4$ of the natural size.

ra, radialia of the anterior margin; *rb*, basal radialia; *fb*, bunches of fibrils, partly inserted between the distal radialia; *rmt*, metapterygoid radialia, with their distal sections (rmt_2 – rmt_4); *lg*, vertical ligament of the dorsal fin, investing in its lower part (lg_1) the elastic ligament of the spinal column (*h*) — the last ligament is partly removed to show the roof of the spinal canal, composed partly of the interneural arches, partly of special supraspinal cartilages; *in*, interneural cartilages; *nt*, neurapophyses; *c*, vertebrae, complete, amphicoelous, with longitudinal lateral cavities and ribbed; monospondylous, each vertebra answering to only one neurapophysis; *ha*, haemapophyses; *ih*, interhaemal cartilages; the two last-mentioned cartilages together forming on each side of the spinal column a rim projecting outwards and downwards (answering to *h* in the preceding figure).

hsc) and the vestibule. On the upper side of the skull (figs. 298—300) this region is usually depressed into a parietal cavity, where the two endolymphatic ducts or *aquaeductus vestibuli* (*aqv*) have their orifices.

latoquadrate cartilage) on a postorbital process, and with an anterior articular cavity for the same cartilage at the bottom of the orbit, on an expansion of the cranial cartilage which has been called the basal disk, and which

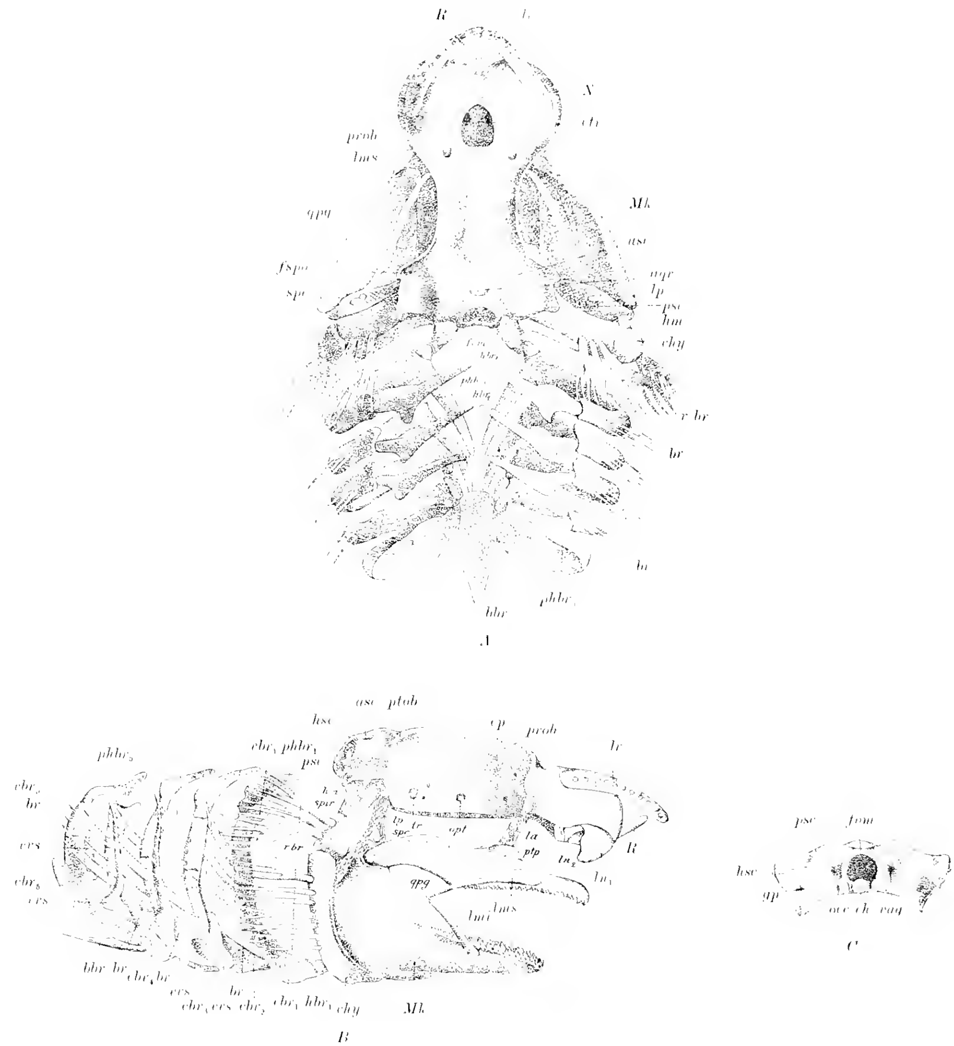

Fig. 298. Skull of Rough Hound (*Scylliorhinus canicula*), seen from above (*A*), from the right (*B*), and from behind (*C*). Natural size. After PARKER.

aqv, *aquaeductus vestibuli*; *asc*, external prominence of the anterior semicircular canal of the labyrinth; *bbr*, *basibranchiale* (*copula*); *br*, cartilaginous rods of the branchial membranes; cbr_{1-5}, ceratobranchials of the first—fifth branchial arches; *ch*, space for the notochord, filled with cartilage; *chy*, *ceratohyoideum*; *cp*, preorbital canal; *ctr*, *cornua trabecularum* in the floor of the skull, seen through the prefrontal fontanelle; ebr_{1-5}, epibranchials of the first—fifth branchial arches; *evs*, extravisceral cartilages; *fom*, foramen magnum; *fspo*, supraorbital foramen; *gp*, foramen for the *nervus glossopharyngeus*; hbr_{1-2}, hypobranchials of the first and second branchial arches (other hypobranchials not denoted); *hm*, *hyomandibulare*; *hsc*, external prominence of the horizontal (outer) semicircular canal of the labyrinth; *la*, anterior suspensory ligament, for the palatoquadrate cartilage; *lmi*, labial cartilage of the lower jaw; *lms*, labial cartilage of the upper jaw; ln_{1-2}, anterior and outer nasal labials; *lp*, posterior suspensory ligament, for the palatoquadrate cartilage (upper jaw) and the mandibular arch (Meckelian cartilage); *lr*, rostral labials; *Mk*, Meckelian cartilage (lower jaw); *N*, nasal capsule; *occ*, occipital condyles; *opt*, optic foramen; $phbr_{1-5}$, pharyngobranchials of the first—fifth branchial arches; *prob*, preorbital process; *psc*, external prominence of the posterior semicircular canal of the labyrinth; *ptob*, postorbital process; *ptp*, suspensory process of the pterygopalatine arch; *qpg*, pterygopalatine cartilage; *R*, rostral cartilage; *r. br*, branchiostegal rays; *spc*, spiracular cartilage; *spir*, spiracle; *tr*, foramen for the *nervus trigeminus*; *vag*, foramen for the *nervus vagus*.

projects downwards in an angle, known as the basilar angle[a]. But in the more recent forms of Sharks and in the Rays these articulations have been loosened, and are replaced by ligaments, the postorbital process and the basilar plate having meanwhile suffered reduction[b]. The Chimæras have undergone an opposite development, the palatoquadrate cartilage (fig. 294, *qpq*) being confluent with the skull — whence the name of *Holocephali* — and forming a firm floor to the orbit. Within the skull, above and just behind the basilar angle, lies the *Turkish saddle* (with the *infundibulum*, *glandula pituitaria*, and *canalis caroticus*), and here the septum between the orbits is pierced by a transverse canal, in and around which the *musculi recti* of the eye have their insertions, and which is consequently homologous with the posterior orbito-muscular canal present in most of the Teleosts. In the orbital region the roof of the skull (the forehead) is sometimes (in the Rays) imperfectly closed, being completed by a membrane (frontal fontanelle, fig. 300, *fonf*). The anterior limit of the orbits is formed by the preorbital process (figs. 298—300, *prob*), which is pierced, as well as the more or less arched and expanded roofs of the orbits (with their supraorbital foramina, fig. 298, *fspo*), by ramifications of the ophthalmic branch of the trigeminal nerve. The canal (preorbital canal, figs. 294 and 298, *cp*) that traverses the upper part of the preorbital process for this purpose either opens on the top of the skull (fig. 299, cp_1) and soon descends again into the cartilage of the ethmoid region (ethmoidal canal, fig. 294, *ce*), or proceeds uninterruptedly, without appearing on the surface, into the said cartilage, or leads to a deep incision on each side of the skull (fig. 299, *ie*), the limit between the orbital and ethmoid regions. In the lower part of the preorbital process runs another canal, the so-called orbitonasal canal (fig. 294, *on*), to receive another ramification of the said ophthalmic nerve. Behind the optic foramen there often projects within each orbit a cartilaginous rod to support the eyeball, this rod being the so-called eye-stalk. The tip of each preorbital process sends out in the *Notidanidæ* (the most primitive in type of the surviving Sharks) a backward process, which in the Rays (fig. 300, *pob*) becomes a free cartilage jutting out laterally and jointed by a well-developed articulation with the preorbital process and the nasal capsule. By PARKER[c] this cartilage was interpreted as a vestige of a preoral (situated before the mouth) visceral arch; but it would seem to have most in common with the preorbital bone of the Teleosts, especially as this appears in the *Cobitidæ*. In the Rays it meets the prorsal basal cartilage (propterygium) of the pectoral fins, and is most highly developed in the Electric Rays (*Torpedines*) and Eagle-Rays (*Myliobatidæ*).

The ethmoid region composes the anterior limit of the cranial cavity, being the product of the strong expansion and development of cartilage attained by the side-angles of the embryonic trabeculæ (fig. 298, *ctr*). Medially this mass coalesces into a septum, the internasal cartilage, between the large nasal capsules (figs. 294 and 298—300, *N*), each of which is pierced with a large foramen for the olfactory nerve. On the upper side of the skull there appears at this point, in most of the Elasmobranchs, the large prefrontal fontanelle (figs. 299 and 300, *fonpf*), filled with a loose, mucoid connective tissue, the backward continuation of which passes, in the interior of the skull, into the hard membrane of the brain (*dura mater*). The lateral parts of the ethmoid region are formed by the large nasal capsules (*N*), which are of an inverted bowl-shape, arched above, open below, and the posterior walls of which coalesce on each side with either preorbital process. The structure of these capsules originates, it is true, from the side-ends of the embryonic trabeculæ; but also includes up to three so-called labial cartilages (figs. 294 and 298, ln_1 and ln_2), originally free, which form the margin and marginal valves of the nostrils.

The rostral region, which attains its greatest development in the Rays and Saw-fishes — being produced in the latter into the so-called saw with its large lateral serrations and its two pairs of longitudinal canals, the inner pair continuations of the above-mentioned preorbital canals — is least developed in the most primordial Sharks, where it forms a compressed and narrow, or depressed and broad prolongation of the cranial floor. In most Sharks, however, the snout is furnished on each side with a supporting cartilage (figs. 298 and 299, *lr*), originally a so-called labial

[a] Cf. the Sturgeons, see above p. 1045, fig. 284, *B*.

[b] An exception to this is the Hammerhead (*Zygæna*), in which the posterbital process as well enters into the laterally elongated orbits.

[c] *Skull of Sharks, Skates*, Trans. Zool. Soc. Lond., vol. X, p. 224 (*ao*).

cartilage, which is directed from the tip of the rostral cartilage (R) to the roof of the nasal capsule on the same side. These two lateral cartilages and the rostral cartilage thus build up a three-sided pyramidiform case, within which is enclosed the fibrous capsule wherein the ampullæ hereafter to be described have their cæcal base. In the *Holocephali* — where, as in the generality of deep-sea fishes, the rostral system of the lateral line is particularly well developed — the soft snout and the said capsule are supported by a pair (fig. 294, lr_2) of cartilaginous rods, widely separated at the bases but converging towards the tips, with the bases resting on the snout in front of the nasal capsules, and by an

The morphological homologues of the jawbones of the Teleosts and the higher vertebrates also appear in the Elasmobranchs under the guise of labial cartilages. The Elasmobranchs are in general raptorial fishes of a pronounced type, with powerful teeth in the mouth; but these teeth are set, not on the jawbones proper, but on the predecessors, in the development of the vertebrate type, of the palate and lower jaw, on the palato-quadrate cartilage (figs. 294 and 298, *qpq*) and the so-called Meckelian cartilage (*Mk*) of each side, the predecessors of the lower jaw, which cartilages appear even in the embryos of the highest vertebrates as gradually evanescent rudiments in the structure of the

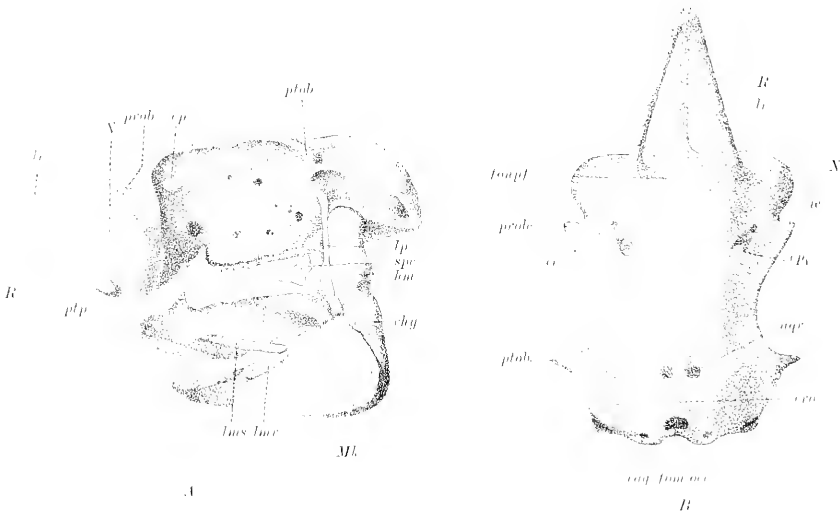

Fig. 299. Skull of a Tope (*Galeorhinus*), seen from the left (*A*) and from above (*B*). After Gegenbaur.
cro, rudiment of occipital crest; *foupf*, prefrontal fontanelle; *ie*, *incisura ethmoidalis*. The other letters are explained in the preceding figure.

unpaired, thicker and firmer cartilaginous rod (lr_1), set on the bridge of the snout between the two anterior openings of the ethmoidal canal (*ee*), a confluence of the anterior parts of the preorbital (*cp*) and orbitonasal (*on*) canals. The males also possess a similar cartilaginous rod (*lf*) above the preorbital process, free and mobile, transformed to a prehensile organ set with teeth, and probably serving to hold the female during copulation. The history of evolution has not yet elucidated the morphological significance of these cartilaginous rods in the *Holocephali*, but from this point of view they should probably be ranged, one and all, beside the labial cartilages of the Sharks.

mandible. The relation of the palatoquadrate cartilage to the skull we have already considered. At the posterior (quadrate) extremity it articulates with the Meckelian cartilage, which here functionates as a lower jaw, so that the two pairs of cartilages form a ring around the gape. But these cartilages, especially the Meckelian, are closely united behind by ligaments to the hyoid arch, an opening (the spiracle, fig. 298, *spir*) being left, however, between the quadrate (*qpq*) and the hyomandibular (*hm*) cartilages, and the anterior margin of this spiracular canal being furnished either with a more or less developed cartilaginous disk (*spc*), answering to the metapterygoid bone of the Teleosts, or, as in the Rays (fig. 300, *mpl*), by a more extensive cartilage, stretching from the lower part of the hyomandibular bone to the postorbital region. Outside this pharyngeal and masticatory apparatus there lie as a rule three (sometimes — as in several Sharks fig. 298, *lms* and *lmi* — only two, sometimes — as in the Rays — none) pairs of labial cartilages, the two largest and most constant meeting at each corner of the mouth. Where they are all present, two of them (*lms*) lie, one before and below the other, on the outside of the palato-quadrate cartilage, the third (*lmi*) outside the Meckelian cartilage. The former two answer to the intermaxillaries and maxillaries, the latter is homologous with the mandible.

The position occupied in relation to the said skeletal parts by these cartilages recurs in a number of cartilaginous rods (fig. 298, *ers*), first described by RATHKE[a], which lie in the skin between the gill-openings, forming the outer support of the above-mentioned cartilaginous rods in the branchiostegal membranes (fig. 298, *br*). GEGENBAUR[b] called the first-mentioned rods *outer gill-arches*, and considered them, as CUVIER had partly done[c], to be vestiges of the more complex branchial arches of the Marsipobranchs. PARKER[d] called them *extravisceral*s or *extrabranchials*, and saw in them homologues of the shoulder-girdle (the scapulae and coracoid bones), as being *extracostal* growths. Where their development is highest, as in the majority of the Sharks, they consist of two parts, a dorsal and a ventral, which meet and are applied to each other throughout a greater or less portion of their extent. In several Sharks and in the Rays they either are rudimentary, or have only the ventral parts developed (fig. 298), or are entirely absent. The angular, hooked or forked ventral ends of these "outer gill-arches" are joined below, from one side of the body to the other, by an horizontally set, fibrous membrane; and in this manner is formed, under the hypobranchial (lowest, figs. 298 and 300, *hbr*) and copular (*bbr*) parts of the true branchial arches, a special chamber, a prolongation of the pericardial cavity, to receive the heart with the *conus arteriosus* and, within an anterior division, the *truncus arteriosus*.

The hyoid arch shows an entirely different composition and suspension in the Sharks and Chimaeras on the one hand and in the Rays on the other. In the former the true middle part (*ceratohyoideum*, figs. 294 and 298, *chy*) is suspended from the lower extremity of the hyomandibular cartilage (*hm*), and these parts are united below, from one side of the body to the other, by the first copula (*basihyoideum*, *bhy*). In the Rays the hyoid arch consists on each side, as a rule, of 3 or 4 parts, the lowest (*hypohyoideum*, fig. 300, *hhy*), as well as the lowest part of the first branchial arch (*hypobranchiale*), meeting the first copula (bbr_1). Among the remaining parts of the hyoid arch the ceratohyoid (*chy*) and epihyoid (*ehy*) are the most constant; the uppermost part (*sthy*), answering to the stylohyoid of the Teleosts, is either cartilaginous or represented by a ligament, and suspends the arch from the upper posterior angle of the hyomandibular cartilage. The true branchial arches consist as a rule of four parts on each side — the hypobranchial (*hbr*), the ceratobranchial (*cbr*), the epibranchial (*ebr*), and the pharyngobranchial (*phbr*). But between the lowest parts (the hypobranchials) there appear in the Sharks, though their occurrence is irregular, unpaired pieces (copular parts), sometimes five in number. Only the hindmost and largest (*bbr*), under which the heart is situated, is constant, and this is always present in the Rays as well, where it attains a still greater development.

Gill-rakers are usually wanting in the Elasmobranchs; but two remarkable exceptions are formed by the largest Sharks known, the North Atlantic Basking Shark and the Whale-Shark (*Rhinodon typicus*) of the Cape of Good Hope and the Indian Ocean east of Africa. Like the whales, these Sharks live on small animals, and like the Teleosts that feed in the same way, they are furnished with a filtering apparatus ("gill-grating", STEENSTRUP, see fig. 332, p. 1115), which separates the food from the water that pours from the mouth at the same time and finds an outlet through the gill-slits. This filtering apparatus is composed in the Basking Shark[e] of fine, setiform, and dense gill-rakers, up to 6 inches long, the microscopical structure of which

[a] *Anat. Phil. Unters. Kiemenapp., Zungenb. Wirbelth.* (1832), p. 83.

[b] *Unters. Vergl. Anat. Wirbelth.*, 3:tes Heft, p. 164.

[c] *Lecons*, ed. 2, tom. VII, p. 307.

[d] Trans. Zool. Soc. Lond., vol. X, p. 212.

[e] GUNNERUS, Trondhj. Selsk. Skr., part. III (1765), p. 16; FOTLIS, Proc. Bost. Soc. Nat. Hist. 1854, p. 203; STEENSTR., Overs. D. Vid. Selsk. Forh. 1873, No. 1, p. 47, tab. II.

was shown by Hannover to be the same as that of (the teeth and) the dermal spines.

Among the peculiarities of the internal organs in the Elasmobranchs we have already considered the structure and position of the heart. A further characteristic of these fishes is the communication afforded to the pericardial cavity by means of two holes behind, in the diaphragm, with the abdominal (peritoneal) cavity; and as the latter, being pierced by the abdominal (anal) pores, one on each side of the anal aperture, is in a certain degree open to the surrounding water, this element may find a passage to the heart itself[a]. The intestinal canal is comparatively simple (fig. 301). The wide, but sometimes very short œsophagus (*d*) passes into a stomach (*e*) usually of greater length, and this terminates behind in a more or less prolongated blind

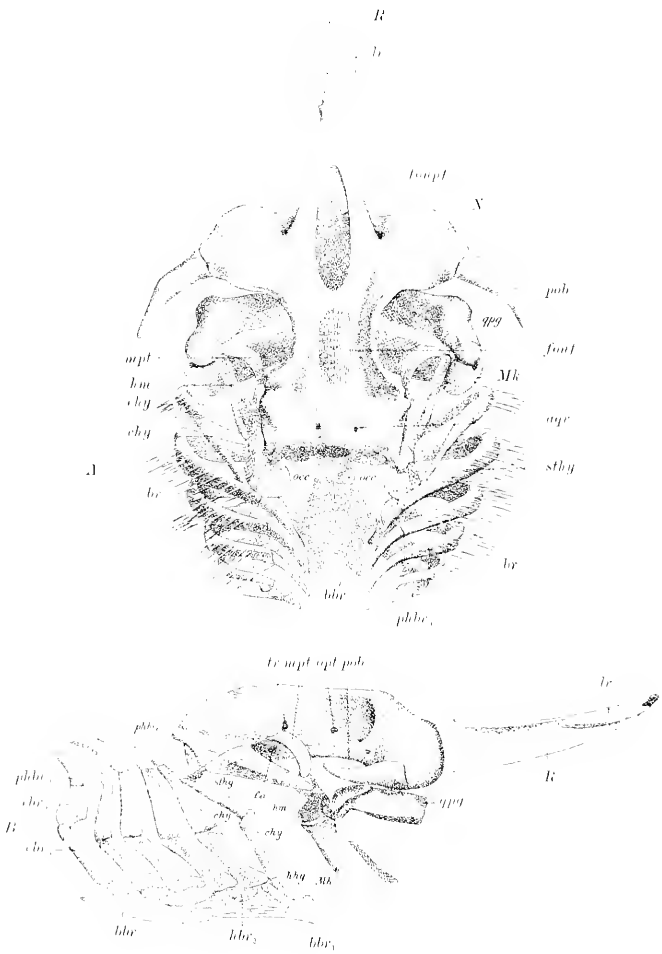

Fig. 300. Skull of a Thornback (*Raja clavata*) seen from above (*A*) and from the right (*B*). Natural size. After Parker. *ehy*, epihyoid; *fa*, foramen for the *nervus facialis*; *fonf*, frontal fontanelle; *fonpf*, prefrontal fontanelle; *hhy*, hypohyoid; *mpt*, metapterygoid; *pob*, preorbital; *sthy*, stylohyoid. The other letters are explained in fig. 298.

[a] Monro, *Struct., Physiol. Fish.*, Edinburgh. 1785, p. 20, pl. II, 22, 23, pl. XVIII, 10, 11, 12. Blainville, Ann. Mus. Hist. Nat., tome XVIII (1811), p. 111.

sac, but bends forward in a pyloric part (to *f*). From the pylorus the duodenum runs straight back, and passes into the spiral intestine (*h*), which is continued by the short rectum. The mucous membrane of the intestinal canal differs in the various sections much as in the case of the Chondrosteans. In the œsophagus it forms longitudinal or, in addition, transverse folds, or is reticulated; or it may be studded with more or less hard papillæ, pointed excrescences, in considerable number. The mucous membrane of the stomach is usually coursed by strongly developed (but few) longitudinal folds. The pyloric part, where there are also longitudinal folds of the mucous membrane, is sometimes without internal limits, but sometimes bounded, both at the beginning and end, by an annular valve[a]. As we have remarked above (p. 1052, note *b*), the spiral intestine is usually regarded at the present day as a section of the duodenum. The spiral fold in its interior is very highly developed in the generality of the Elasmobranchs[b], with reticulated mucous membrane and with transverse ridges on most of the coils. The rectum is short, and its mucous membrane smooth.

The liver (fig. 301, *c*) is large and oily, usually consisting in the Sharks of two lobes, in the Rays of three. The gall-bladder lies free, or is embedded in the liver. The spleen (*r*) lies at the posterior part of the stomach. To the right thereof (vertically below *f* in the figure) lies the pancreas, which is usually of less volume. Into the beginning of the rectum there opens a digitiform gland (*i*), which was first remarked by MONRO[c] under the name of vermiform appendage or cæcal sac[d], but whose glandular, botryoid structure, around a central efferent duct, was first clearly described by LEYDIG[e].

There is no air-bladder. The kidneys (fig. 301, *m*) are situated as in the Teleosts. They taper in front and expand behind, sometimes so greatly that they seem to be confluent. Their general shape adapts itself to the external form of the body. Thus they are elongated in the Sharks, broader and shorter in the Rays. The urinary bladder is usually double, forming a dilatation of each ureter. The anterior part of each

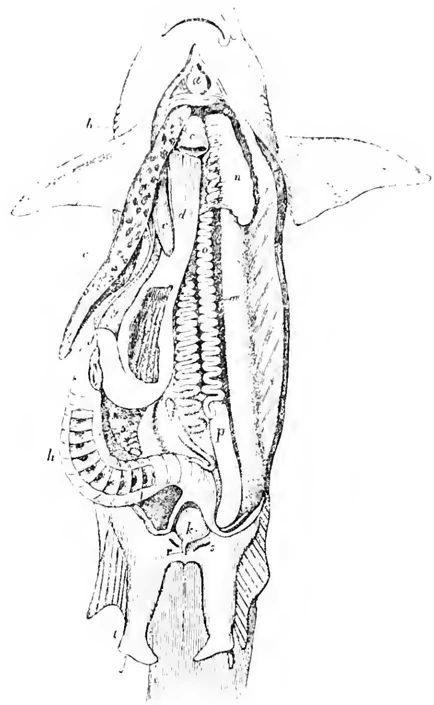

Fig. 301. Abdominal viscera of a male Shark. After RYMER JONES.

a, heart; *b*, gill-openings; *c*, *c*, *c*, lobes of the liver, the left removed, the middle (*lobulus Spigelii*) and right retained; *d*, œsophagus, passing into the stomach (*e*), which is continued by the duodenum (*f*), into which the gall-duct (*g*) opens; *h*, spiral intestine; *i*, *glandula retroanalis*; *k*, urogenital cloaca; *l*, pterygopodium; *m*, left kidney; *n*, left testis; *o*, *vas deferens*; *p*, dilatation of the *vas deferens* (*vesicula seminalis*); *r*, urogenital papilla; *s*, abdominal (peritoneal) pores; *r*, spleen.

[a] In the Basking Shark BLAINVILLE (l. c., p. 100, pl. 6, fig. 2, *D*) hence gave to this section the name of *the third stomach*. In the Picked Dog-fish I find no valve, either between the stomach and the pyloric part or between the latter and the duodenum.

[b] In a Picked Dog-fish I find 14 coils; KRØYER found 16 or 17. The last coil terminates in a broad, labiated fold. In several Sharks, however, the spiral fold is less developed. In *Alopias vulpes* and *Carcharias glaucus* it is described as very short. In *Thalassorhinus vulpecula* and *Zygæna tudes* no stair-like coils are formed along the inside of the intestine, but a long and broad membrane curves in cornet-shaped folds, one within the other, and lies like a packet within the intestine, with only one margin attached to the wall thereof. At the free margin of this membrane runs, according to DUVERNOY (Ann. Sc. Nat., Zool., 2 ser., tome III, p. 274, pl. 10 and 11), a powerfully muscular venal trunk (*vena mesenterica*), which is continued by the *vena porta* and impels the blood and chyle into the latter.

[c] *Struct. Physiol. Fish.*, Edinb. 1785, Pl. II, 8; Pl. III, *E*; Pl. XI, *D*; Pl. XVIII, 16; Pl. XIX, 14.

[d] *Bursa cloacæ*, RETZ., *Obs. Anat. Chondropt.*, p. 24. *Glandula retroanalis*, COSTA, *Fn. Regn. Nap.*, Chimeridei (1852), p. 36, tav. II, fig. 1, *g*.

[e] *Beitr. mikr. Anat., Entwickel. Haien und Rochen* (1852), p. 56, § 38.

kidney (the Wolffian body) is separated in the males from the posterior part, and is applied, as an *epididymis*, to the anterior part of each testis, receiving the efferent duct thereof.

In the structure of the generative organs the Elasmobranchs are even more closely approximated than the Chondrosteans to the higher vertebrates. These organs are generally more restricted in extent, whence it naturally results that the offspring is far less numerous than that of the Teleosts. The efferent duct (*vas deferens*, fig. 301, *o*) of the male organs (*n*) passes, as in the higher vertebrates, first through an *epididymis*. Before opening into the cloaca, it widens into a dilatation (seminal vesicle, *p*), the posterior extremity of which is applied to the corresponding part of the seminal vesicle on the other side of the body, and then finds outlet, in common with the other seminal vesicle their slimy secretion. A large gland of this kind is situated on the under side of the ventral fins. In most cases the said organs are besides furnished at the tip with cards of teeth or with spines.

The copulation between the sexes that is practised with the aid of these organs by the Sharks has been observed in the case of the Nurse Hound (*Scylliorhinus stellaris*) by BOLAU at the Hamburg Aquarium, and is illustrated by the appended figure (302). Of the copulation of the Rays HOLLBERG writes[b]: "During the season of propagation they repair to the surface of the sea and, for the purpose of depositing their eggs, to the shores. At these times they are taken with the harpoon. The female is frequently attended by several males, who endeavour by lifting and tossing her with their snouts to turn her over on her back. The first to succeed in this applies and presses his ventral side

Fig. 302. Male Nurse Hound clasping the female during copulation. After BOLAU, Zeitschr. f. wiss. Zool., Bd. XXXV, p. 322.

and the ureters, into a special cloaca (*k*, the urogenital cloaca, MOREAU, *Hist. Nat. Poiss. Fr.*, tome I, fig. 26, p. 246), which projects on the wall of the anal cloaca in the form of a papilla (*r*) only requiring the erectile tissue to represent a true penis. In the Chimaeras the urogenital aperture of the males lies externally on the ventral side, at the anterior extremity of an oblong and compressed, but posteriorly tumid protuberance behind the vent.

The external copulatory organs of the males we have mentioned above. The most important, the so-called *pterygopodia* of PETRI[a], consisting of the transformed hindmost radialia of the ventral fins (*metapterygium* in GEGENBAUR; fig. 301, *l*; fig. 295, *ptpd*), are composed of several parts and furnished with a longitudinal channel, into which several glands discharge so closely to hers that, if only one of them be harpooned, both may be drawn out of the water without being parted." On the occasion described by BOLAU the right pterygopodium of the male was inserted into the sexual aperture of the female. The male flung his tail upwards and forwards along the right side of her body and bent his own in the opposite direction, though with the dorsal side under, so that the top of his head pressed his tail to the back of the female above her pectoral fins. In the last-mentioned circumstance we may perhaps find a clue to an explanation of the manner in which the male Chimaeras employ the mobile prehensory organ situated on their forehead. The copulation of the Chimaeras has never been observed; but as the mouths of the two oviducts, which open in the females of these fishes beside each other and externally,

[a] Zeitschr. wiss. Zool., Bd. XXX, p. 296.

[b] Gbgs Vett., Vitt. Samh. N. Handl., III Delen (1819), p. 16.

in the skin of the ventral side, between the anus and the urethral aperture, are equally tumid during the breeding-season, it seems highly probable that both the pterygopodia functionate simultaneously. The situation of the urogenital opening in the males, relatively to the base of the pterygopodia, is such that the semen may apparently be received almost immediately in the above-mentioned channel on the pterygopodia.

The ovaries (fig. 303, *n*) occupy the same position as the testes — in the anterior part of the abdominal cavity they are attached by means of their mesoarium (peritoneal fold) to the spinal column — but are separated from their efferent (the Müllerian) ducts, which unite before them, under the œsophagus and just behind the diaphragm, in a curve, at the middle of which they have their common opening (*q*). To this opening the eggs thrown off by the ovaries are conducted by a current produced by the ciliary motion of the investing cells of the serous tissue lining the interjacent organs. The said current may be observed even shortly after the death of the fish by opening the belly, removing or lifting aside the liver, and strewing finely powdered charcoal on the parts. The oviducts (Müllerian ducts) bend backwards, one on each side, and are each furnished with two dilatations. The anterior (*o*) of these is glandular, its walls being traversed by ramified ducts that secrete a nidamental substance to envelop the eggs; while the posterior (*r*) is a uterine pouch within which the impregnated ova either undergo the earliest stages of their development, or remain until the young are fully developed and capable of free motion. In the latter case, when only the right ovary as a rule is functional, the glandular dilatation of the oviducts is little developed, but the uterus all the more so, its walls being lined with vascular folds or even with a *placenta uterina*, into which the vitelline sac of the embryo is fitted by means of warty placental growths (cotyledons), an arrangement that would be fully analogous to the viviparous development of the mammals, if the yolk sac were replaced by the fœtal membranes of the latter. The oviducts open either into the common cloaca (*s*, *s*), on each side of the urethral aperture (*l*), or, as mentioned above, at special orifices in the skin.

The primeval type of the Elasmobranchs has ramified in two essentially different directions of evolution, on the one hand to the *Holocephali*, on the other to the *Plagiostomi*.

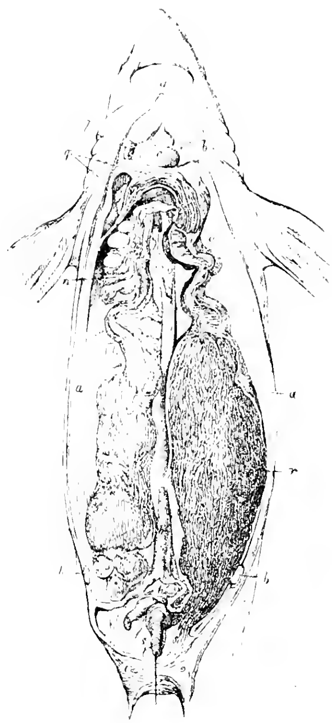

Fig. 303. Female organs of a Shark. After Owen.

a, ventral wall, cut open and laid back; *b*, sections of the shoulder-girdle and pelvis; *c*, heart in its *pericardium*; *h*, hindmost part of the rectum and the ascending *glandula retroanalis*; *n*, right ovary; *o*, nidamental dilatation of the left oviduct (*glandula nidamentalis*); *q*, common aperture of the two oviducts; at its bottom the orifice of the right oviduct (to the left in the figure); *r*, uterine division of the left oviduct (the right oviduct lies unopened to the left of the figure); *s*, posterior mouths of the two oviducts; *l*, urethral papilla, at the tip of which a bristle is inserted into the urethra. On each side of this bristle may be seen an abdominal pore (the mouth of a peritoneal canal).

ELASMOBRANCHII HOLOCEPHALI[a].

Elasmobranchs with one gill-opening common to all the gill-slits on each side of the body. No spiracles. Skin smooth, without placoid scales (spines[b]). Notochord unaltered, not constricted by the formation of vertebræ, only with superficial rings of cartilage, considerably exceeding in number the vertebral spaces (polyspondyli). Palatoquadrate part not divided from the skull, but furnished like the lower jaw with dental disks.

That course of development from the *primordial fishes*[c] which is represented in the present age by the *Holocephali*, the suborder of the Chimaeras, has been arrested as regards the structure of the spinal column at a lower stage than the Plagiostoms. It is probable too that the structure of the palate in the *Holocephali* is a relic of the said ancestral types; but only the history of evolution can decide whether the union between the palatoquadrate parts and the skull, a peculiarity which we shall again meet with in the still more primitive Marsipobranchs, is here of a primary or a secondary nature. Equally indispensable is the aid of the history of evolution to a determination whether the absence of spiracles is original or rather the consequence of reduction. SOLGER has described in *Chimæra monstrosa* small cartilages (fig. 294, *s*) which occupy in relation to the lower jaw the same position as that assumed in relation to the palatoquadrate cartilage by the spiracular cartilages (supports of the spiracular gills) common in the Plagiostoms. It may reasonably be assumed that these so-called Solgerian cartilages admit of interpretation as vestiges of aborted spiracular gills. On the other hand, the structure of the branchial cavity in the *Holocephali* more clearly indicates a higher degree of differentiation, a step in the direction of the Chondrosteans and Teleosts.

The *Holocephali* are marine and deep-sea fishes with a wide geographical range. How great is their geological age, can hardly be stated at present with certainty, for ichthyologists have supposed[d] that remains of these fishes have been discovered even in Devonian deposits. It is certain, however, that they lived in the Jurassic period, when its very earliest stratum (the Lias) was formed; and during the latter part of this period they attained a size far surpassing that of modern *Holocephali*. TOWNSEND, for instance, found in the Portland chalk at Great Milton (near Oxford) an under tooth of *Chimæra* (*Ischyodon*) *Townsendii*[e] that measured 11 cm. at the symphyseal margin, a dimension which in a *Chimæra monstrosa* 75 cm. long is represented by 14 mm.

The suborder contains only one family.

FAM. CHIMÆRIDÆ.

Body of a compressed clavate form, most nearly resembling that of the Macruroids. Dentition of the mouth made up of two upper pairs and one under pair of dental plates, most similar to those of the Lung-fishes (Dipnoi). Two[f] dorsal fins, the anterior, above the pectoral fins, triangular and armed with spines, the posterior low and long; a small, sometimes scarcely distinguishable anal fin, situated far back; caudal fin diphycercal or heterocercal.

Of this family only four[g] species survive at the present time. These have been ranged in two genera, one of which, the Antarctic *Callorhynchus*, contains a solitary species and is characterised by the more obliquely for-

[a] ὅλος, *whole*, and κεφαλή, *head*.

[b] In the young of *Callorhynchus* (a genus from the Pacific Ocean and the Antarctic regions) spines have been found in two longitudinal rows, partly on the forehead, partly on the back, between the first and second dorsal fins (see DUM., *Hist. Nat. Poiss.*, Suites à Buffon, tome I, p. 694, pl. 14, fig. 4), an indication that the skin of the primitive forms was clothed with spines.

[c] *Pisces aspondyli*, HASSE, *Naturl. Syst. Elasmobr.*, Allgem. Theil, p. 31.

[d] Cf. GÜNTHER, *Introd. Study Fish.*, p. 349.

[e] AGASSIZ, *Rech. Poiss. Foss.*, tome III, p. 343, tab. 40, fig. 20.

[f] Sometimes the posterior dorsal fin is so deeply sinuous that three dorsal fins have been counted.

[g] GILL has besides described a *Chimæra plumbea* from the Atlantic coast of North America; but there would hardly seem to be any specific distinction between this form and our Chimæra.

ward direction of the upper front teeth, by a special dermal appendage at the tip of the snout, and by the upward direction of the tip of the tail, the upper part of the caudal fin being extremely small (heterocercal).

GENUS CHIMÆRA.

Front teeth in the upper jaw of a vertical or but slightly oblique forward direction; tip of the snout without special appendage; tip of the tail prolongated straight back, in a line with the spinal column, the caudal fin narrowing behind and being of about the same height and extent above as below.

In the Iliad (VI, 179) HOMER depicts the slaying by Bellerophon of the *Χίμαιρα*, a fire-breathing monster shaped in front as a lion, behind as a dragon, in the middle as a goat. In the seventeenth century KENTMAN sent to GESNER a drawing of a fish from Denmark which he called *Meeraff* (*Simia marina*); and when LINNÆUS found the same kind of fish from Bohuslän in the Royal Museum at Ulriksdal, he called it *Monkey-fish* or *Monster-fish* (*Chimæra*). "Monster is the name given to this fish, which is so unlike all others and as it were a medley of all fishes. At certain seasons when this strange fish dieth and is cast ashore, the common people behold in him a miracle and imagine that they see laces, points, topknots, and other finery, which they believe have so displeased the great God that He hath seen good to warn them with signs and wonders, which belief news-men, no less wise than they, speed the whole world through to the edification of all"[a]. Thus the name of *Chimæra* was introduced into ichthyology; and though the monstrosity formerly seen in the structure of the genus has disappeared in the light of modern researches into its relations to the other Elasmobranchs, the life led by these fishes is still in great part a mystery to us.

Three species are recognised within the genus, one from the west coast of North America, one from the North Atlantic and Japan, one from the coast of Portugal.

THE NORTHERN CHIMÆRA (SW. HAFMUSEN).

CHIMÆRA MONSTROSA.

Plate XLVI, figs. 2 and 3.

All the vertical fins contiguous or nearly so; the anal lobe distinct just in front of the beginning of the lower caudal lobe and below the end of the second dorsal fin. Tip of the tail prolongated into a finless, whip-like appendage. The tips of the pectoral fins, when laid back, extend to the anterior margin of the ventral fins or still further. Pterygopodia (posterior appendages of the ventral fins) of the males forked throughout the greater part of their length.

Syn. *Meeraff* (*Simia marina*) sec. KENTMANN in litt.: GESN., *De Aquatilibus*, p. 878 (fig. in p. 877). *Galeus Acanthias* CLUSII *Exoticus*, WILLUGHBY (ed. RAY), p. 57, tab. B. 9, fig. 6. *Is-Galte*, STRÖM, *Sondmors Beskriv.*, Tom. I, p. 289.

Chimæra monstrosa, LIN., *Mus. Ad. Frid.*, part. I, p. 53, tab. XXV: *Syst. Nat.*, ed. X, vol. I, p. 236; *Fna Suec.*, ed. II, p. 197; GUNN. (*Har-Katten*), Trondhj. Selsk. Skr., vol. II, p. 270, tabb. V et VI; OLAFS. (*Harmus*), *Reise Isl.*, pp. 360 et 598; ASCAN. (*Sølvhaaen*, *argentea*), *Icon. Rer. Nat.*, fasc. II, p. 6, tab. XV; MÜLL., *Prodr. Zool. Dan.*, p. 38; BL., *Naturg. Ausl. Fisch.*, part. I, p. 60, tab. CXXIV; LACEP. (*Chim. arctique*), *Hist. Nat. Poiss.*, tom. I, 392, tab. 19, fig. 1; RETZ., *Fna Suec. Lin.*, p. 308; DONOV., *Brit. Fish.*, tab. CXI; RISS., *Ichthyol. Nice*, p. 53; FLEM., *Brit. Anim.*, p. 172; FABER, *Fisch. Isl.*, p. 41 (+ *Chim. cristata*, p. 45); NILSS., *Prodr. Ichthyol. Scand.*, p. 112; VAL. in GAIM., *Voy. Isl., Groenl.*, tab. 20; BONAP., *Iconogr. Fna Ital., Pesci*, tab. 130; SCHLEG. in SIEB., *Fna Japon.*, p. 300, tab. CXXXII; EKSTR., Gbgs Vet., Vitt. Samh. Handl., Ny Tidsf., vol. I (1850), p. 21; COSTA, *Fna Regn. Nap., Chim.*, tabb. 1—7; KR., *Danm. Fisk.*, vol. III, p. 784; NILSS., *Skand. Fna, Fisk.*, p. 705; DUM., *Hist. Nat. Poiss.* (su. à BUFF.), tome I, p. 686; GÜNTH, *Brit. Mus. Cat., Fish.*, vol. VIII, p. 349; COLL., Forh. Vid. Selsk. Chr:nia 1874, Tillægsh., p. 206; CEDERSTR., Öfvers. Vet. Akad. Forh. 1876, No. 4, p. 67; MALM, *Gbgs, Boh. Fna*, p. 605; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 56; MOR., *Hist. Nat. Poiss. Fr.*, tome I, p. 455; MELA, *Vert. Fenn.*, p. 363, tab. X; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 286, tab. CLI; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 511.

[a] *Mus. Ad. Frid.*, part. I, p. 54

Chimæra borealis, Shaw, *Gener. Zool.*, vol. V, part I, p. 365, tab. 157.

Chimæra arctica, Holmb., *Bohusl. Fisk.*, fasc. II, p. 1 cum tab. (Gbgs Wett., Witt. Samh. N. Handl., part. IV).

Chimæra mediterranea, Risso, *Eur. Mer.*, tom. III, p. 168.

(?) *Chimæra plumbea*, Gill, Proc. Philos. Soc. Washington, Dec. 22, 1877; vide Jord., Gilb., Bull. U. S. Nat. Mus., No. 16, p. 54.

The Northern Chimæra attains a length of about a metre[a]. The greater part of this length — $^2/_3$ or more — is occupied by the prolongated tail[b], which is thread-like at the tip. The greatest depth, just behind the pectoral fins, measures $^1/_5$—$^1/_7$ of the length; and the greatest breadth (thickness), just in front of the said point, is about $^1/_2$—$^3/_5$ of the greatest depth. Where the first dorsal fin is situated, the dorsal line is straight; from this part it slopes at an angle of about 45° towards the snout, but very slowly towards the tip of the tail. The inferior profile of the head ascends from behind about as much as the upper profile descends or, when the mouth is open, a little more; but the belly is usually rounded and tumid, the inferior caudal profile (behind the ventral fins) thus ascending in a very gradual curve. The body is, however, so loose and slippery that no constancy in these respects can be expected.

The length of the head, which is conical and behind laterally compressed, decreases as usual during growth, varying between 15 and 11 % of that of the body in specimens 7—9 dm. long. Its most characteristic features, the position of the mouth and nostrils, as well as the structure of the soft and somewhat translucent snout, have already been described. The longitudinal diameter of the large and ovally rounded eyes in the specimens just mentioned measures about $^1/_3$ (37—31 %), and their vertical diameter about $^1/_5$ (22—18 %), of the length of the head. They are set high, their superior margin lying but slightly below the frontal profile, but somewhat obliquely, sloping in a forward direction; and whereas the length of the snout in front of them measures about $^1/_2$ (48—51 %) of the length of the head, the postorbital length of the head is not much more than $^1/_3$ (35—38 %) of its entire length. The elongated form is not restricted to the orbits, but is shared by the pupils. At the anterior margin of the eyes the forehead of the females is somewhat tumid, and in the males the corresponding prominence is medially concave; but behind the concavity articulates the singular hooked organ (fig. 294, *lf*) whose probable function as a prehensile organ during copulation we have already pointed out. It is a curved rod of hard cartilage, the base of which is widened and prolongated, gliding by means of a longitudinal articulary groove on the median edge of the forehead, and the top of which is furnished on the under surface with a card of 40—50 pointed, recurved teeth. As the form of the articulary surface shows, the hook is only slightly erectile; but when it is depressed, the card of teeth works against the anterior part of the said prominence.

On the external surface of the snout the Northern Chimæra acquires one of its most characteristic singularities, consisting in the ramifications of the lateral line. The lateral line itself extends, as usual, along the sides of the body, in front rather high, behind nearer to the middle of the sides, until it descends just behind the beginning of the lower caudal lobe to follow the base thereof. It is without true pores, but instead has a fissure-like opening throughout its length, this being due to the structure of its wall, as first described by Leydig[c]. Instead of piercing through scales, which are wanting in these fishes, the wall of the lateral line is supported by half-rings[d] set beside each other and branched at the tops. In this form the lateral line advances on the head, where it runs upwards and inwards[e] on the occiput, and just behind the mouths of the *aquæductus vestibuli* sends out a transverse canal[f], a line of communication between the two sides of the body, with a backward offshoot in the middle. Forward from this transverse canal a supraorbital branch[g] runs on each side of the head, above the eye and laterally along the bridge of the snout, to the side of the tip of the snout, where it bends downwards and backwards, though only to meet and join in a curve on the under surface of the snout the supraorbital branch of the opposite side. A

[a] Day and Lilljeborg give 4 feet (1,200 mm.). Our largest specimens are females about 95 cm. long. The true length of the body is in many cases doubtful, for it is difficult to see whether the tip of the tail is entire or broken.

[b] Our specimens corroborate Lilljeborg's statement that the males have the comparatively longest tail; but Kroyer's measurements show the reverse, and rather indicate that young Chimæras have a comparatively longer tail than old.

[c] Arch. Anat., Physiol. 1851, p. 251, taf. X, figs. 2 and 9.

[d] Of an osseous structure, according to Leydig.

[e] This ascending portion is called by Garman (Bull. Mus. Comp. Zool. Harv. Coll., Cambr., vol. XVII, No. 2) the *occipital canal.*

[f] *Aural canal*, according to Garman.

[g] *Cranial canal* and *rostral canal*, according to Garman.

more immediate continuation of the lateral line proper consists of a suborbital branch[a], running obliquely downwards and forwards along the posterior margin of each orbit and thence obliquely upwards and forwards along the suborbital margin, to a point about twice as far from the tip of the snout as from the eye, where it forms an *S*-shaped curve, first downwards and backwards[b], then downwards and forwards, afterwards joining the supraorbital branch, just before the junction of the latter with the corresponding canal on the other side of the body. Where the suborbital branch first alters its course, on the cheek, below the lower posterior corner of the orbit, it sends out a branch downwards and backwards, an opercular canal[c], which becomes narrower and narrower until it disappears externally, being continued, however, by a row of narrow, transversely set, sharp-edged pores, right across the branchiostegal membrane. Just before the origin of the opercular branch from the suborbital, the latter sends out another branch in a downward direction, a malar canal[d], which soon forks into a maxillary[e] and a mandibular canal. The former runs along the cheek, below the middle thereof, to a line with the anterior margin of the nostril, where it divides into two branches, an upper anterior (maxillo-rostral[g]) and a lower posterior (maxillo-nasal[h]). Each of the last-mentioned canals crosses the under surface of the snout to meet and join the corresponding canal on the opposite side of the body; but the maxillo-rostral branch also sends out, upwards and forwards, in the median line of this under surface, an unpaired canal[i], which unites it to the above-mentioned junction between the supraorbital branches. The mandibular branch crosses over behind the lower jaw in the same manner as the opercular branch across the isthmus. All these ramifications of the canals belonging to the system of the lateral line mark the head and in particular the snout with an extremely singular design, all the more striking as their anterior parts, on the cheeks and snout, become coarser, with more distinct fissure, and at certain points are widened and deepened, thus acquiring a moniliform appearance. Between the dilatations the inside of the canal is pierced by the inward ramifications of the caecal ducts described by COSTA[j]. In addition to these canals appertaining to the true system of the lateral line the snout is furnished with the numerous muciferous sacs (ampullae) described by LEYDIG[k]. From the many pores that partly follow, in single rows, the above-mentioned canals and the sharp fold which the skin forms in a curve just before the nostrils and above the lateral portion of the upper lip, partly are scattered, in groups or more isolated positions, between the said canals, these long ampullae take their origin, in the form of ducts directed upwards and forwards (as they approach the very tip of the snout, backwards). The posterior ampullae terminate caecally under the skin, between it and the large fibrous capsule, filled with a gelatinous mass, that occupies the interior of the snout, resting on the cartilaginous rods which we have observed above in the rostral region of the *Holocephali*. The anterior ampullae on the under surface of the snout, as well as the above-mentioned ducts issuing from the anterior parts of the branches of the lateral line, penetrate within the said capsule. In the gelatinous mass are also embedded the large and numerous ramifications of the fifth pair of cranial nerves[l], which innervate the ampullae. The skin itself is marked on the back of the snout with a network (thimble-like pattern) of pits, and within each of these may be seen in miniature the same rotiform figure as we remarked above in the dermal covering that invests the muciferous sacs of the Sturgeons.

The mouth is comparatively small. It presents, in combination with the large preoral nostrils, an appearance seldom exemplified in the preceding fishes. The dermal fold which bounds in front both the mouth and the nostrils has a great resemblance, it is true, to the lower

[a] *Orbital* and *suborbital canals*, according to GARMAN.

[b] In Plate XLVI, fig. 3 of the present work there is an error, this branch being connected with the supraorbital canal.

[c] *Jugular canal*, according to GARMAN.

[d] Sometimes the opercular and malar branches issue in a common canal (*orbitonasal*, according to GARMAN) from the suborbital branch.

[e] *Angular canal*, according to GARMAN.

[f] *Oral canal*, ...

[g] *Subrostral canal*, ...

[h] *Nasal canal*, ...

[i] *Median canal*, ...

[j] *Fna Regn. Nap., Pesci, Chimaeroidei*, tav. VII, figs. 1—4.

[k] Arch. Anat., Physiol. 1851, p. 253, taf. X, fig. 1.

[l] According to EWART, to whose investigations we shall return below, the nerves which innervate both the ampullae and the other parts of the cephalic system of the lateral line are homologous with an anterior division of the *nervus facialis* of the higher vertebrates.

suborbital (preorbital) margin of the Teleosts; but it cannot be fully homologous therewith, for here the nostrils are situated below it. The nostrils, which lie just in front of the median upper lip, are externally — each being bounded laterally by the lateral upper lip of that side — simple, round, and rather large apertures, separated by a thin septum. On raising the lateral upper lip we find, however, that each nasal cavity besides possesses a posterior opening, a dermal fold, bent into several curves and internally supported by a cartilaginous disk (fig. 294, lu_2), being turned inwards from the outer margin of the nasal cavity and forming the greater part of the posterior limit of the anterior nostril. To meet the inner edge of this dermal fold — though without being contiguous with it — a longer fold rises from the inner margin of the nasal cavity, a true narial passage being thus present, though not fully closed behind[a]. Externally the nasal cavity is covered by the lateral upper lip, so that the posterior nostril opens within the lip,

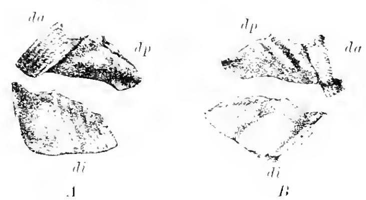

Fig. 304. Jaw-teeth of the left side in the Northern Chimæra (*Chimæra monstrosa*). After AGASSIZ. *A*, seen from without; *B*, from within. *da*, anterior dental plate of the upper jaw; *dp*, posterior dental plate of the same; *di*, dental plate of the lower jaw. Cf. fig. 294 (p. 1065).

inside the cavity of the mouth. The Chimæra can thus respire even when the mouth is closed.

The lips are thick and fleshy, studded outside and at the margins with small protuberances (papillæ), the upper lip, as we have already hinted, being divided into three parts, a quadrangular middle part (median upper lip) and two larger wing-shaped lateral lobes (lateral upper lips). The median upper lip as well as the underlip is double. The former partially covers the two anterior dental plates (fig. 294, *da*) of the upper jaw. The underlip is entire in front, but furnished behind with a broad, pendent flap at each corner of the mouth. The dentition of the mouth consists of two pairs of palato-dental plates, one pair (figs. 294 and 304, *da*) before the other (*dp*), at the margins of the upper jaw, and a single pair of mandibular plates (*di*). The intermaxillary (prepalatine) plates (*da*) are quadrangular and most distinctly grooved, with 6 rounded ridges; the lateral maxillary (palatine) plates (*dp*) and the mandibular plates (*di*) are more triangular, undulate and nodose on the inside. The tongue is small, but free at the tip, and is densely set with papillæ. The front of the branchial arches is also studded with similar papillæ; but soft gill-rakers, about 12 on the first branchial arch, are besides present.

The three free gill-arches are complete (with branchial lamellæ on both sides), but both before and behind them lies a half gill (single row of lamellæ), the former coalescent with the operculum, the latter with the hind (abdominal) wall of the branchial cavity. The gill-openings are about equal in depth to the length of the orbits, and are set far down, though separated by an isthmus the breadth of which is about equal to the depth of the orbits.

The general form of the fins we have already noticed. The triangular first dorsal begins just behind the head, the length of which varies between 80 and 90 % of the distance from this fin to the tip of the snout. The spine at its anterior margin lies exactly above the base of the pectoral fin and sometimes (in the males) is only a little shorter than the head; sometimes (usually in the females) only $^4/_5$ as long. It is rather sharp in front and is marked anteriorly on each side with a distinct groove. Both its posterior margins are armed superiorly, usually somewhat more than half-way down the spine, with pointed, descending prickles, and its top is usually free from the remainder of the fin to a point a little further downwards. Behind the spine the fin is supported by fibrils, gathered into about a dozen separate bundles, which resemble fin-rays. The posterior margin is somewhat concave, and the fin-membrane is prolongated to the vanishing point backwards along the dorsal margin and more or less near to the second dorsal fin. The latter fin begins at a distance from the tip of the snout measuring a little more or less than twice the length of the head and extends back about half-way along the rest of the body, measured from the commencement of the fin. Its height is almost uniform and only about $^1/_4$ or $^1/_5$ of that of the first dorsal. Just behind its termination the upper caudal lobe begins. The lanceolate caudal fin is made up of two almost similar lobes, one over and one under the tail, whose tip narrows uniformly to a filament, and of which they occupy the anterior half or third, before they gradually and, at last, imperceptibly disappear. The anal fin con-

[a] Answering to one of the stages in the development of the nostrils of the higher vertebrates.

sists of a small lobe, obliquely triangular and posteriorly somewhat elongated, below the end of the second dorsal.

The paired fins are *lobate* (with fleshy, broad, brachial base, so far as the radialia [fig. 294, *1—6* and fig. 295, *1—2*] extend and form the rounded basal disk) and obliquely pointed, more or less sickle-shaped, the pectorals more than the ventrals. The former are set vertically on the lower part of the sides, just behind the gill-openings, and are very large. Their tips extend, when laid back, at least to the insertions of the ventrals, in the males usually beyond the said points. The ventral fins are set about half-way between the tip of the snout and the beginning of the caudal fin, the length of the head being about $^2/_5$ of their distance from the tip of the snout. They are only about half as long as the pectorals, measuring in the females about $^3/_4$, in the males about 88 %, of the length of the head. Before them lies in the males, within a dermal sac, opening at an oblique, slit-like aperture, the tongue-shaped, flat, but somewhat twisted anterior copulatory organ (fig. 295, *prp*), armed at the inner margin with 6 or 7 pointed, curved teeth, and articulating with the fore end of the pelvis. Behind them and on their inside are situated the posterior copulatory organs (pterygopodia) of the males, which are trifid at the tip for about $^2/_3$ of their length. The three branches are equal in length, but differ in thickness, the lowest (lower inner) branch (fig. 295, *ii*) being invested only with a thin dermal covering, whereas the two upper branches have a thick skin, with numerous prorsal denticles on one side. When at rest, however, the lower inner branch (*ii*) lies so close to the upper inner (*si*) that the apparatus seemingly consists of only two sections.

The Northern Chimæra, when alive, is a brightly coloured fish of a beauty more striking than agreeable. The back is reddish brown, lighter or darker; the sides are for the most part silvery, shading above into blue; the lower parts of the body white. But under the silvery lustre of the sides the dorsal colour spreads in curious figures, oblong spots, arranged in longitudinal rows, or irregular, sinuous, and indefinite patches (clouds), a kind of marbled pattern being thus formed. The silvery lateral line is sharply marked by its brown edges. The top of the head partakes of the dorsal coloration, but in front is crossed with the retiform design which we have already noticed; its under surface shares in the white of the belly. The iris has either a golden or a silvery sheen; the pupil a greenish lustre. The unpaired fins are of the same colour as the back; but a black border extends throughout the length of the caudal fin, more or less far forward along the second dorsal, and along the upper posterior margin of the first dorsal. The paired fins too are similar in coloration behind to the back[a]; the anterior (under) surface is lighter, with rays of an ashy gray. The cavities of the mouth and pharynx are more or less black, but the tongue and the branchial arches yellowish.

Of the internal organs RETZIUS and HOLLBERG (l. c.) have given an exhaustive description, and we shall here merely refer the reader to our above remarks on this head, adding that the bluish black intestinal canal is short and almost straight, with only three coils in the spiral intestine, the heart extremely small, and the bilobate liver, especially the right lobe, very large and oily. The well-developed spleen is of a triangular fusiform shape and lies beside (under and behind) the pancreas, between the inferior edges of the lobes of the liver.

The Northern Chimæra has its proper home in the depths, some hundreds of fathoms below the surface, but frequently ascends to a higher level, to a depth of 40 or 30 fathoms, where it is occasionally taken on Haddock-lines. It often falls a victim also to the not unusual fate of deep-sea fishes, being carried involuntarily to the surface and cast ashore dead or in a helpless condition by storms. It has a wide geographical range in the North Atlantic and the Mediterranean as well as in Japanese waters. It occurs besides, according to DUMERIL's statements from the Museum of Paris, off the Cape of Good Hope. Within the limits of the Scandinavian fauna it is known from East Finmark to the west coast of Jutland and the Sound. It is most common on the coasts of Norwegian Nordland and Bergen (COLLETT). HOLLBERG remarked that it was common in Bohuslän during the Herring-fishery of last century; but it afterwards became rare, and each time a Chimæra was seen there, the revival of the said fishery was eagerly expected. Off Mount Kullen it has been caught on several occasions, and in the Sound it has been met with between Landskrona and Hveen (NILSSON). From the Belts and the Baltic it is unknown. Off the coasts of Iceland it is rare (FABER). It is equally rare in its occurrence off the Shetland and Orkney Islands and on the

[a] See the special figures to fig. 3 in our plate, which represent the form and colour of the left pectoral and ventral fins, seen from behind, in the female.

Scotch coast, off Banffshire (FLEMING and DAY). In the Mediterranean, according to GIGLIOLI[a], it is not uncommon off Nice, Genoa, and Palermo; but during 21 years COSTA could only procure 16 specimens from the Bay of Naples. On the east coast of North America it is found from Cape Cod northwards (JORDAN and GILBERT); but FABRICIUS does not include it among the fishes of Greenland. According to SCHLEGEL it is rare off Southern Japan, but common to the north, especially in autumn, when it pursues the Herring-shoals to the very heads of the inlets.

The life and habits of the Northern Chimaera are otherwise little known. Its intestinal canal has been found to contain the remains of fishes[b], testaceans, crustaceans, Echinoderms, and worms. A few fragments of seaweed among the contents have, no doubt, been swallowed accidentally with the food. The dentition of the mouth is evidently intended both to cut up flesh and crush shells. The spawning-season of this fish is unknown; but in the month of February, according to LILLJEBORG, each oviduct of a female nearly 1 m. long contained in the uterine dilatation an egg with the parchment-like shell almost fully developed and 122 mm. long. ESMARK received from Christiania Fjord another egg, which has been described by COLLETT. It was of a lustrous brown, but empty, and had probably been washed ashore. The thick end was cylindrical[c], the small end prolongated into a filamentous appendage. The whole egg was longitudinally fringed all round with a fin-like membrane[d], containing rays directed obliquely outwards towards the thick end. A similar, though rayless membrane followed the middle of the egg, at right angles to the plane of the former membrane, along the whole of one side and the narrower part of the other. The length of the egg was 163 mm., exclusive of the thread at the small end, which appendage measured 42 mm. Its greatest breadth was 42 mm., exclusive of the fin-like membrane on each side, which was 4 mm. broad. During the English expedition on board the *Triton* a young male 4 1/2 in. long, which appeared to have just been hatched, was taken, according to GÜNTHER (*Deep Sea Fish.*, Chall. Exped., p. 12), at a depth of 505 fathoms.

The economical importance of the Northern Chimaera cannot be considerable, for as a rule only solitary specimens are met with, and the flesh is worthless as food; but the oil that flows from its liver has been highly esteemed in medicine. "Since olden times", wrote HOLLBERG in 1821, "the islanders of Bohuslän and especially of Norway have appreciated the value of the fat prepared from the liver of the Chimaera, as an excellent external remedy for stiffness of the joints, gout, rheumatic pains, glandular swellings, cataract, etc. The fishermen of the northern island-belt of Bohuslän frequently offer this fat for sale in the stomachs of Ling, for it does not fail to find a ready market either in chemists' shops or among the peasantry. In all likelihood, however, not all this fat is procured from the rare Chimaera, though it always bears the name of that fish." The oil of the Chimaera is also used internally, like that of the Ling and Cod, to alleviate weakness and disease of the respiratory organs; and it has been especially prized as an internal remedy for the sting of the Weaver. The great oiliness of the liver may be seen even in Chimaeras that have been preserved entire for scores of years in the spirit-jars of museums. On opening their abdominal cavity, oil runs copiously from the belly.

The Northern Chimaera has many names. The nostrils and the invariably visible front teeth, in combination with the mobile snout, give it a certain resemblance to a grinning monkey, whence the name of *simia marina* (*hafsapa*). The thread-like tail and the wriggling movements have given rise to the name of *hafmus* (Sea-mouse). LINNÆUS called the species *vidunderfisk* (Monster-fish). In Norway it has borne the names of *Isgalt*, *Gulha*, *Blankha*, *Sorotte*, *Somus*, *Hämus* (the last three = *hafmus*), *Soræv*, *Solvfisk*, *Harkrage*, *Harkatt*, *Spilstræng-Hyse*. In the Shetland Islands it is known, according to DAY, as the *King of the Herrings* and the *Rabbit-fish*. The former name occurs even in DAUBENTON[e], and is said to be derived partly from the ravages committed by the Chimaera among the Herring-shoals, partly from the hooked organ on the forehead of the males, which appendage has been compared to a crown. The latter name has the same origin as *hafsapa*.

[a] Espos. intern. di Pesca in Berlino 1880, Sez. Ital., Catal., p. 111.

[b] One of our specimens had Herring-scales in the mouth.

[c] According to LILLJEBORG's description of the egg-shells, which had not quite reached their full development, compared with DUMÉRIL's figure of an egg probably belonging to the nearly related genus *Callorhynchus* (*Hist. Nat. Poiss.*, pl. 8, fig. 8), the thick end of these eggs is furnished with two short filamentous appendages.

[d] In the egg described by DUMÉRIL this membrane was covered with silky hairs.

[e] In the old *Encyclopédie Méthodique*.

ELASMOBRANCHII PLAGIOSTOMI[a]

Elasmobranchs with several outer branchial apertures and with more or less distinct spiracles.[b] Skin commonly[c] shagreened, with papillæ and spines (placoid scales). Notochord constricted by the formation of vertebræ. Palatoquadrate part mobile independently of the rest of the skull and dentigerous. Paired fins inserted horizontally.

That course of evolution from the *Palæichthyes* which is represented in our times by the Plagiostoms, the suborder of the Sharks and Rays, has advanced so far, as regards the structure of the spinal column, that the most highly developed forms possess complete vertebræ, fully divided from each other, and retaining the notochord only in the intervertebral spaces between the centra, which are amphicœlous or conically hollowed at both ends. In their typical forms the two well-known phalanxes — the Sharks, with their elongated, fusiform or clavate body, and the Rays, whose pectoral fins, expanded and coalescent with the sides of the body, give the forepart (the head and trunk) a discoidal shape — are even externally so unlike each other that no other character than the outer shape seems necessary, especially in the case of the Scandinavian fauna. But intermediate forms, Rays with less expanded pectoral fins or with an unusually terete and thick tail, and Sharks with triangular, wide-based pectoral fins and a body more than commonly depressed, occur in foreign seas; and during youth — in a larval stage when the Plagiostoms are still furnished with filamentous external gills — the Rays have a great external resemblance to Sharks. The latter were undoubtedly the earlier forms, geologically speaking, and in the present age the most imperfectly developed forms — as HASSE in particular has pointed out with respect to the structure of the spinal column — are Sharks.

Even from the Silurian deposits ichthyodorulites are known which have been referred to a Selachoid genus (*Onchus*), and in the Carboniferous seas Sharks were very numerous: — the family of the *Cestraciontidæ*, which still survives in the Pacific, already existed. And ever since the Jurassic Period the Notidanoid family has survived with a structure which in the tropical and subtropical seas of the present age represents the lowest stages in the evolution of the Plagiostomous type.

Individually too most of the Plagiostoms show great tenacity of life. During the fishery for the Greenland Shark in the Arctic Ocean between Norway and Bear Island, these large fishes are hauled up from a depth of a hundred fathoms or so and deposited on the deck of the fishing-vessel. There they lie motionless, partly, no doubt, owing to their sluggish temperament, but probably stupefied as well by the sudden reduction of the pressure in which they are accustomed to live. Their belly is opened with a large knife, and the liver removed for the sake of the oil which it contains; but nothing is done with the rest of the body, unless a fresh bait be required for the huge hook. A Greenland Shark in this condition may be skinned and entirely disembowelled; but the manifestations of life do not cease for many hours. Even after the head has been cut off from the body and has lain some hours by itself, it is dangerous to get one's fingers between the jaws, for they may easily be bitten off, and the bite is so tenacious that one may attempt in vain to extricate what the jaws have once grasped. COUCH tells an anecdote of a Blue Shark which had been hooked and deprived of its liver in a similar manner. With the entrails hanging out of the belly it was restored to the water and followed the fishing-vessel for some time. It was not long before the fish tried to seize a Mackerel that had dropped from the net of the vessel. On another occasion a Shark was thrown overboard after being decapitated. For some hours the fish kept swimming round about — as a boy on board expressed himself — as if the body was looking for its head. Of the common Skate the same author relates that its heart may be cut out and retain contractile powers for at least 25 hours, when he saw the auricle beating five times a minute.

[a] *πλάγιος, slanting, oblique,* and *στόμα, mouth.*

[b] Though sometimes obliterated.

[c] The Electric Rays and young Eagle-Rays, with smooth skin, are exceptions.

PLAGIOSTOMI BATOIDEI[a].

Base of the pectoral fins extended backwards along the sides of the body and forwards along those of the head, above the five branchial apertures. Tail slender, terete (whip-like) or depressed. No anal fin. All the vertical fins belong to the tail.

The most important distinctions between the Rays and Sharks we have already mentioned in the introduction to the Elasmobranchs. They are bound up with the different habits of these fishes. Nearly all the Rays are ground-swimmers and live in the same manner as the Flounder-fishes, only seldom attempting rapid excursions or movements in the water. The above-mentioned intermediate forms — the well-known Saw-fishes (*Pristis*) and their nearest relatives, without a saw, the *Rhinobatidæ*, a family common principally in Indian waters — therefore approach, in their way of life as well, the transition to the Sharks.

Among the vital capacities of the Rays one, namely the power of giving electric shocks, possesses a special interest. Not only is this faculty a rare phenomenon in the whole animal kingdom and the peculiar property of fishes — even among these it is shared, in a singular and hitherto unexplained manner, by representatives of widely separated orders and families. At least two Teleosteous families[b] are endowed with this power, and a third[c] possesses it in so slight a degree that doubt is still felt whether this family should be included among the electric fishes or not; but none of these Teleosts is so nearly connected with the Scandinavian fauna as to have induced us to describe its faculties.

That electricity is really present both in muscles and nerves, or, to express ourselves more cautiously, that at least under certain circumstances electricity may be stored in muscles and nerves, has long been known; but nowhere has this electricity such an opportunity of accumulating as in certain fishes. The earliest and best known among these fishes are the *Electric Rays*. Their family, the *Torpedinidæ*, is fairly rich in forms: about 20 species, distributed among 6 genera, have been described with varying accuracy from the tropical and temperate seas. Three of them — *Torpedo nobiliana*, *Torp. ocellata* (*narce*), and *Torp. marmorata* — live in the Mediterranean and the adjoining parts of the Atlantic, the last-mentioned species being besides an inhabitant of the Indian Ocean.

The power possessed by the Electric Rays of accumulating electricity in their organs and voluntarily discharging these at need has been known at least since the time of Aristotle and Theophrastus; and Roman physicians, when Galen lived, if not before, employed these Rays in the treatment of gout and nervous diseases. In recent times this electricity has been more minutely studied, and has been found to be identical in its effects with other electricity. It has the same influence on the magnetic needle, it can decompose chemical compounds, and it emits the electric spark. When the Neapolitan fishermen have drawn their seines ashore, it is usually, according to Owen, their first care to pour a bucket of water over the catch. If the net contains an Electric Ray, its presence is at once betrayed by the shock transmitted along the stream of water to the hand holding the bucket. To handle a live Electric Ray is unpleasant enough, for the arm at least is paralysed by the shock for a long while.

Like the still more powerful Electric Eel — which is not an Eel, though it has the external appearance of one, but rather a Sheatfish, an inhabitant of fresh water in tropical South America — these Rays employ their electric power both to kill or at least to stun their prey and to defend themselves against their enemies. The other electric fishes known to us are far inferior in their capacity of accumulating electricity, and probably have recourse to this faculty in defence alone. Other fishes again scarcely have the power of giving appreciable electric shocks, but possess true electric organs, which on account of their feebleness have been called pseudoelectric. Such organs appear in several of our common Rays. Their strength is not great, and it has seldom been observed; but in 1888

[a] Gr. βάτος, Ray.

[b] Fam. *Gymnotidæ* (Electric Eels) and the subfamily *Malapterurina* of the great Sheatfish family.

[c] Fam. *Mormyridæ*.

it was tested by SANDERSON and GOTSCH[a] in the case of the Thornback (*Raja clavata*) and found to be about $^1/_{10}$ of that possessed by the electric organs of the Torpedo. Strange to say, however, these so-called pseudoelectric organs of our common Rays are situated in an entirely different part of the body from the electric organs of the *Torpedinidæ*. Whereas the latter (fig. 305, *E*) lie on the sides of the head and the branchial cavities, the former are placed on each side of the dorsal line of the tail. With this difference are connected two other essential dissimilarities: the nerves which run to these organs are of a totally different origin in the Electric Rays and the common Rays, and the arrangement of the respective organs is entirely unlike. The electric organs of the Torpedinoids lie in

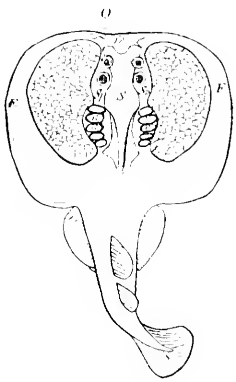

Fig. 305. An Electric Ray (*Torpedo marmorata*) with the skin removed from the electric organs (*E*), the skull (*S*), and the branchial cavities (*K*). *O*, eyes; *Sp*, spiracles. After WIEDERSHEIM.

the region of the transverse muscles, the levators and depressors of the branchial arches, and are supplied with nerves from the fifth and tenth cranial pairs and have their elements transversely arranged — the piles are vertical. The electric organs of our common Rays, on the other hand, are situated in the region of the great caudo-lateral muscles, at the lateral edges of the tail, close under the skin, and their nerves are spinal, their elements arranged in the longitudinal direction of the body. The difference thus affects both the parts of the body to which the organs belong and the innervation of the organs. Such a genetic connexion between these organs in the different fishes as that one form of them can have derived its origin immediately from the other, we can therefore scarcely expect to find; but they have one thing in common, their development from muscular substance: — the electric organs are transformed muscle fibres. This was first shown by BABUCHIN[b] in the case of the Rays, and was still more clearly elucidated by FRITSCH's examination of the Electric Eels brought home by SACHS[c]; but a special interest, of a yet wider importance, attaches to EWART's investigations[d] of the development of the electric elements in our common Rays. From these researches it appears as if we might be able to deduce from the structure of the electric organs an explanation of the composition of striated muscular tissue and of the importance of the different substances in this composition[e].

A muscle or a portion thereof may be converted into an electric organ at entirely different periods in the life of the fish. In the Torpedo, for instance, this transformation takes place at an early stage, during its embryonic existence within the egg and almost simultaneously with the appearance of muscular cells, before these are fully differentiated from other embryonic cells. In a common Ray, on the other hand, that part of the upper caudal muscles which is destined for conversion into a pseudoelectric organ exhibits the same formation in the larval stage as the other parts of these muscles, with the typical composition of the muscular fibres unaltered; and the observation of the subsequent changes shows in a series of different developmental stages how one constituent of the muscle fibre separates from the other, each being destined for a distinct purpose, the *sarcoplasma* probably to intercept and store the electricity, the *rhabdia* to serve as a non-conductor. In the common Skate (*Raja batis*), for example, this indeed takes place before the embryo leaves the egg-capsule, but not until it has attained a length of about 3 in. ($7^1/_2$ cm.) and has its entire organic system, even the muscles, typically formed. In the Starry Ray (*Raja radiata*) the development of the electric organs does not commence until the fish measures 12

[a] Journ. Physiol., vol. 9, Nos. 2 and 3.
[b] Centralbl. Medicin. Wiss. 1870, p. 259; Arch. Anat., Physiol. 1876, p. 501.
[c] *Dr Carl Sachs Unters. am Zitteraal*, Leipzig 1881.
[d] Phil. Trans. Roy. Soc. Lond., vol. 179 (1888), *B*, pp. 399 and 539.
[e] Cf. above, p. 662, on ROLLETT's investigations of the muscle fibres in *Hippocampus*.

cm., long after it has left the egg and in general assumed the external form of an adult member of the species. The course of the development is, however, the same and simple enough. One muscle fibre after another (fig. 306, *A*, *1*—*5*) thickens at one end—where the many terminal fibrils of the motor nerve are at-

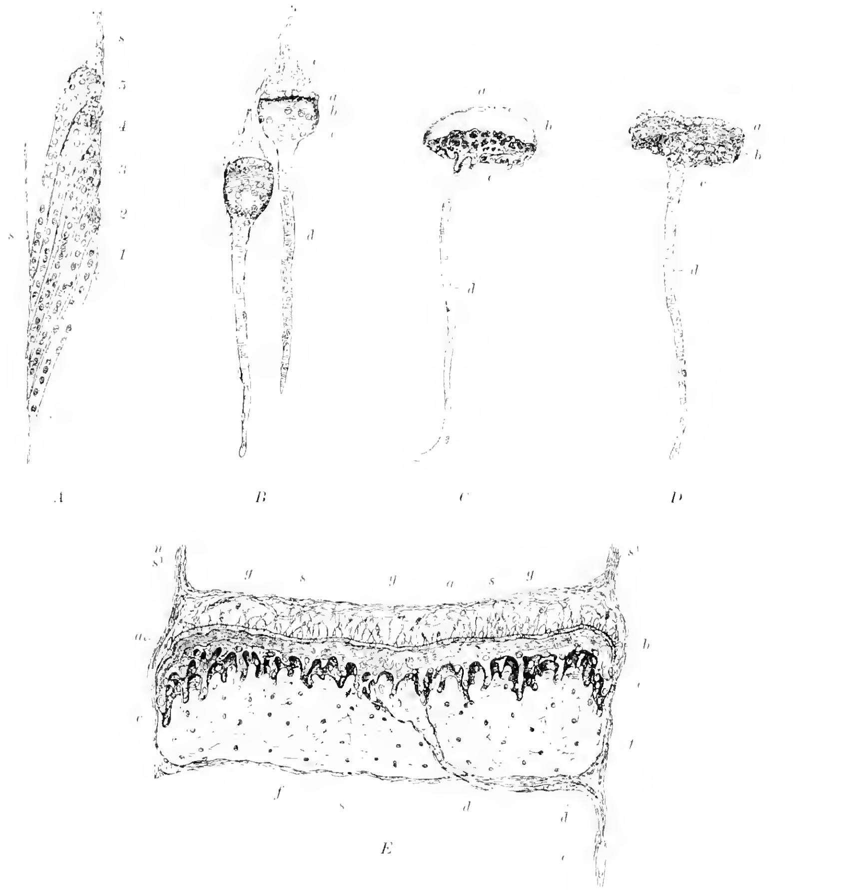

Fig. 306. Development of the electric elements in the tail of a common Skate (*Raja batis*). Magnified. After EWART.

A: Horizontal section through a part of the lateral muscle of the tail in an embryo 7 cm. long. The muscle fibres are obliquely extended between the intermuscular septa (*s*), and their transformation proceeds from in front, the hindmost of the figured fibres (*1*) being entirely unaltered, the others (*2*—*5*) more and more club-shaped the further forward they lie. In all these fibres the muscle nuclei and the striation are still distinct, even at the expanded end; but in the most transformed (club-like) fibres the nuclei begin to pass towards the thickened end. Between the fibres and the intermuscular septum lie numerous connective tissue cells, and between these nerve fibrils are supplied to the fibres.

B: Two isolated clubs from a somewhat older embryo. The thick end is here flattened and at the top (in front) has a layer of sarcoplasma with muscle nuclei (*a*), under this a denser striation (rhabdia), within which the nuclei are beginning to disappear (*b*), next a layer of sarcoplasma with nuclei and sparser striation (*c*), and at the bottom the aborting stem (*d*). *a* is the rudiment of the so-called electric plate, to which the nerve fibrils (*e*, with nerve nuclei and connective tissue bodies) are attached; *b* is destined to form the so-called striated layer, *c* the so-called alveolar layer.

C and *D:* Two different stages of development approximating to the bilboquet form. Letters as in *B*.

E: A fully developed electric element, with a part of the stem (*d*) still persistent and at the posterior end (*e*) still showing traces of striation; *a*, *b*, and *c* as in *B*. *f*, gelatinous layer of connective tissue; *g*, nerve fibrils; *n*, nerve fibre; *s*, septum between two electric elements; s^1, part of the original transverse intermuscular septum.

tached — and the fibre now resembles a club. The thick end (inner or anterior end) soon expands still more (fig. 306, *B*) and is hollowed into a cup shape, from the bottom of which the thin end (*d*) of the fibre proceeds in the form of a shaft, the fibre now having the appearance of a *bilboquet*. The body is further flattened (fig. 306, *C* and *D*), and the shaft is more and more reduced, until it finally bends quite to one side (fig. 306, *E*) or disappears, the fibre being now similar to a flat disk. In the common Skate the electric elements pass through all the three stages of development, in the Sandy Ray (*Raja falsavela*) only the first two, in the Starry Ray only the first stage.

In the electric elements of a Starry Ray, which are club-shaped but always somewhat concave at the top, the two constituents of the muscle fibre, the sarcoplasma and the rhabdia, are partly separated from each other. They have gathered at the thick end more densely than in the slender portion of the fibre, and a special layer of sarcoplasma, a so-called electric plate, is interposed at the top, immediately below that part of the sarcolemma where the nerve fibrils are inserted. Under this electric plate lies a densely striated mass, consisting principally of rhabdia, but containing numerous muscle nuclei, an indication that a considerable amount of sarcoplasma is present. In the cup-like (bilboquet-shaped) elements of a Sandy Ray the striated layer contains far fewer and more scattered muscle cells; and under this part the granular substance (the sarcoplasma) has formed a distinct layer with processes and alveoli (sponge-like meshes), a so-called alveolar layer. In the common Skate the rhabdia is entirely separated from the sarcoplasma and contains no muscle nuclei. Each electric element thus consists in this species (fig. 306, *E*) of three plates (*a*, *b*, *c*), one above another, the outer pair (*a* and *c*) being, however, confluent at the margin. With the addition of the secondary growths of gelatinous (*f*) and fibrous (*s*) tissue that extend into and fill up the spaces between the electric elements proper and also support capillaries and nerves, we find here, in the common Skate, an electric apparatus of essentially the same structure as in the Torpedo and Electric Eel. On each side of a comparatively firm plate, in section densely striated and originally formed of rhabdia, are set layers of sarcoplasma differing in their histological structure. This difference may perhaps produce different kinds of electricity. In that case we should here possess an analogue to the well-known galvanic piles. Or perhaps the electricity may be of the same kind in both layers of sarcoplasma. In the latter case the electric apparatus of these fishes corresponds to an agglomeration of electrophori.

The manner in which these organs are employed by our common Rays is not yet known. Their electric faculty cannot be doubted; but thousands of these Rays pass through the hands of fishermen without any recorded instance of a human being having experienced an electric shock from one of these fishes. When a Ray feels the resistance of the hook, and the fisherman begins to haul in the line, it first endeavours to cling to the bottom by clasping its pectoral fins round some hard object or tightly pressing them to the ground; and when it emerges from the water, it tries to defend itself by raising the pectoral fins as a shield for its body, bending the tail upwards and forwards, and dealing violent blows with the latter member. Now the tail of these Rays is so formidably armed with large, pointed spines that these in themselves are a sufficient warning to the fisherman against handling the Ray with the naked hand until he has given it a finishing blow, and hence it may well happen that as a rule he has no opportunity of experiencing the electric powers of the fish. Whether the electricity is utilised in combats with other inhabitants of the deep, in self-defence or to stun a victim, is also unknown. We know that dolphins (toothed whales) are the worst enemies of the large Rays, Ling and Halibut of the smaller ones; but SAVILLE-KENT saw dolphins seize Rays by the tail, the very part where the electric organs are situated. From observations in aquaria we learn that the Rays secure their prey by casting themselves over it with a sudden movement of the pectoral fins, squeezing it under their body, and gliding over it, until it can be grasped with the jaws. In these operations the tail can evidently serve merely as a rudder to direct the course of the fish. So too, when the Rays swim freely about in the water, propelling themselves by undulating movements of the pectoral fins, the tail can only steer and preserve the equipoise of the body. SAVILLE-KENT compares the movements of a swimming Ray to those of a wading bird that stretches its long legs behind it in its flight.

The system of the lateral line in the Rays requires a special chapter, though it rather closely resembles that of the *Holocephali*. It is generally far more developed than in other fishes. Four kinds of organs belonging to this system may also be distinguished: 1) the true lateral line with its ramifications on the head, the trunk, the pectoral fins, and the tail; 2) the so-called Lorenzinian ampullæ (muciferous sac ducts); 3) the so-called Savian vesicles; 4) the so-called pit organs.

The lateral line, the histological structure of which has been elucidated by LEYDIG (fig. 307), has numerous ramifications, and opens on the surface of the body not only into simple pores, but also into long transverse branches originating at right angles or obliquely from the line itself and its ramifications. The main branches of the system indeed find their parallels in the ramifications we have seen above in the Chimæra; but peculiar to the true lateral line of the Rays is the complex network of canals on the pectoral fins. In the genus *Raja* we recognise on the upper surface of the head the transverse occipital (supratemporal or aural) branch (fig. 308, *21*), the frontorostral branch with its divisions, the occipital (*20* to *1*) and the supraorbital

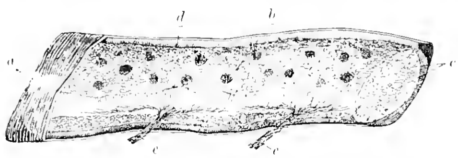

Fig. 307. Part of a branch of the cephalic system of the lateral line in the Thornback (*Raja clavata*). Magnified. After LEYDIG.

a, outer wall of hard membrane, removed on one side to show *b*, the inner, soft membrane, on which are visible the papillæ (*c*) and the nerve centra (sensory spots, *d*), with extended ramifications of the entering nerves (*e*).

(*1* to *2*), and the suborbital branch (*7* to *8*), which runs on each side of the body between the eye and the spiracle. When these branches have advanced nearly to the margin of the body (at *2* and *8*), the former quite close to the tip of the snout (*2*), the latter somewhat further back (*8*), they pierce the body to reappear on the under surface of the head (*2* to *6* and *8* to *11*), and join each other as in the Chimæra. This junction is simple, however, in the said species and follows the median line of the snout (*median canal*, GARMAN); here it is double, one branch on each side of the median line, and the immediate continuation of the frontorostral branch (supraorbital division) bends outwards on the under surface of the snout in a sharp crook (from *3* to *4* and *5*). After the junction the suborbital branch is continued backwards by a maxillary part (*6* to *9*), that bends inwards, in about a line with the middle of the length of the nasal valvule, to a naso-maxillo-rostral branch (*9*), which indeed (at *10*) joins the corresponding branch of the other side to form a maxillo-nasal canal, but also sends out a maxillo-rostral canal, straight to the tip of the snout, within the continuation of the supraorbital branch on the under surface of the snout. The posterior and more immediate backward continuation of the suborbital branch and its maxillary part answers to the opercular canal of the Chimæra, and has been named by EWART the hyomandibular branch (*12* to *19*). This branch runs here (*12* to *13*) on the outside of the branchial apertures (*apbr*), following the direction of the series formed by the latter, and on the under surface of the pectoral fin bends in a great loop, first backwards and outwards (*13* to *14*), then almost straight forwards (*14* to *15*), to a point near its origin, where it bends inwards (*15* to *16*) and afterwards runs forwards (*16* to *17*), parallel to its commencement and to the suborbital branch, until (at *17*) it comes in a line with the nostrils, where it turns upwards straight through the body. On the dorsal side it now bends straight back (from *17* to *18*), and after an inward curve (at *18*), where it receives connecting ducts from the suborbital branch, it pursues its course along the margin of the pectoral fin, and in the posterior part of the dorsal side thereof (at *19*) joins a pleural branch (*22* to *23*) from the lateral line proper. The last-mentioned part of the system follows on each side of the body the same course as in the Teleosts, from the temporal region (at *21*) to the tip of the tail. At the shoulder-girdle it forms an outward bend and here it gives off on the dorsal side of the pectoral fin both the anterior pleural branch which we have noticed above at its junction with the termination of the hyomandibular branch, and, in the genus *Raja* and its nearest relatives, a posterior pleural branch (*24* to *25*), which ramifies in the posterior part of the pectoral fin. Just behind the mouth there lies, as a detached portion of the hyomandibular branch, a transverse canal (*27*), answering to the mandibular branch of the Chimæra.

The ampullary system (fig. 309) properly belongs to the head alone, where all its canals have their caecal base. These organs have been known for more than three centuries[a], but their true nature was first eluci-

[a] LORENZINI, *Osserv. int. alle Torped.*, 1678, and MUNRO, *Struct., Physiol. Fish.*, 1785.

dated by JACOBSON[a], RETZIUS[b], and LEYDIG[c]. We have observed them above in the Chimaera. In the Rays there commonly lie several symmetrical pairs of capsules (fibrous investments of the basal parts of the ampullae and of the nerve twigs supplied to them). 1) at the tip of the snout (fig. 308, *Ra*), 2) further back on each side of the base of the rostral cartilage, on the ventral side before the nasal capsules, 3) on the

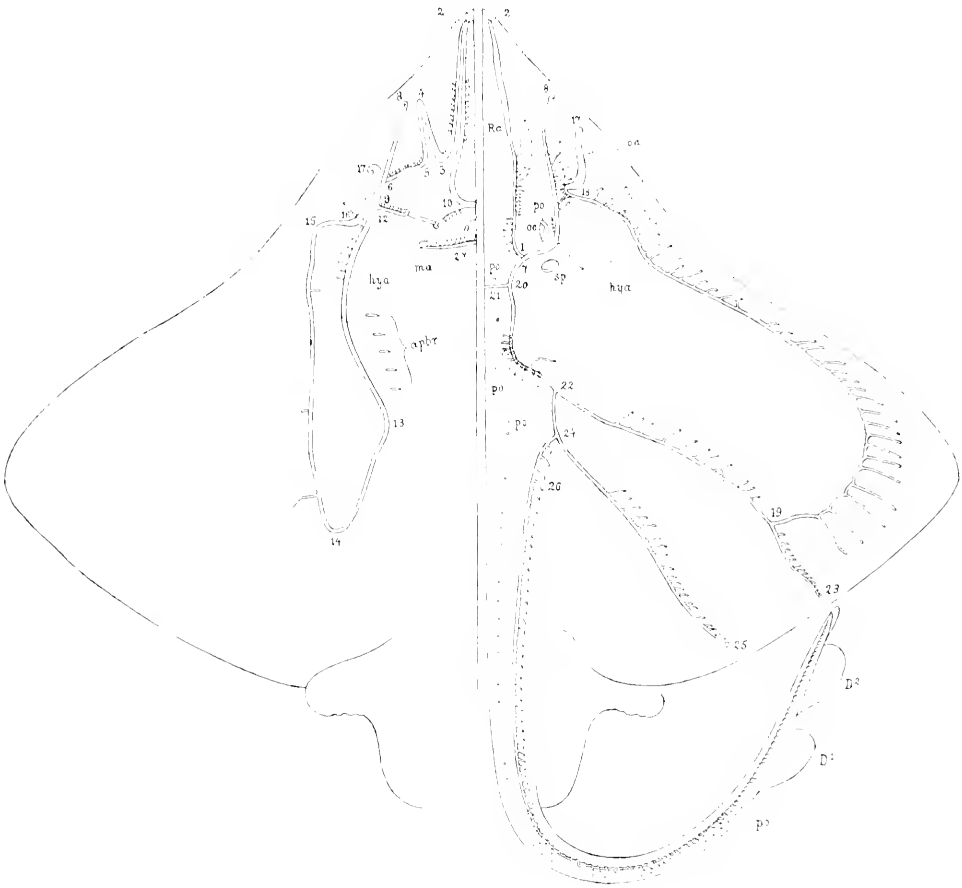

Fig. 308. Schematic figure of the distribution of the lateral line canals in a *Raja*, partly after GARMAN and EWART. Right half of the body; to the right the dorsal side, to the left the ventral.

1—2, course of the supraorbital branch on the forehead and the dorsal side of the snout; *2—3*, its backward continuation on the ventral side of the snout; *3—4—5*, its outward crook on the ventral side of the snout; *5—6*, canal by which it communicates with the suborbital branch; *7—8*, course of the suborbital branch on the dorsal side of the head; *8—9*, its backward continuation on the ventral side of the head; *9—10*, its inward ramification, which at *10* gives out a transverse canal inwards to join the suborbital branch of the other (left) half of the body, and then advances to its termination at the tip of the snout, at *11*; *12—13*, backward course of the opercular (hyomandibular) branch on the ventral side of the head and pectoral fin, in a curve outside the gill-openings (*apbr*); *13—14—15*, its ventro-pleural bend; *15—16*, its inward, ventral continuation; *16—17*, its forward, ventral course side by side with the suborbital branch; *17—18*, its backward course on the dorsal side of the head; *18—19*, its dorso-pleural curve, which at *19* joins the anterior pleural branch of the lateral line; *20—26*, the lateral line proper; *21*, transverse occipital branch; *22—23*, anterior dorso-pleural branch of the lateral line; *24—25*, posterior dorso-pleural branch of the lateral line; *26*, lateral line of the trunk and tail; *27*, mandibular branch; *Ra*, rostral ampullae; *oa*, orbital ampullae; *hya*, hyoid ampullae; *ma*, mandibular ampullae; *po*, pit organs; *o*, mouth; *oc*, eye; *sp*, spiracle.

[a] Bull. Sc. Soc. Philom. Sept. 1813.

[b] Öfvers. Vet. Akad. Förh. 1845, p. 177, where references are given to the remaining literature on this question.

[c] *Rochen, Haie*, Leipz., 1852, p. 41.

dorsal side, one pair on the outside of the preorbital cartilage (*oa*) and another outside the spiracle (*hya*). Asymmetrical capsules also occur, as in *Trygon* between the anterior ends of the two nostrils. The ampullary canals extend throughout the sides of the body, those of the pectoral fins for example, which run to the hyoid capsules, attaining a considerable length (fig. 309). In the Electric Rays FRITSCH[a] has observed a regular alternation on the dorsal side of the pectoral fins between the ducts of the ampullæ and those of the lateral canal proper, the outer (distal) part and the orifice of each ampullary duct lying as a rule between a pair of the outward transverse branches of the lateral line. To this he appends the remark that the presence of

Fig. 309. Hyoid ampullæ and their opening ducts together with the dorsal course of the lateral line in the left half of a *Raja*. After GARMAN.

true sensory bulbs (nerve-bulbs) with the hair cells occurring in the lateral line has not yet been demonstrated in the nerve ends on the inner wall of the ampullæ, whence he infers that the ampullæ should be regarded as a secretory part of the system of the lateral line. Their cavity is filled with an endolymph-like, more or less coagulated mucus.

The third kind of organs belonging to this system, the so-called sensory vesicles of SAVI[b], appear only in the Electric Rays, and are situated in one or two series on the snout of these fishes and around the anterior part of their electric organs. They are homologous with the cæcal bottoms of the ampullæ, but are entirely closed, and their inner surface is usually furnished with three sensory spots, the middle spot being the largest and furnished with numerous hair cells.

The fourth kind (fig. 308, *po*) of the sense organs now under consideration are the so-called *pit organs*[c] (called by FRITSCH[d] *spalt-papillen*). These are present in our common Rays, and are wart-like dermal growths, open at the top and containing a spherical or somewhat more prolongated (bottle-shaped) cavity, which is filled with sensory cells furnished with hair-like processes and surrounded by supporting cells. The pit organs or sensory follicles lie scattered in rows along the inferior orbital margins, in the temporal region, and on each side of the median line of the body, between this and the true lateral line.

The innervation of the entire system of the lateral line is supplied, according to EWART, almost exclusively from branches of the facial nerve[e] and from the lateralis. The supraorbital branch (fig. 308, *1—6*) and the rostral ampullæ (*Ra*) are supplied by the superficial ophthalmic division of the facial, the suborbital branch and the anterior part of the occipital, the orbital ampullæ (*oa*), and the pit organs (*po*) at the orbits by the buccal division of the facial, and the hyomandibular branch (*12—19*) together with the hyoid ampullæ (*hya*) and the mandibular branch (*27*) by the hyomandibular division of the facial nerve. The lateral line proper, as well as the posterior part of the occipital branch, the transverse occipital canal (*21*), and the majority of the pit organs (*po*), is innervated by the lateralis, one of the main divisions of the vagus.

As FRITSCH has remarked, some obscurity still obtains in the question of the physiological importance of the entire system of the lateral line; and the division

[a] *Die Elektrischen Fische*, II, p. 87.

[b] MATTEUCCI and SAVI, *Traité des phénomènes électrophysiologiques des animaux*, Paris 1844.

[c] Trans. Roy. Soc. Edinb., vol. XXXVII (1891—92), p. 101.

[d] Stzber. Akad. Wiss. Berl., VIII (1888), p. 291.

[e] This nerve consequently consists in fishes, according to EWART, of both sensory and motor fibres. In the higher vertebrates it is motor alone, the sensorial parts, according to EWART, having disappeared. According to the older opinion, which is no doubt still maintained by the majority of anatomists, the divisions enumerated above belong to the trigeminal group.

of work which he assigned on the one hand to the ampullæ as secretory organs, on the other to the lateral line proper and the Savian vesicles as organs of sense, requires further demonstration. Its anatomical structure ranges the system of the lateral line with all its modifications as intermediate between the organs of hearing and those of the senses of pressure (touch—especially as in the worms), taste, and smell; and its physiological significance is perhaps best expressed as yet by LEYDIG's assumption that it appertains to a sixth sense, foreign to us, and receptive of the impressions yielded by such vibrations of the surrounding medium as are too grave (slow) for appreciation by the organs of hearing.

The Rays probably spend the greater part of their existence in a stationary position at the bottom, and to facilitate their respiration, to keep the gill-slits supplied with fresh water, they have been provided with large spiracles on the upper side of the head, just behind the eyes. Above each spiracle is simple, below the passage divides into two, one branch entering the cavity of the mouth, the other passing to the gills. To prevent the water thus supplied from escaping through the mouth, they have a palatal fold, usually of powerful development, in the upper jaw. On the under surface of the head the nasal cavities show about the same relation to the mouth-cavity as in the *Holocephali*, only that no lateral upper lip encloses them outside and in front. Here the median upper lip instead is still more developed, and forms a broad dermal fold extending from the anterior margins of the nostrils and between them back to the corners of the mouth[a], on each side covering a deep groove that runs from the nasal cavity to the corner of the mouth. On the outside this groove is bounded by a dermal ridge, which is indeed furnished anteriorly with a more or less prominent, blunt or rather pointed protuberance, but which does not form any limit between the anterior and posterior nostrils. The five pairs of branchial apertures are set on the ventral side[b], in two more or less straight lines converging behind or in a curve anteriorly concave, posteriorly interrupted, behind the head and between the prorsal parts of the pectoral fins.

As the form-series of the Rays, which includes about a hundred and fifty species, is a developmental offshoot of the Selachian type, the forms that have most widely diverged from the Sharks must, of course, be regarded as the most advanced in the scale of evolution. Among the Rays observed in Scandinavia there are two families which are both distinguished by the exceedingly slender (whip-like) tail and by the loss of at least one dorsal fin. In the third family of Scandinavian Rays both dorsal fins are persistent on the much broader and depressed tail, which is besides fringed on the sides with a more or less distinct dermal fold. But even this family is more widely removed from the Selachian type than the three remaining families, which are strangers to our fauna: the *Torpedinidæ*, *Rhinobatidæ*, and *Pristidæ*.

FAM. MYLIOBATIDÆ.

The whip-like tail without caudal fin, but with a dorsal fin in front, behind which there generally appears a serrated spine, with or without compensatory spine. The large pectoral fins interrupted on the sides of the head, but continued on the sides of the snout by so-called cephalic fins.

This family contains the giants among the Rays, some forms being veritable monsters of the deep. In addition to the characters given above the members of the family are distinguished by the elevation of the head above the plane of the pectoral fins, the forehead being especially high, and causing the eyes to assume a vertical position with lateral aspect, instead of the oblique or horizontal position they occupy in the other Rays. The skin too is smooth during youth in most of these fishes, and in older specimens is commonly shagreened on the tail alone or also on the bases of the pectoral fins, but sometimes over the whole body. The family derives its name from the form and molar function of the jaw-teeth, which are adapted for the

[a] The above-mentioned intermediate forms (the *Rhinobatidæ* and *Pristidæ*) between the Rays and Sharks are approximated to the Sharks in this respect too, and have the nostrils entirely separated from the mouth.

[b] Hence the name of *Hypotrèmes*, applied by DUMÉRIL to the suborder of the Rays.

crushing of hard-shelled animals. These flat, plate-like or tuberous teeth are also characteristic of different genera and species. They are set as if in a mosaic, fitted beside one another like the stones in a pavement (*dentes pavimentati*), and arranged, in the longitudinal direction of the body, in several rows or in a quincunx, with the pointed corners wedged in between each other (fig. 310). Here, as in the Sharks, the largest forms have relatively the smallest teeth. On account of the differences that prevail in this respect, MÜLLER and HENLE[a] distinguished among the forms now under consideration two families, the *Myliobatides* and *Cephalopterae*, which GÜNTHER[b] united into a single family

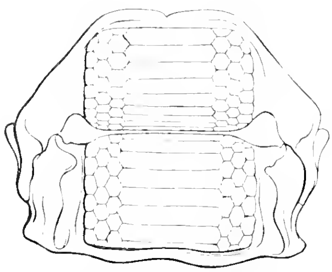

Fig. 310. Jaws of an Eagle-Ray (*Myliobatis aquila*). After AGASSIZ and GÜNTHER.

under the name and with the definition given above, but divided into two subfamilies, *Myliobatina* and *Ceratopterina*[c].

Our knowledge of the gigantic but comparatively small-toothed Rays of the latter subfamily is indeed extremely defective; but they have long afforded material for fabulous narratives, and should probably be included in the list of marine monsters that have posed as the great sea-serpent. Their true homes are the great oceans and the Mediterranean. As an example of their magnitude we may cite, after MITCHILL, the dimensions of a *Ceratoptera vampyrus* taken in September, 1823, in Delaware Bay, on the east cost of the United States[d]. Its length was 10 ft. 9 in. ($32^{3}/_{4}$ dm.), exclusive of the tail, which measured 4 ft. ($12^{1}/_{5}$ dm.), and its breadth between the tips of the pectoral fins 18 ft. (nearly 55 dm.). Its weight was so considerable that three yoke of oxen, a horse, and twenty-two men were required to haul it ashore. The pectoral fins, as well as the cephalic fins, which in the above instance were 2 ft. 6 in. ($7^{2}/_{3}$ dm.) long, may be folded over so as to meet at the mouth; the latter fins are besides mobile in all directions. These Rays often swim in pairs, male and female. They cleave the water with rapid strokes, like the flight of a bird of prey; and in pursuit of their victims, which consist principally of Cephalopods and fish, they display a litheness in their movements which one would hardly credit to a Ray. Sometimes they swim so high that their fins emerge above the surface[e]; and when the cephalic fins are thus exposed to view, the seaman compares them to horns, and hence confers upon the fish such names as ox, cow, or calf, or even that of the prince of darkness, which appears in the form of *Devil-fish*. Others have compared the movements of these Rays to the flitting of a bat, whence the name of *Vampire-Ray*. On the Irish coast a small specimen of a *Ceratoptera* has once been met with (about 1828).

GENUS MYLIOBATIS[f].

Cephalic fins (on the sides of the snout and at its tip) in the same plane as the pectoral. Molars in the middle of the jaws of adult specimens much (3—8 times) broader than long, and larger than the lateral teeth, which are set in several rows.

This genus too, which contains 7 or 8 species, can boast of considerable dimensions of body, though not so great as those of *Ceratoptera*: one species, the Mediterranean *Myliobatis bovina*, often attains, according

[a] *System. Beschreib. Plagiostom.*, Berlin 1841, pp. 176 and 184.

[b] *Cat. Brit. Mus., Fish.*, vol. VIII, p. 488.

[c] *Cephaloptera*, the genus established by the elder DUMERIL, has necessarily been altered to *Dicerobatis*, the name more recently conferred upon it by BLAINVILLE, *Cephaloptera* having been previously employed as a generic name among birds.

[d] *Isis*, vol. XXV, 1832, p. 1063. According to BROWN-GOODE (*Fisher. Industr. U. S.*, sect. I, p. 666) this species attains a breadth of 30 ft. (9 m.) between the tips of the pectoral fins.

[e] Thus we may perhaps explain the account of the "sea-serpent" as seen by Lieutenant HAYES from H. M. yacht *Osborne* in June 1877. See HENRY LEE, *Sea Monsters Unmasked*, Handbooks, Intern. Fisher. Exhib. London 1883, p. 94, fig. 23.

[f] C. DUMERIL, in CUV., *Regn. Anim.*, ed. 1, tom. II, p. 137. From μύλιας, *millstone*, and βατίς, *Ray*.

to Bonaparte, a weight of 300 Italian pounds (about 100 kilo.), and the Japanese form, Günther's *Myliobatis cornuta*, which is probably identical in species with the Atlantic form, sometimes turns the scale, according to Schlegel[a], at 400 pounds (about 180 kilo.). The genus belongs properly to the tropical and subtropical seas; but one species has strayed northwards within the limits of the Scandinavian fauna.

THE EAGLE-RAY (Sw. Örnrockan)

MYLIOBATIS AQUILA.

Fig. 311.

Molars in the middle row within the jaws of adult specimens 4–6 times as broad as long. Tip of the snout blunt, with a small, prominent protuberance at the middle. A more or less distinct similar protuberance on the front of the upper orbital margin in the males. Anterior margin of the pectoral fins convex, posterior margin concave, tip somewhat obtuse. Beginning of the dorsal fin situated about three times the length of its base behind the insertions of the ventral fins. Length of the tail at least equal to the breadth of the body between the tips of the pectoral fins or greater. Skin quite smooth or roughened with spinulæ only at the root of the tail. Coloration above brownish green or yellowish gray with a bronze lustre, below of a dirty white or grayish brown. Tips of the pectoral fins dark. Young sometimes spotted with white. Faint traces of dark transverse bands sometimes present on the dorsal side.

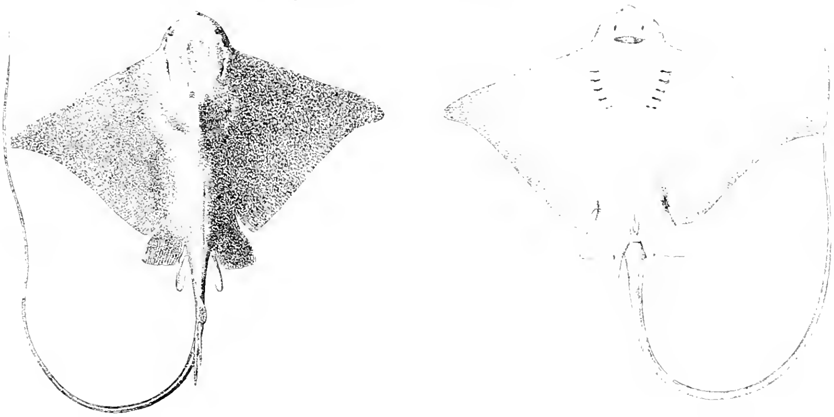

Fig. 311. An Eagle-Ray, *Myliobatis aquila*, ♂. $^1/_6$ of the natural size. From the Museum Adolphi Friderici.

Syn. Ἀετός, Aristot., *Anim. Hist.*, lib. V, cap. V. *Aigle de mer* (*Aquila marina*), Belon., *Nat., Divers. Poiss.*, p. 85. *Secunda Pastinaca species*, Rondel., *Pisc. Mar.*, p. 338. *Aquila*, Salv., *Hist. aquat. anim.*, p. 147. *Raja* corpore glabro, aculeo longo serrato in cauda pinnata; Art., *Ichth. Gen.*, p. 72; *Synon.*, p. 100.

Raja aquila, Lin., *Syst. Nat.*, ed. X, tom. I, p. 232; Cuv. (*Myliobatis*, ex Dum.), l. c.; Johnst. (*Raia*), Proc. Berwicksh. Nat. Cl., Sept. 1839 (vide Yarr., *Brit. Fish.*, ed. 2, vol. II, p. 592); Müll., Henl. (*Myliobatis*), *Syst. Beschr. Plagiost.*, p. 176; Dum., *Hist. Nat. Poiss.* (su. à Buff.), tom. I, p. 634; Gthr., *Cat. Brit. Mus., Fish.*, vol. VIII, p. 489; Mor., *Hist. Nat. Poiss. Fr.*, tom. I, p. 442; Coll., Forh. Vid. Selsk. Chrnia 1882, No. 29; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 352, tab. CLXXVI; Döderl., *Man. Ittiol. Medit.*, fasc. III, p. 234; Lillj., *Sv., Norg. Fisk.*, vol. III, p. 534.

Myliobatis noctula, Bonap., *Iconogr. Fna Ital.*, tom. III, Pesci, tav. 159.

The Eagle-Ray attains a length of $1^1/_2$ m. or more. According to Bonaparte, however, it is commonly smaller than its Mediterranean congener *Myliobatis bovina*, which is characterized by a more pointed and more elongated snout and more pointed pectoral fins. The rhombic disk is remarkable for its great breadth, which is sometimes more than twice its length. The

[a] *Myliobatis aquila* in Sieb., *Fna Japon., Pisces*, p. 310, tab. CXLII.

head — with the semicircular[a] or still more obtuse and depressed snout — presents an appearance which was compared by RONDELET to that of a toad's head, by JOHNSTON to the print of a horse's hoof, the great fontanelle representing the impression left by the frog of the hoof. The eyes are set so high that their superior margin is almost in a plane with the forehead. Their longitudinal diameter in the young is about half the length of the snout, in old specimens less. Just behind the eyes lie the large spiracles, the length of which is about twice that of the former. The nostrils are approximated rather closely to each other, the dermal flap which covers their internal parts (the nasal valvule) being medially attached only at its base by a narrow frenum. This valvule is trapezoidal in form, broad, and expands behind to the truncate edge that lies, with a shallow median sinus and fringed with papillæ, close to the anterior margin of the mouth and outside the very thin true upper lip. The underlip too is thin at the middle, but thickened at the corners of the mouth. The breadth of the mouth is about $^2/_3$ of the distance between it and the tip of the snout.

The body is somewhat depressed (flattened) behind the head, but a little further back rises again to the shoulder-girdle, where the depth is about equal to the length of the fontanelle mark on the top of the head. In the median line behind this point there is a low ridge, which passes on the tail into a dermal edge in front of the dorsal fin, which is rounded above or obliquely truncate. Behind this fin lies the spear-like caudal spine, with faintly convex front, carinated back, and numerous (40—50) retral barbs on the sides[b].

The large triangular pectoral fins have been compared to the wings of an eagle, and have given the genus its vulgar name. The ventral fins are quadrangular, with straight or somewhat convex posterior margin.

The general features of the highly variable coloration have already been indicated.

The Eagle-Ray, which is known from Australia (Sydney) — probably from Japan too — and from the Cape of Good Hope, has its principal European habitat in the Mediterranean and the neighbouring parts of the Atlantic. On the north-west coast of France it is fairly common, but even on the English coast it is rare. Further north it is still rarer. On the 16th of November, 1882, however, a young male[c] of this species was taken among small Herrings at Vettre Farm in Asker, 20 kilom. south of Christiania. The Herring-seine was drawn on a clay bottom, at a depth of 12—14 fathoms (COLLETT).

The habits of the Eagle-Ray essentially resemble those of the Devil-fishes as described above. It is a less marked bottom-fish than the true Rays. It appears to fly rather than to swim, says MOREAU, whether it is traversing mid-water or lashing the surface with one of its pectoral fins. An Eagle-Ray was kept in an aquarium at Arcachon, the same author states, and whenever it was taken out of the water, it uttered a rather loud bellowing noise. Its flesh is of little value and is not much eaten. On the other hand, it is greatly dreaded by the fishermen for the sting of its spine. The tail is usually chopped off before handling the fish. According to MOREAU the Eagle-Ray is viviparous. A fisherman from Roscoff told him that a female of this species had given birth to seven living young just after she had been hauled into the boat.

FAM. TRYGONIDÆ.

The whip-like tail with or without either fins or spine. Pectoral fins extended without a break forward along the sides of the head and contiguous in front of the tip of the snout.

This family has its true home in the seas and rivers of the tropics, where many of its members are a scourge to bathers. They generally live in shallow water, concealing their body in the sand or mud, so

[a] In a male 66 cm. long the length of the flattened snout in the median line before the fontanelle is half its breadth at the same point.

[b] In the specimen described by COLLETT, the tailless body of which measured 318 mm. in length, the true caudal spine was 82 mm. long, but in front of it lay a compensatory spine, still covered with skin and 11 mm. long. In a male 66 cm. long, the tail of which measured 40 cm., the former spine was 63 mm. long, the compensatory spine 55 mm.

[c] Length of the body 853 mm., including the tail (535 mm.). Greatest breadth (between the tips of the pectoral fins) 540 mm. Length of the copulatory organs (pterygopodia) 78 mm.

that only the eyes and spiracles are free. On being alarmed they usually take to flight at once — and bathers or waders therefore stir up the bottom in front of them with a stick, an oar, or the like, or by scraping their feet — but if accidentally trodden on, they promptly dart their caudal spine into the foot or leg, inflicting an extremely painful, perhaps even a mortal wound. About fifty species are known — not all, however, armed with caudal spine — and among them are several (7) inhabitants of the Mediterranean, which have rendered the family notorious since prehistoric times. A Greek myth relates how the sorceress CIRCE tipped with the spine of a Sting-Ray — or perhaps of an Eagle-Ray — the spear she gave to her son TELEGONUS, when he was setting out to seek his father ODYSSEUS, and how this spine became the latter's bane.

The family occupies an intermediate place between the preceding and the following families. Often the head is perceptibly elevated, the eyes assuming almost the same position as in the preceding family, the ventral fins are undivided, never deeply forked or lobed, and the skin is sometimes almost entirely smooth; but the extension of the pectoral fins along the sides of the head ranges this family beside the true Rays. Several of the forms are also furnished with vertical dermal folds, sometimes with a true caudal fin, on the superior or inferior caudal margin, sometimes on both. Most of them have a caudal spine and sometimes as many as two or three compensatory spines in front of the former. One dorsal fin is occasionally present within this family, but there are never two.

DUMERIL[a] divided the family into four subfamilies, distinguished by the absence of the caudal spine (*Urogymni*), or by the presence of a caudal fin (*Urolophi*), of a dorsal fin (*Trygonopterae*), or by the absence of both these fins (*Pastinacae*). To the last-mentioned subfamily, which contains the greatest number of species, belongs the

GENUS TRYGON[b].

One or more dagger-spines furnished with retral barbs on the tail. Where vertical dermal folds appear on the tail, these are low and do not extend out to the tip thereof. No rayed vertical fins. The transverse cleft of the mouth almost straight or at most but slightly curved. Jaw-teeth (fig. 312) flattened, triangular, and set in a dense quincuncial arrangement; in the males sharpened. Disk of the body rhomboidal, of almost equal breadth and length.

Thus defined the genus includes about a score[c] of ascertained species from tropical and temperate regions all round the globe. The generic name is of classical Greek origin, and occurs in many passages of ARISTOTLE's works in its present signification, though it was originally applied to a dove. The notorious and dreaded Ray thus became the namesake of the symbol of innocence, "not on account of its colour," says RONDELET[d], "for this is yellow, but because of the resemblance of the pectoral fins to expanded wings." Among the Romans the genus was called *Pastinaca*, a name that RONDELET derives from the colour and terete form of the tail, which in these Rays is like a parsnip.

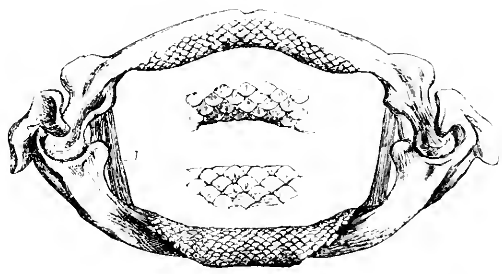

Fig. 312. Jaws and teeth of a Sting-Ray (*Trygon pastinaca*), ♀. Natural size. After MOREAU. Within the figure teeth on a magnified scale. *l*, ligaments.

[a] *Hist. Nat. Poiss.* (su. à BUFF.), tome I, p. 579.

[b] ADANSON, *Cours d'Histoire naturelle*, 1772, vol. II, p. 170. This work first appeared in print in 1825; but GEOFFR. ST. HIL. adopted the name of *Trygon* from it in 1809 (*Descr. de l'Egypte*).

[c] GÜNTHER diagnoses 23 species in his *Catalogue*.

[d] *De Pisc.*, p. 332.

THE STING-RAY (SW. SPJUTROCKAN).

TRYGON PASTINACA.

Figs. 313 and 314.

Tail, which occupies about half (in the young rather more than half) the length of the body, furnished both above and below with a shallow dermal fold, the upper, however, insignificant. Length of the disk about 80—85 % (88 %) of its breadth. Tip of the snout more or less obtuse, lateral tips of the disk (of the pectoral fins) rounded. Ventral fins rectangular, with the inner posterior angle strongly rounded.

Length of the head (from the tip of the snout) to the occiput about $^{2}/_{5}$ (37—40 %), to the first gill-opening somewhat more than $^{1}/_{3}$ (34—36 %), of that of the disk. Length of the snout (from the anterior

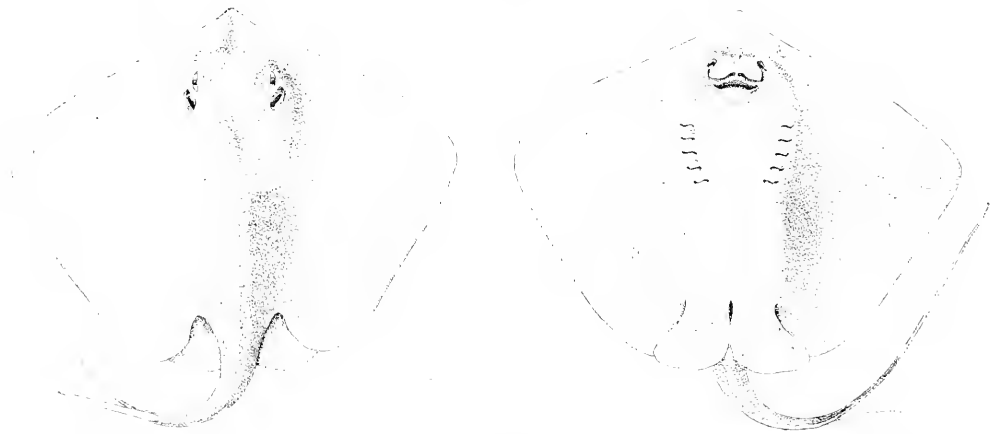

Fig. 313. *Trygon pastinaca*, ♀. $^{1}/_{4}$ nat. size. From Mount Kullen, July 24th, 1849. Baron GYLLENSTJERNA. The property of the Museum of Lund.

margin of the eyes) about $^{2}/_{3}$ of the former length of the head. Nasal valvule, which is attached by a narrow frenum almost throughout its length, of a rectangular form, about twice as broad as long[a], and its breadth at the base somewhat greater than the width of the mouth. Greatest depth of the body (the thickness at the shoulder-girdle) somewhat less than half the length of the head to the occiput. Teeth of the upper jaw, with thimble-like indentations on their surface, set in about 20—30 rows directed obliquely backwards. Distance of the caudal spine from the root of the tail about equal to the length of the head. Breadth of the tail at the base about equal to the width of the mouth. Skin of young specimens entirely smooth, of old often tuberculated in the median line of the back and above the shoulder-girdle. Coloration above of a grayish or brownish yellow, or darker, of a blackish green, in front grayish, in the young sometimes spotted with white; under surface of a dirty white.

Syn. *Pastinaca*, la Pastenade de mer, ou Tourterelle, ou Tareronde, BELON, *Nat., Div. Poiss.*, p. 82. *Pastinaca marina Oxyrinchos*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 58. *Raja* corpore glabro, aculeo longo anterius serrato in cauda apterygia, ART., *Ichthyol., Gen. Pisc.*, p. 71; *Syn.*, p. 100.

Raja Pastinaca, LIN., *Syst. Nat.*, ed. X, tom. I, p. 232; PENN., *Brit. Zool.* (ed. 1776), tom. III, p. 83; RETZ., *Fna Suec. Lin.*, p. 304; DONOV., *Brit. Fish.*, tab. XCIX; CUV. (*Trygon*), *Regn. Anim.*, ed. 1, tom. II, p. 136; NILSS. (*Raja*), *Prodr. Ichthyol. Scand.*, p. 120; PARN. (*Trygon*), Mem. Wern. Nat. Hist. Soc., vol. VII, p. 440; BONAP., *Iconogr. Fna Ital., Pesci*, tab. 156; NORDM. in DEMID., *Voy. Russ. Mér.*, tom. III, p. 549; MÜLL., HLE, *Syst. Beschr. Plagiost.*, p. 161; EKSTR., Gbgs Vet., Vitt. Samh. Handl., Ny Tidsf.,

[a] Length of the nasal valvule 48—56 % of its breadth at the base.

II. 1. p. 41; Kr., *Danm. Fiske*, vol. III, p. 1018; Nilss., *Skand. Fna, Fisk.*, p. 741; Rhdt. Vid. Meddel. Naturh. For. Kbhvn 1864, p. 276; Dum., *Hist. Nat. Poiss.*, tom. I, p. 600; Gthr. *Cat. Brit. Mus., Fish.*, vol. VIII, p. 478; Winth., Naturh. Tidskr. Kbhvn, ser. III, vol. XII, p. 61; Mör., Heke, *Fisch. Osts.*, p. 158; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 350, tab. CLXXV; Doderl., *Man. Ittiol. Medit.*, fasc. III, p. 220; Peters., Vid. Meddel. Naturh. For. Kbhvn 1884, p. 160; Lillj., *Sv., Norg. Fisk.*, vol. III, p. 539.

Trygon lymma, Geoffr., *Descr. Egypt., Poiss.*, p. 219, tab. 27, fig. 1.

Raja Sayi, Lesueur, Journ. Acad. Nat. Hist. Philad., vol. I, p. 42. Vide Gthr.

Trygon vulgaris (= *Pastenague commune* ex Cuv.), Risso, *Eur. Mérid.*, tom. III, p. 160; Mor., *Hist. Nat. Poiss. Fr.*, tom. I, p. 448.

Trygon Akajei, Müll., Hle, l. c., p. 165, tab. 53; Schl. in Sieb., *Fna Japon., Pisc.*, p. 308. Vide Gthr.

The Sting-Ray, which is common in Southern Europe, is stated to attain rather considerable dimensions, at least a length of $2^1/_2$ m. and a breadth of $1^1/_2$ m., though the occurrence of so large specimens has not been authenticated in European waters. Bonaparte indeed speaks of Sting-Rays from the Mediterranean weighing 10 centners; but Risso says that their average weight in that sea is about 10—12 kilo., and according to Doderlein the largest Sting-Rays in the fishmarket of Palermo weigh 20 kilo. or more. Schlegel states that the Japanese form (*Trygon Akajei*) attains a weight of several centners; and the dimensions given above are those of a specimen from the Cape of Good Hope, now in the Museum of Paris.

It seems rather probable, however, that several species are included in the above list of synonyms. Our material is indeed scanty, consisting of two females, which we figure here, of about the same size; but even these show divergencies of form uncommon at least in the other Rays. The one, which was probably the type of Linnæus's *Raja Pastinaca*, has a less expanded disk, and apparently comes nearer to the American *Trygon Sayi*; the other, the only Swedish example of this species on record, corresponds more closely to Bonaparte's and Day's *Trygon pastinaca*. The most important differences are expressed in the following percentages:

	Specimen in the Lund Museum	Specimen from the Mus. Ad. Frid
Length of the disk in % of its breadth	80.0	88.6
„ „ „ head to the occiput ... in % of the breadth of the disk	30.0	35.3
„ „ „ „ „ „ first gill-opening „ „ „ „ „ „ „ „	27.5	31.5
Distance between the caudal spine and the root of the tail „ „ „ „ „ „ „ „	31.6	37.2
Length of the snout from the corners of the mouth in % of the length of the head to the occiput	57.2	63.4
Distance between the nostrils in % of that between each of them and the tip of the snout	75.6	59.6

According to Risso the Sting-Ray is a fish of nocturnal habits, hiding itself as we have described above, and lying in wait for any prey that may approach; but at night-time it may be taken in gill-nets. When it attacks a fish, it flings its tail round the victim, which it then pierces and tears with its sting; and it defends itself in the same manner from the hand that would grasp it. Its food consists of fish, crustaceans, and mollusks. On the Sicilian coast, according to Doderlein, it approaches land and is taken in numbers from the middle of December till the end of March, during which season it contains eggs of but little development. This is probably the breeding season, for the more isolated females caught in summer are more or less gravid. The young are born alive.

From the Black Sea and the Mediterranean the true geographical range of the Sting-Ray extends along the Atlantic coast of Europe hardly further north than to England. Even there, as well as on the north-west coast of France, it is far from common; and to the north it becomes rarer and rarer. Now and then it is met with off the Scotch coast. Schonevelde knew it from Heligoland. Bloch received it from Hamburg. Kroyer heard fishermen speak of its occurrence off Hirsholm. Reinhardt received a specimen that had been taken in the autumn of 1862 off Frederikshavn. Schrader sent to the Museum of Copenhagen a specimen that had been caught on June 10th, 1882, on the south side of the Skaw. From the fishing-village of Arild, at the foot of Mount Kullen in Scania, Baron Gyllenstjerna received, on the 24th of July, 1849, a specimen which is now preserved in the Museum of Lund. This example (fig. 313) has a disk $34^1/_2$ cm. broad and $27^1/_2$ cm. in length from the tip of the snout to the extreme end of the margin of the pectoral fin. Whether more Sting-Rays have been found on the coast of Scandinavia, we are ignorant; but RETZIUS included the species in his edition of LINNÆUS's *Fauna Suecica*: and the Museum of Drottningholm contained a specimen about 6 dm. long (now preserved in the Royal Museum, but with the tail broken off short), which had certainly been in LINNÆUS's hands, but is probably of foreign origin, as he did not personally recognise the species as Swedish. The last-mentioned specimen is represented in the appended figure.

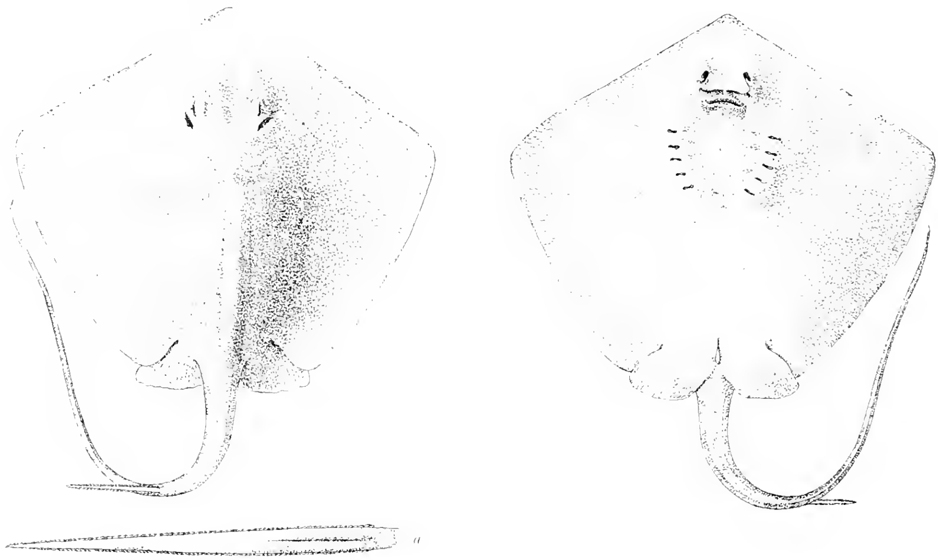

Fig. 314. *Trygon pastinaca*, ♀, 1/4 nat. size; *a*, caudal spine, nat. size. From the Museum Adolphi Friderici.

FAM. RAJIDÆ.

Tail depressed, with dermal edge on the sides, flat underneath, convex on the top, and furnished with two dorsal fins, with or without caudal fin. The pectoral fins extend forward to the snout or even in front of the rostral cartilage. Where electric organs are present, they lie on the sides of the tail. No spear-like spine on the tail.

As we have remarked above, these fishes, the family of the true Rays, in spite of the singular development of the pectoral fins, deviate less than the preceding families from the form of body typical of the Sharks. A distinct expression of this is given by the arrangement of the nostrils and the nasal valvule. Each nostril is indeed continued here too by a groove to the corner of the mouth; but the nostrils are farther apart, and the nasal valvule coalesces throughout the greater part of its inner surface with the bottom of the snout, so that in many cases only its posterior lateral corners form free dermal flaps.

The stronger flattening of the body, especially of the head, imparts to the eyes, as we have mentioned above, a more horizontal position; but they are protected above by an expansion of the frontal skin, and to mitigate the excessive brilliancy of the light, the upper margin of the iris is prolongated in most of the species into finger-shaped processes partly covering the pupil.

The family as a whole — it is dispersed round the globe from the tropical to the frigid zones — is about as varied in form as the preceding one, but in our seas more so; and its members are often difficult to distinguish. In manner of life they essentially resemble the preceding Rays; but many of them descend to greater depths. They are oviparous; but the embryo leaves the egg very soon after the exclusion of the latter from the cloaca, or even during its transmission through the said passage.

Of the four or five genera which the family contains, the Scandinavian fauna possesses only one.

GENUS RAJA[a].

The pectoral fins do not extend in front of the rostral cartilage. The ventral fins are deeply forked at the hind margin. Where a caudal fin is present, it does not extend to the under surface of the tip of the tail.

The foundation of our knowledge of the species belonging to this genus and their mutual relations, especially as they appear in the Scandinavian fauna, was laid in its essential details by B. FRIES[b]. His first remarks had reference to the value of the specific characters employed at his time within the genus.

The spiny armature of the body, he wrote, has been the chief specific distinction employed since the infancy of science, and it also affords beyond all question not only clear, but also really trustworthy characters, if only we refrain from minutiæ, such as counting the number of the spines, determining their positions and size, as has hitherto been customary, for it is in this very manner that most of the nominal species and the constant confusion of the species arise. Every one who studies the species by comparing a number of individuals, and who afterwards compares nearly related species with each other, will find without fail that the armature, however similar it may appear at first sight, yet follows in each species a distinct development, characteristic of the species, and expressed not only in the form, size, position, growth, and shedding of the spines, but also in such normal deviations from the original specific type as age and, in part, the difference of sex entail. For the attainment of descriptive lucidity FRIES proposed the following terminology. *Smataggar* (*spinulæ*) he called the prickles that cause the asperity of the skin. They are quite small and short, either subulate, with a bifid or quadrifid, stellate base (*spinulæ stellares*), or granular (*granulosæ*). *Knaggor* (*aculei*) was the name he applied to the large, claw-shaped, and usually recurved, thorn-like spines which stand as wound-inflicting weapons partly at certain fixed spots on the body (*aculei ordinarii*), namely in rows along the spinal column, on the rostral cartilage, around the orbital margin, and on the dorsal side above the scapular region, partly at other undefined spots and in highly variable number both on the dorsal side and the ventral (*aculei extraordinarii*). Both these kinds of aculei vary in number, form, and size, are shed periodically or accidentally broken off, in which case, however, they always leave, at least for a time, a mark in the skin. Furthermore both may occur with expanded, flattened or nail-headed base (*aculei clavati*), or with expanded, conical base, deeply grooved on the sides and as it were radiate (*aculei radiati*). Besides spinulæ and aculei the Rays have a third kind of spines, but only the males. These FRIES called *the cards of the males* (*carmines maris*). They are situated on the dorsal side of each half of the body, partly at the outer margin of the head, partly and principally on the pectoral fins, a little way from the tips thereof. They consist of rather long, simply bent or hooked, and very pungent spines, set in rather irregular longitudinal rows, and furnished with a mobile attachment, so that the Ray can depress or erect them at will. When depressed, they lie close to the skin, and may easily escape observation. By the distribution of the aculei on the tail FRIES distinguished between two types among our indigenous species, the one with an odd number of longitudinal rows, the other with an even number. The latter type — as exemplified in the Shagreen Skate and the Sandy Ray — seems hardly ever to be impaired by exceptions or to alter with the age of the individual, but is always recognisable by the symmetrical rows of aculei (arranged on each side of the median line). The former type, on the other hand, is often overlooked and mistaken owing to the considerable modifications

[a] ARTEDI, *Ichthyol., Gen. Pisc.*, p. 70. "Est vocabulum PLINII. Derivatio dubia" (ART., *Phil.*, p. 75).
[b] See Vet. Akad. Handl. 1838, p. 126.

induced by age. Judging by those species whose development FRIES had an opportunity of tracing, he remarked, as a rule probably of general application, that no species of Ray belonging to the type with an odd number of rows of caudal aculei, when young or newly hatched, has more than one such row, which then invariably occupies the median line of the tail. The lateral rows do not appear until the fish has reached a more advanced age. Most of the Scandinavian species fall under this type, but develop in a direction involving something peculiar to and characteristic of each. In some the lateral rows always project from the side-margin of the tail, in others between this margin and the median line. In certain forms the spines of the lateral rows never attain the same size and strength as those of the median row, while in others the relations are reversed. In some species the spines of the median rows are persistent even at a very advanced age, in others they are normally lost or shed.

The form of the jaw-teeth, remarked FRIES, has been rejected as a specific distinction by CUVIER and other writers, and on the whole with good reason, for greater differences of dentition may often be observed between the young and the old, between the male and the female, than can be determined between two nearly related species. But it is equally certain, he wrote, that most of the species, not to say all the Scandinavian ones, have a fixed form of dentition proper to them, whereby some of them can safely be distinguished, and some — e. g. the Thornback, Shagreen Skate, and Starry Ray — are so well marked in this respect that they can be confounded with no other species. To gain a right conception of the dentition of each species, the development of the teeth must be carefully followed, and a good clue is afforded to the investigator by a comparison of the teeth nearest the corners of the mouth with those in the middle of the jaw. The former are arrested, as it were, at a lower grade of development, and most nearly resemble the teeth of the young; the latter exhibit the highest stage in the dental development of the species. The several intermediate rows between the said points show the transitions from the lowest to the highest development of the teeth. If attention be paid to this, and the gradual detrition to which the outermost (foremost) transverse rows in the mouth are subjected be also taken into consideration, the greater number of the said anomalies in the dentition of a species disappear. As in the preceding family, the males are characterized by more pointed jaw-teeth than those of the females; but only in one of the species indigenous to Scandinavia (the Thornback) is the dentition of each sex thoroughly distinct; in the others the difference is sometimes so slight that it has even been overlooked.

The form of the snout affords characters of no little importance and constancy, especially if the alterations of growth be kept in mind; and the variations in the form of the snout are attended by differences in the general configuration of the body, which form is really determined by that of the snout and the pectoral fins. To find a safe expression for these variations in the form of the snout, FRIES compared the length of two lines, one drawn right across the head through the centre of the pupils, the other at right angles to this and extending to the tip of the snout. The species in which the latter line is less than half as long as the former, he called blunt-snouted; those in which the length of the snout is more than half or at least half the breadth of the head at the said point, he ranged among the sharp-snouted Rays (the Skates). Another expression of this, which besides affords an often requisite character from the under surface of the head, may be obtained by comparing the least width between the inner margins of the nostrils (the base of the nasal valvule) with the distance between the nostrils and the tip of the snout, whereby we find that in the blunt-snouted species the length of the base of the nasal valvule is more, in the sharp-snouted species less, than 70 % of the distance between the nostrils and the tip of the snout. The form of the snout also supplies another character, which was indeed remarked by FRIES in his descriptions, but has won greater recognition in more recent times[a]. In the Rays with a very pointed snout a line drawn from the tip of the snout to the anterior margin of the outer tip of the pectoral fin falls entirely outside the disk, whereas in the blunt-snouted Rays it at least partly cuts the same.

From the position of the dorsal fins with relation to each other NILSSON[b] deduced a specific character the value of which was also appreciated by FRIES. Some species, such as the Starry Ray, have the two dorsal fins set quite close together on the tail and without

[a] See E. MOREAU and DÖDERLEIN.
[b] *Prodr. Ichthyol. Scand.*, p. 119.

aculei between them. In others, as in the Thornback, the two fins are farther apart, and the median line between them is armed with one or more spines.

Of the coloration of the body FRIES observed that, in spite of its variability, it is partly characteristic in some degree of different species — especially that of the under surface. As a natural result of the life led by the Rays, which are bottom-fishes, this side of the body is commonly light and colourless (whitish), and it would appear as yet to be uncertain whether the dark colour, entire or distributed in large spots, where it occurs on the ventral side, affords trustworthy specific characters or not. But good characters may be drawn from the sometimes distinctive coloration of the long winding canals and apertures of the ventral system of the lateral line, and these characters are of so much greater utility as being present from earliest youth and persistent in specimens either stuffed or preserved in spirit. The spots and ocelli which occur on the dorsal side of certain species, showing endless variation in size, colour, and extent, are utterly worthless as specific characters.

With regard to the external differences of sex, which have long been known, FRIES stated that they are, as usual, less marked in young specimens than in mature individuals, most of the male attributes being commonly absent or only rudimentary in the former, and developing in proportion as the age of puberty is approached. In general the females are armed with far more numerous and much larger spines than the males; but this rule is not without exceptions.

Most of the true Rays are good and esteemed food-fishes. When boiled fresh, their flavour calls to mind that of the Halibut, or is not unlike that of lobster. They may also be dried and kept till required for use, in which case the fish is scored along the body. In this form they are usually eaten after having been lyed in the same manner as stock-fish. They are consequently sought after by the fisherman, and they are in general well distinguished and familiar to all, their vulgar names affording valuable aid in the definition of the species and their synonymy. HOLLBERG (1819) knew three Scandinavian species of the genus, the *klorocka* (*Raja radiata*), *knaggrocka* (*Raja clavata*, which he called *prickrocka*), and *slätrocka* (*Raja batis*). In his *Prodromus* (1832) NILSSON characterized four, the above-mentioned species and the *blagarnsrocka* (*R. lintea*, which he called *R. fullonica*). In 1838 FRIES added two, the *gökrocka* (*R. fullonica*) and *plogjernsrocka* (*R. oxyrhynchus*). To these six species MALM supplemented in 1857 the *sandrocka* (*R. falsavela*, which he called *spittrocka*); and in 1881 COLLETT described as Scandinavian LILLJEBORG's *svartbaksrocka* (*R. nidrosiensis*). All these forms unquestionably belong to the Scandinavian fauna; but COLLETT further established in 1878 another species, *Raja hyperborea*, to which the said fauna can probably lay claim. These species may be distinguished as follows:

A: Blunt-snouted. Internasal width more than 70 % of the distance between each nostril and the tip of the snout: — Rajæ clavatæ.

- *a:* Root of the aculei nail-headed. Distance between each nostril and the tip of the snout 15 % or less of the breadth of the disk .... *Raja clavata.*
- *b:* Root of the aculei grooved. Distance between each nostril and the tip of the snout at least 16 % of the breadth of the disk.
  - *α:* Upper median line of the tail armed with a series of aculei.
    - *aa:* Aculei in the median line of the back and tail at most about 16 *Raja radiata.*
    - *bb:* Aculei in the median line of the back and tail at least about 24.. *Raja hyperborea.*
  - *β:* Upper median line of the tail without aculei .... *Raja falsavela.*

B: Sharp-snouted. Internasal width less than 70 % of the distance between each nostril and the tip of the snout: — Rajæ læves.

- *a:* Ventral side light, plain, without dark punctuation.
  - *α:* Upper median line of the tail without aculei .... *Raja fullonica.*
  - *β:* Upper median line of the tail armed with aculei .... *Raja lintea.*
- *b:* Ventral side dark or marked with small dark dots and streaks.
  - *α:* Length of the snout less than 18 % of that of the body or than 28 % of the breadth of the disk .... *Raja batis.*
  - *β:* Length of the snout more than 18 % of that of the body or than 28 % of the breadth of the disk.
    - *aa:* Aculei (even if small) at the eyes. Ventral side blackish and with indistinct punctuation .... *Raja nidrosiensis.*
    - *bb:* No aculei at the eyes. Ventral side comparatively light and with distinct dots and streaks . *Raja oxyrhynchus.*

Sectio 1: **Rajæ clavatæ, Rays.** *Snout short, its tip blunt,* the length of the snout from its tip to the centre of the eyes being less than half its breadth at the latter point.

These species are the smallest, or at least do not attain the same magnitude as the Skates. The females are larger than the males and more plentifully armed both with spinulæ and aculei. Spines of the latter kind, known by FRIES as extraordinary aculei, occur, sometimes in considerable number, scattered here and there on the body without definite arrangement and often without symmetry. Iris furnished with lobate lid overlapping the pupil (FRIES).

THE THORNBACK (SW. KNAGGROCKAN).

RAJA CLAVATA.

Plate XLVII, figs. 1 and 2.

Length of the snout (from the anterior margin of the eyes) about 12—13 % of that of the body or 17—19 % of the breadth of the disk. Distance between each nostril and the tip of the snout at most about 15 % of the said breadth. Dorsal fins well separated, and the median line between them usually spinigerous. Aculei ungrooved, their number in the median line of the back and tail in front of the first dorsal fin about 26—30 %[a].

Syn. *Raia clavata*, RONDEL., *De Pisc.*, lib. XII, cap. XIII, p. 353; SCHONEV., *Ichthyol. Slesv. Hols.*, p. 58; WILLUGHB., *Hist. Pisc.*, p. 74. *Raja* aculeata, dentibus tuberculosis, cartilagine transversa in ventre, ART., *Ichthyol.*, *Gen.*, p. 71; *Synon.*, p. 99; *Spec.*, p. 103; LIN., *Fna Suec.*, ed. I, p. 100; *It. Westrog.*, p. 175.

Raja clavata, LIN., *Syst. Nat.*, ed. X, tom. I, p. 232; BL., *Fische Deutschl.*, pt. III, p. 65, tab. LXXXIII (♀ + *Raja rubus*, p. 67, tab. LXXXIV, ♂); RETZ., *Fna Suec. Lin.*, p. 304; HOLLB. (p. p.), Gbgs Wett., Witt. Samh. N. Handl., III (1819), p. 29 (nec fig.); FAB., Tidskr. Naturv. Kbhvn, vol. V (1828), p. 246; YARR., *Brit. Fish.*, ed. I, vol. II, p. 436; FR., Vet. Akad. Handl. 1838, p. 140; BONAP. (*Dasybatis*), *Iconogr. Fna Ital.*, *Pesci*, tab. 149, figg. 3 et 4 (+ *D. aspera*, ibid.); EKSTR., v. WR. (*Raja*), *Skand. Fisk.*, ed. I, p. 154, tab. 35; MÜLL., HLE, *Syst. Beschr. Plagiost.*, p. 135; KR., *Danm. Fiske*, vol. III, p. 962; NILSS., *Skand. Fna, Fisk.*, p. 735; COUCH, *Fish. Brit. Isl.*, vol. I, p. 99, tab. XXII; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 456; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 214; N. Mag. Naturv., Bd 29 (1884), p. 118; MALM, *Gbgs. Boh. Fna*, p. 606; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 60; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 391; MÖB., HCKE, *Fisch. Osts.*, p. 154; STORM, N. Vid. Selsk. Skr., Trondhj. 1883, p. 45; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 343, tab. CLXXI; DÖDERL., *Man. Ittiol. Medit.*, fasc. III, p. 176; LILLJ., *Sv.*, *Norg. Fisk.*, vol. III, p. 555; CARUS, *Prodr. Fnæ Medit.*, vol. II, p. 521.

Raja scabra, LIN., *Mus. Ad. Frid.*, tomi II:di prodr., p. 52 (sec. specimen ex Musæo Drottninghholmensi).

Raja Dasybatus punctatus, HOLLB., Gbgs Wett., Witt. Samh. N. Handl., pt. IV (1821), p. 25 cum tab.

Raja pontica, PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 58; RATHKE, Mém. div. sav. étrang. Acad. Sc. Petersb., tom. III (1837), p. 309.

Raja Rubus, NILSS. (ex BLOCH), *Prodr. Ichthyol. Scand.*, p. 118.

The males attain a length of about 7 dm. from the tip of the snout to the end of the tail; the females sometimes measure 9 or 10 dm. Until they have reached or nearly reached this size, they are apparently incapable of propagating their species; FRIES at all events never found an individual under 6 dm. in length with the external or internal genital organs developed.

The disk is rhombic, with somewhat pointed pectoral and ventral fins. The anterior side-margins of the body form two bends, the anterior situated just behind the tip of the snout, where a small, blunt muzzle is thus produced, the posterior beginning a little in front of a transverse line drawn through the centres of the eyes. The posterior side-margins are more convex, but in their outer parts curve slightly inwards. The greatest breadth of the disk is on an average[b] 69 % of the length of the body. The distance from the tip of the snout to the extreme end of the hind margin of the pectoral fin (the length of the disk) is on an average[c] 75 %, to the anterior angle of the cloaca 64 %[d], and to the tip of the posterior ventral lobe 84 %[e], of the breadth of the disk.

[a] Provided that the series be complete, no aculei having been lost.
[b] In 14 specimens 36—92 cm. long. The variations run between $65\frac{1}{2}$ % and $72\frac{1}{2}$ %.
[c] The variations run between 71 % and 79 %.
[d] „ „ „ „ $61\frac{1}{2}$ % and 68 %.
[e] „ „ „ „ 79 % and 91 %.

The length of the head from the tip of the snout to the occiput is about ${}^1/_4$ of the entire length of the body. The length of the snout varies between 12 and 13 % (exceptionally 14 %) of that of the body, or between 17 and $19^1/_2$ % of the greatest breadth of the disk. The least interorbital width of the concave forehead (exclusive of the dermal fold above the eyes) varies between 30 and 37 % (exceptionally 39 %) of the length of the snout. The longitudinal diameter of the oblong eyes is about ${}^1/_3$[a] of the length of the snout, and the longitudinal diameter of the spiracles, which lie just behind the eyes, is in young specimens only about ${}^2/_3$ of that of the latter, in old Thornbacks almost equal to the same. The internasal width is in young specimens about ${}^3/_4$, in old ${}^9/_{10}$ (exceptionally 95 %), of the distance between each nostril and the tip of the snout, or about 18—20 % of that between the cloaca and the last-mentioned point. The lateral flaps of the nasal valvule are fimbriated behind. The breadth of the mouth, which is transverse and but slightly curved, is equal in young specimens to the internasal width, somewhat greater in old. The dentition differs considerably in the young and old and in the males and females. All young specimens have small, blunt, granular teeth, set in rows running obliquely on each side, and without any distinction between the sexes (fig. 315, *A*); but as the males approach maturity, the crowns of the teeth become more and more flattened, with the hind margin pointed and prolongated, a transition to the characteristic dentition of the old males. The teeth of the adult males are set in fairly regular rows, both longitudinal and transverse, and those forming the 14—22 rows in the middle of the mouth have a somewhat prolongated crown with subulate cusp (fig. 315, *B*), which is directed inwards towards the pharynx, thus lying like a scale over the tooth behind it. The rows nearest to the corners of the mouth have quite small, flat crowns, with the hind margin slightly prolongated into a flat, sharpened heel, which is more and more extended and approximated to the subulate form, the nearer the row to which it belongs lies to the first-mentioned median rows. Only the teeth with subulate cusp have a very narrow rim at the base, and as these are most exposed to detrition, the tips of the foremost (oldest) teeth are always worn and blunt. In old females the teeth have broad, lozenge-shaped, and sloping crowns, set in pentagons (so-called mosaics, fig. 315, *C*). This dentition is peculiar to the Thornback, and cannot be confounded with that of any other among the Scandinavian Rays.

The whole upper surface of the body is densely strewn with fine, compressed spinulæ, branching at the root into a star with two—four or even six arms. Similar small spines, more scattered, however, are set on the ventral side of the body in full-grown specimens, especially under the snout and tail, but are wanting on the pectoral and ventral fins, which are smooth. In young individuals, on the other hand, especially of the male sex, the whole ventral side seems smooth to the touch; but on careful examination very fine spines are detected even there, at least under the very tip of the snout and at the sides of the abdominal cavity. All the aculei belong to the type which, when

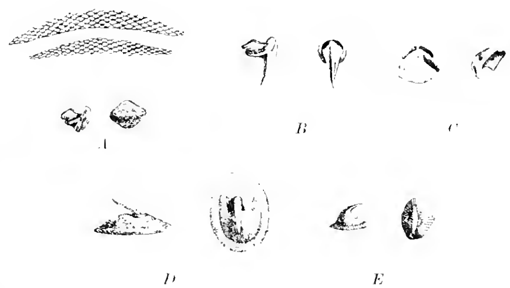

Fig. 315. Jaw-teeth and aculei of the Thornback (*Raja clavata*). *A*, teeth of a young male, natural size, and (below) a tooth magnified, lateral and superior aspects; *B*, tooth of an old male, magnified, lateral and superior aspects; *C*, tooth of an old female, magnified, aspects as before; *D*, dorsal aculeus of an old Thornback; *E*, caudal aculeus of a younger specimen.

fully developed, has a smooth, expanded base (*aculei clavati*). The ordinary consist in young specimens of 1) a row running along the back, containing some twenty spines, with base as yet but conically expanded, 2) an aculeus on the scapular cartilage, on each side of this row, 3) one or two before and two or three behind the eyes, and 4) a few quite small aculei on the rostral cartilage, set in two rows. In older specimens we find, besides those enumerated above, a row on each side of the median series at the root of the tail, and sometimes, especially in the females, two rows at the same point, containing aculei of the same size as or even larger than those of the median series.

[a] In a young specimen 14 cm. long the diameter of the eyes, according to KRØYER, was $37^1/_2$ % of the length of the snout.

These lateral rows do not occupy the extreme side-margin of the tail, but the space between this and the median series, except where there are two lateral rows on each side, in which case the outer row projects from the said margin. They do not extend throughout the length of the tail, but only a short distance along it; they are not symmetrical, and contain an extremely variable number of aculei. A little behind the termination of these lateral rows and before the origin of the first dorsal fin, we usually find in old specimens 1—3 true lateral aculei (set at the extreme side-margin), in most cases the largest on the tail, seldom of equal number on both sides. These few lateral aculei at the said point and those occupying the space between the two fins are, though not constant, good characters, where they are present, of the Thornback. The extraordinary aculei are so variable, both in distribution and number, that no rule can be stated. They seemingly appear a short time before the period of puberty, for in all young specimens there is not even a sign of their presence. They are most numerous in middle-aged females, but in very old ones most of them have again disappeared[a]. They are extremely seldom symmetrical, sometimes preponderating in number on the dorsal side, sometimes on the ventral; sometimes scattered, sometimes collected in groups. Their basal scutes are often of considerable extent. Among the Scandinavian species of the family the Thornback is the only one in which aculei appear on the ventral side.

The coloration of the dorsal side is yellowish gray, with a number of large, round, whitish yellow spots of varying size and without symmetry. Between these appear smaller, black spots, like round dots, which gather round the former and compose black frames, sharply defined especially in young specimens. Sometimes there also occur in old individuals large ocelli, circular black spots with light margin, in one or two pairs on the dorsal side. The ventral side is white, with a dash of violet round the margins of the fins. On the tail the dark colour now and then, especially in young specimens, forms several (up to 6—8) broad transverse bands, most distinct on the under surface thereof.

The sex is manifested externally, in part and with most clearness, by the large pterygopodia of the male and the cards of spines peculiar to him on the upper surface of the pectoral fins — two patches of erectile spines on the sides of the orbital region and another pair of larger patches within the outer angles of the fins — in part by several other differences already noticed. However distinct all these characteristics may be at an advanced age, during youth they are wanting or only subindicated, and at first the sexes are externally indistinguishable. As the time of puberty approaches, they all appear almost simultaneously, and afterwards the difference between the sexes grows more marked year by year. In a male 216 mm. long (presumably a year old) taken in August, MALM estimated the length of the pterygopodia at only 3 mm. In a male about 42 cm. long FRIES found the pterygopodia still quite small and short, their tips extending only a little more than half-way along the ventral fins; there were no signs of cards; the teeth were still of a granular, lozenged and blunt form; the ventral side of the body was quite smooth, only a few spots (the tip of the snout and the sides of the belly) being rough to the touch; there were no extraordinary aculei, and of the ordinary caudal aculei only the median row was present. In a specimen 52 cm. long the circumstances were essentially the same, only that the pterygopodia were somewhat longer in relation to the ventral fins, and the ventral side of the body was rougher, especially under the tail. But in an individual rather more than 60 cm. long the pterygopodia are so developed that their tips extend more than half-way along the tail, and all the other characteristics of the male have appeared, though the cards are still small, containing few spines, and these set in 2 or 3 rows, whereas in larger and older specimens as many as 6—8 rows may be counted, each containing some twenty spines or more.

The Thornback is the commonest of all the Swedish Rays. In the Sound it occurs southwards to the shallows off Saltholm (WINTHER). It has occasionally been met with in the south-west of the Baltic, on the east coast of Schleswig-Holstein (SCHONEVELDE and MÖBIUS and HEINCKE) and the north coast of Mecklenburg (BOLL[b]). It is most plentiful in the Cattegat and the North Sea. To the north, according to STORM, its range probably does not extend beyond the neighbourhood of Trondhjem. To the south it penetrates into

[a] FRIES met with very old males as well as females destitute of a single extraordinary aculeus.

[b] *Die Ostsee*, Arch. Ver. Fr. Naturg. Meckl., Heft. 1, p. 89 (sep.).

the Mediterranean and the Black Sea (PALLAS), and it has been found off Madeira (GÜNTHER).

In the island-belt of Bohuslän Thornbacks both young and old are taken all the year round. During winter, however, they are less common, and the fishermen state that at this season the Thornback repairs to deep water. In spring and summer it is very plentiful off the coast, where it seems to prefer water of a moderate depth[a] and with a sandy bottom. It lives almost invariably at the bottom and extremely seldom ascends to a higher level. Its food consists of small fishes, crustaceans — crabs, lobsters, shrimps, etc. — mollusks, Annelids, Echinoderms, and *Actiniæ*[b].

Throughout the summer the females contain developed ova; but according to FRIES only one egg is laid at a time, and the period of oviposition for each female must consequently be of long duration. FRIES observed that, on opening old females in summer-time, the egg-clusters in the ovaries are found to be considerably tumid, the several eggs showing different grades of development, from the size of a pea to that of a plum. In the two oviducts however — each of them dilated below into a uterine organ — he never found more than a single egg, and this already invested with the singular corneous shell. When one of the uteri contained an egg, the other was empty. The ovum is of the form normal among the Rays, rectangular, with the four corners prolongated in its longitudinal direction, and according to MALM[c] is 55—57 mm. long and 40 mm. broad, but including the filaments at the corners 110—115 mm. long. FRIES once found a female Thornback with a half expelled egg in the cloaca. On examination the protruding end of the egg proved to be open, the larva having already left the shell. He dissected the specimen, and saw that the left uterus was empty, but that in the right there lay a recently descended ovum, the shell of which was still very soft. In this case it was consequently evident that the embryo had freed itself from the egg immediately on the expulsion of the latter. MALM, on the other hand, never found a viable fœtus, scarcely a distinct embryo, in newly deposited ova, whence he inferred that the development of the embryo does not commence until the egg is laid[d]. The process of development may thus vary in its acceleration; but by far the greater number of the eggs found after liberation are empty. During their early life, according to KRÖYER, the fry keep to the shallows of shelving coasts.

The Thornback is taken on long-lines and in Flounder-nets, less frequently in the seine. As an article of food it enjoys a good reputation in Great Britain and Ireland, especially in the latter country[e]; but in the island-belt of Bohuslän, according to EKSTRÖM, it is regarded as one of the poorest fishes. It is hardly ever eaten fresh there, at all events by the islanders, who instead dry the flesh in the open air on flakes (*gallar*) or platforms, constructed in elevated situations. After drying it is sold to the peasants of the agricultural districts, who use it as a substitute for *lutfisk*[f] at their Christmas festivities, and consider it good eating.

Besides *knaggrocka* (Spiny Ray) this species bears in the island-belt of Bohuslän the names of *piggrocka*, as adult, and *rockhök* and *peruk*, while young. On the coast of Scania it shares with the following species the name of *torr-borr*, according to LILLJEBORG a corruption of the Danish *Tærbe*. (FRIES, EKSTRÖM, SMITT.)

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[a] According to MALM the full-grown Thornback is only seldom found in less than 14 fathoms of water.

[b] See OLSSON, *Fiskarnes föda*, Lunds Univ. Årsskr., tom. VIII, 1871.

[c] Öfvers. Vet. Akad. Förh. 1876, No. 3, pp. 94, 95.

[d] *Gbgs. Boh. Fauna*, p. 607.

[e] See DAY, l. c., p. 345.

[f] Dried Cod etc. soaked in lye before cooking. This is still a staple course in Sweden at Christmas and on other feast-days. TR.

THE STARRY RAY (SW. KLOROCKAN).

RAJA RADIATA.

Plate XLVII, fig. 3.

Length of the snout (from the anterior margin of the eyes) about 13 or 14 % (in one year old specimens about 12 %) of the length of the body or about 19—21 % of the breadth of the disk. Distance between each nostril and the tip of the snout about 17 or 18 %[a] of the said breadth. Dorsal fins set close together, and the median line between them usually without aculeus. Aculei grooved in a stellate form at the base, their number in the median line of the back and tail at most about 16.

Syn. *Raja clavata*, OLAFS., *Reise Isl.*, pp. 359 et 987, tabb. XLIX et L; HOLLB. (p. p.), Gbgs Wett., Witt. Samh. N. Handl., pt. III (1819), p. 29 cum tabb.; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 58; NILSS., *Prodr. Ichthyol. Scand.*, p. 119.

Raia fullonica, FABR., *Fua Groenl.*, p. 125; FABER, Tidskr. Naturv. Kbhvn, vol. V (1828), p. 246; ID. (p. p.), *Fisch. Isl.*, p. 38.

Raja radiata, DONOV., *Brit. Fish.*, tab. CXIV; YARR., *Brit. Fish.*, ed. I, vol. II, p. 439; FR., Vet. Akad. Handl. 1838, p. 146; MÜLL., HLE, *Plagiost.*, p. 137; SUNDEV., V. WR., *Skand. Fisk.*, ed. I, p. 178, tab. 43; KR., *Danm. Fisk.*, vol. III, p. 939; NILSS., *Skand. Fna, Fisk.*, p. 736; MGRN, *Finl. Fiskfna*, p. 72; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 460; GARM., Proc. Bost. Soc. Nat. Hist., vol. XVII (1874), p. 177; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 214; 1879, No. 1, p. 105; Norsk. Nordh. Exped., Zool., Fisk., p. 14; N. Mag. Naturv. Chrnia, vol. 29 (1884), p. 118; CEDERSTR., Öfvers. Vet. Akad. Förh. 1876, No. 4, p. 67; MALM (*Amblyraja*), *Gbgs, Boh. Fna*, p. 607; WINTH. (*Raja*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII (1879), p. 60; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 394; MELA, *Vert. Fenn.*, p. 368, tab. X; MÖB., HCKE, *Fisch. Osts.*, p. 153; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 347, tab. CLXXIII; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 547.

The Starry Ray is the smallest Scandinavian species of the genus. At a length of $4^1/_2$ dm. it has attained maturity, and 6 dm. would seem to be its maximum length. v. WRIGHT's figure represents a fully developed female in which the length of the disk was 253 mm., that of the tail 192 mm., the greatest breadth 309 mm., and the distance between the mouth and the tip of the snout 67 mm. In this species too the males are commonly smaller than the females.

The disk is almost square, but has strongly rounded angles, especially the posterior, which is formed by the very long, broad, and uniformly rounded posterior lobes of the ventral fins. The anterior side-margins of the disk show a slight, *S*-shaped curvature, with broader and more rounded snout than that of the preceding species, and from the tip of the latter projects a very small, blunt muzzle. The posterior side-margins may almost be described as rounded. The greatest breadth of the disk is on an average rather more than $^3/_5$ (58—64 %), and its length somewhat more than $^1/_2$ (50—55 %), of the length of the body, the latter thus measuring 86—88 % of the former. The average distance from the tip of the snout to the cloaca is rather more than $^7/_{10}$ (70—75 %) of the greatest breadth of the body, and the length to the hind margin of the ventral fins is almost equal to the said breadth.

The length of the head is here too about $^1/_5$ (18—21 %) of that of the body, and that of the snout varies, as in the preceding species, between about 12 and 14 % of the latter, but here between about $19^1/_2$ and 21 % (exceptionally 23 %) of the greatest breadth of the disk. The interorbital breadth of the forehead and the dimensions of the eyes and spiracles are about the same as in the preceding species. In the position of the nostrils too there is little difference from the Thornback, the distance between them being about $^8/_{10}$—$^9/_{10}$ of that between each of them and the tip of the snout or 21—17 % of that between the cloaca and the last-mentioned point. The breadth of the mouth is here too in the young somewhat less than or equal to the internasal width, in the old somewhat greater. The dentition is very nearly alike in both sexes. The teeth (fig. 316) are small and pointed, set in about 36 rows along both jaws, the largest in the middle, both the size and number showing diminution towards the corners of the mouth. Each tooth consists of a rounded basal disk,

[a] Sometimes, according to KRØYER, $15^1/_2$ %.

somewhat concave in the middle, from the hind margin of which a fine, subulate cusp rises obliquely upwards and backwards.

Only the upper surface of the body is armed with spines, the under being quite smooth and soft. The spinulæ are of the same form as the aculei scattered over the whole surface, having a conically expanded, stellate base and an extremely fine, pungent tip. The only difference between them is in the size, though no such definite line as in the Thornback can here be drawn between the spinulæ and aculei, large and small of all sizes being indiscriminately interspersed with one another, and their distribution being more scattered and irregular, leaving more or less extensive patches of smooth skin between them. The ordinary aculei occupy in young specimens the same positions as in young Thornbacks, and stand in nearly the same relation to one another; but their distribution is characteristic in three respects: there is no aculeus between the two dorsal fins[a], which are set so close together that the membrane of the first often overlaps the anterior margin of the second; the aculei along the spinal column are only 12—16 in number; and the scapular cartilage is always furnished with two aculei, one behind the other, and sometimes with a third, between this pair and the median series, all with deeply grooved, stellate base. In old specimens there further appears on each side of the median series a lateral row, commencing high up on the dorsal surface not far behind the scapular cartilage, and extending back to the first dorsal fin. On the tail these lateral rows lie about half-way between the median series and the side-margin of the body, and here the aculei never attain the same size as those of the median series. The lateral margins of the tail are never spinigerous. The extraordinary aculei appear, as we have mentioned, only on the dorsal side. They gradually increase in size, but never attain the same dimensions as the ordinary aculei on the spinal column. They are scattered with some degree of symmetry, and are never wanting in adult individuals.

Characteristic as the radiate base of the aculei generally appears in this species, it should be remarked, however, that during earliest youth, in individuals 9—12 cm. long, the base is quite smooth, and the anterior aculei rise to a height of 5 mm. in a subulate form. Even at the former length of body all the ordinary aculei are already present, and their length as just stated is very considerable in proportion to the size of the body, as compared with their dimensions in older specimens, this being a sufficient character by which small young individuals of the two species may immediately be distinguished.

The coloration is above of a plain liver-brown, faintly marbled with yellowish white, and thinly strewn with irregular, very indistinct, blackish spots of small size; but the large, round, whitish spots that appear in the Thornback are entirely absent. The spinulæ and aculei are of a paler, yellowish white colour. The whole under surface is white, somewhat pinkish at the margins of the fins, the canals and pores of the lateral line being colourless. KRØYER remarks, however, that black spots, varying in number and size, frequently occur on the ventral side, especially on the under surface of the tail. Transverse bands may also be observed, but are less numerous than in the preceding species.

Fig. 316. Jaw-teeth and aculei of a Starry Ray (*Raja radiata*), natural size. *A*: teeth of upper and lower jaws; *a*, tooth, magnified, lateral and superior aspects; *B*: dorsal aculeus, lateral and superior aspects, natural size; *a*, aculeus from the tail of a young specimen, lateral and superior aspects, magnified.

The external difference of sex is less marked in young individuals of this species than in young Thornbacks. In adult Starry Rays it is distinctly shown by the long pterygopodia of the male and by the posterior cards at the outer angle of the pectoral fins. The anterior cards, on the other hand, at the side-margins of the head, may be regarded as wanting, for the female, which generally has more numerous spines, is, if anything, better armed at these spots than the male.

The Starry Ray belongs to northern latitudes, and occurs far up in the Arctic Ocean. From Greenland it was described by FABRICIUS. The Norwegian North Atlantic Expedition of 1876—78 found it off Bear Island and the north-west corner of Spitzbergen. In the White Sea it was known even to PALLAS. In the Bay of Biscay, according to MOREAU, lies the southern limit

[a] In adult Starry Rays from the Arctic regions, however, COLLETT frequently found one aculeus between the dorsal fins. In our specimens from the White Sea there is no aculeus between these fins.

of its geographical range, but its occurrence is rare even off the north coast of France. It penetrates into the Sound and, through the Belts, into the westernmost part of the Baltic in the same manner as the

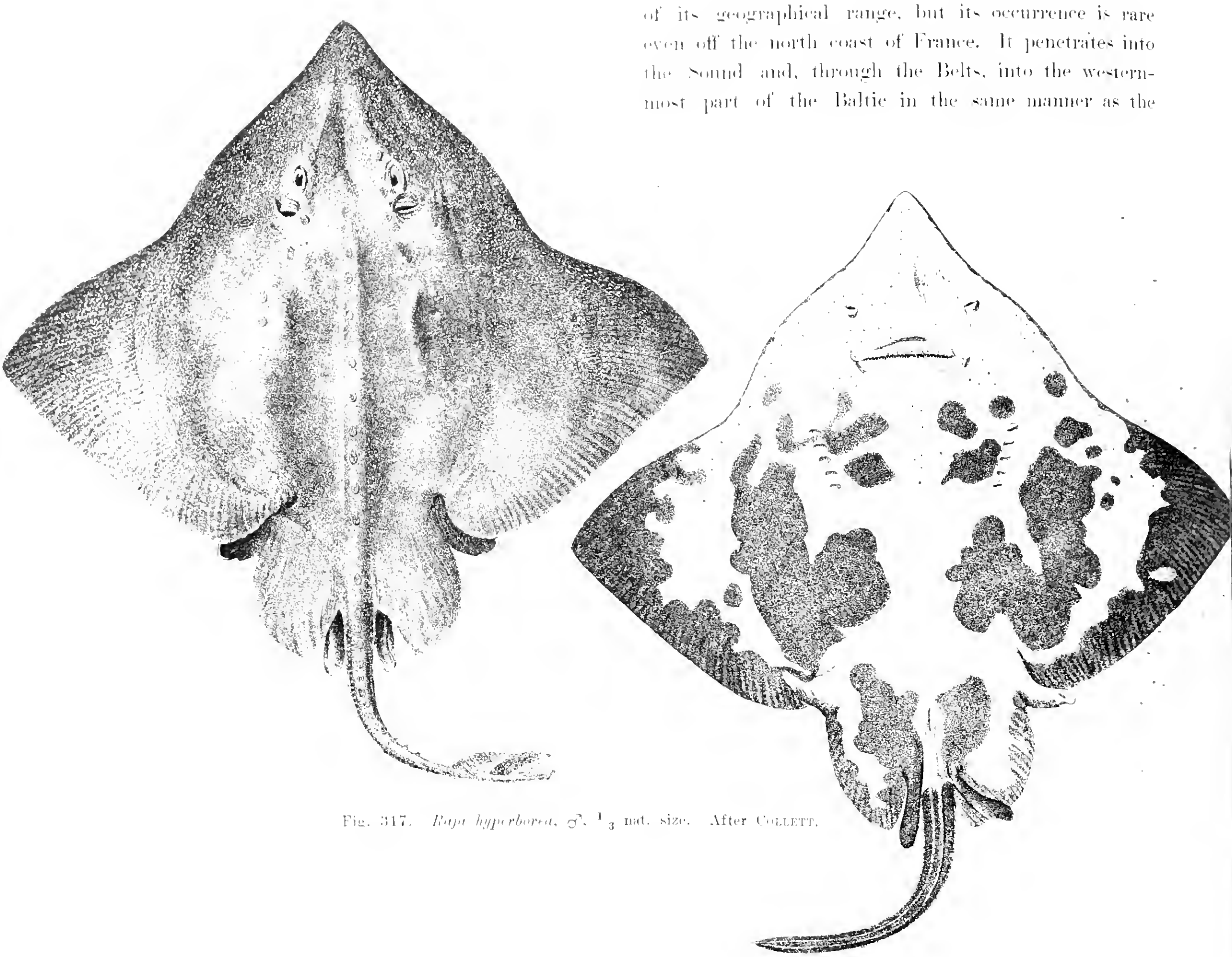

Fig. 317. *Raja hyperborea*, ♂, $^1/_3$ nat. size. After Collett.

Thornback, but is somewhat commoner there, though less numerous on the coast of Bohuslän than the latter. Equally extensive is its bathymetric range. In Scandinavian waters it generally lives at a less depth than the Thornback, but appears also to descend to far lower levels. Storm obtained a specimen from Trondhjem Fjord that had been taken in 250 fathoms of water, and the above-mentioned Norwegian Expedition secured their two young specimens from Spitzbergen at a depth of 459 fathoms.

In its manner of life the Starry Ray seems else to resemble the preceding species; but it is smaller, and is therefore restricted to smaller prey, preferably small fishes, comparatively minute crustaceans (Amphipods), and worms. "Early in spring (in the month of March)", says Krøyer, "it ascends towards the shallows; it appears to lead a secluded life during a great part of the summer; and at the approach of winter it returns to the depths on the completion of its spawning operations." Its egg-shells, he says, are about 61 mm. long, exclusive of the prolongations at the four corners, and 39 mm. broad. The fry seem to remain not far from land during winter, for the small young specimens mentioned above, whose peculiarities were remarked by Fries, were caught at this time of year in Herring-seines.

In Scandinavia the Starry Ray is of less importance than the Thornback, partly owing to its smaller size, partly because it is less common. It is frequently taken, however, on Haddock-lines and in Flounder-nets, occasionally too in seines drawn for Herrings. (Friis, Smitt.)

Fig. 318. *Raja hyperborea*, ♂, $^2/_7$ nat. size. After Günther.

THE DEEP-SEA RAY.

RAJA HYPERBOREA.

Figs. 317 and 318.

Length of the snout (according to Günther's *figures) about 13—14 % (according to* Collett *17 %) of that of the body, or 17—18 % (according to* Collett *22 %) of the breadth of the disk. Distance between each nostril and the tip of the snout about 14—16 % of the said breadth. Dorsal fins set close together, with (in the young) or without (in the old) interjacent aculeus. Aculei grooved, their number in the median line of the back and tail at least about 24*[a].

Syn. *Raja hyperborea*, Coll., Forh. Vid. Selsk. Chrnia 1878, No. 14, p. 7; Norsk. Nordh. Exped., Zool., Fisk., p. 9, tab. I, figg. 1 et 2; Gthr., *Deep Sea Fish.*, Challeng. Exped., Zool., vol. XXII, p. 8, tab. IV; Lillj., *Sv., Norg. Fisk.*, vol. III, p. 604.

As may be inferred from the diagnosis, as well as from the figures given above, it is as yet uncertain whether this Ray should be regarded as a distinct species or merely as a variety (perhaps two different va-

[a] One of Günther's young specimens, however, had only 16.

rieties) of the common Starry Ray, to which it is also similar in size. Only six specimens are known, five of them — including a male 62 cm. long — taken by the Knight Errant Expedition at a depth of 400—600 fathoms between Scotland and the Faroe Islands and now in the British Museum, the sixth a male 52 cm. long taken by the Norwegian North Atlantic Expedition in 459 fathoms of water, off the north-west corner of Spitzbergen, and now at Christiania.

From the common Starry Ray it differs principally by the greater number of aculei in the median line of the back and tail — the ventral side is smooth and quite free from aculei — and by the maculation of the ventral side. This surface of the body is marked on its white ground with large, almost symmetrical spots and patches of the same dark grayish brown colour as appears on the dorsal side. The species is stated to be further distinguished by more scattered and more pointed jaw-teeth. The form of the body differs so widely in COLLETT's and GÜNTHER's figures that in this respect the Deep-sea Ray would seem to be a highly variable intermediate form between the Starry Ray and the sharp-nosed species of the genus. The *species* — which is based principally on a chromatic character — evidently requires revision, a task which, having no specimen within our reach, we cannot undertake in the present work.

THE SANDY RAY (SW. SANDROCKAN OR SPÄTTROCKAN).

RAJA FALSAVELA.

Fig. 319.

Length of the snout about 10—11½ % of that of the body or 19—21 % of the breadth of the disk. Distance between each nostril and the tip of the snout about 16—17 % of the said breadth. Dorsal fins set close together. No row of aculei in the median line of the tail.

Fig. 319. Young female of the Sandy Ray (*Raja falsavela*) from the Skager Rack. ⅓ nat. size.

Syn. *Raja rubus*, LACÉP. (p. p.; nec BL., GMEL.), *Hist. Nat. Poiss.*, tom. I, p. 79, tab. 5 (fig. vera, descr. p. p.).

Sandy Ray, COUCH, Mag. Nat. Hist. (CHARLESWORTH), vol. II (1838), p. 71 (sine nom. system.).

Raja radula, YARR., *Brit. Fish.*, ed. 1, vol. II, Suppl., p. 69 (nec DE LA ROCHE).

Raja falsavela, BNP., *Iconogr. Fna Ital.*, *Pesci*, tab. 148, fig. 1; CANESTR., *Fna Ital.*, *Pesci*, p. 56; GIGL., Esp. Intern. Pesca Berl. 1880, Sez. Ital., p. 114; DÖDERL., *Man. Ittiol. Medit.*, fasc. III, p. 202.

Raja naevus, MÜLL., HLE, *Plagiost.*, p. 138 (+ *R. radula*, p. p., p. 133).

Raja circularis, COUCH in YARR., *Brit. Fish.*, ed. 2, vol. II, p. 574; MALM, Öfvers. Vet. Akad. Förh. 1857, p. 187; COUCH, *Fish. Brit. Isl.*, vol. I, p. 115 (+ *R. miraletus*, p. 112); GTHR. *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 462;

Coll., Forh. Vid. Selsk. Chrnia 1871, Tillegsh., p. 214; 1879, No. 1, p. 105; N. Mag. Naturv. Chrnia, vol. 29 (1884), p. 119; Malm, *Gbgs, Boh. Fna*, p. 608; Mor., *Hist. Nat. Poiss. Fr.*, tom. I, p. 397; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 348, tab. CLXXIV; Lillj., *Sv., Norg. Fisk.*, vol. III, p. 564; Carus, *Prodr. Fna Medit.*, vol. II, p. 521.

The Sandy Ray attains the greatest size among our blunt-nosed species, the females growing to a length of at least 12 dm. It also undergoes the greatest alterations in its proportions, the young having comparatively a much longer tail than the old.

The form of the body is essentially the same as in the case of the Starry Ray; but the disk is still more rounded, and the root of the tail broader (flatter). The breadth of the disk is in young specimens (less than 1 dm. long) about 48—53 %, in old as much as 63 or 64 %, and its length in the former about 44—51 %, in the latter 52—54 %, of the length of the body, the length of the disk thus varying between about 85 and 95 %[a] of its breadth. The distance from the tip of the snout to the cloaca is about 3/4 of the greatest breadth of the body, and that to the hind extremity of the ventral fins about equal to the same.

The length of the head, which varies, according to Döderlein's measurements, between 25 and 38 % of the breadth of the disk, is during youth, in consequence of the great length of the tail, only about 15 % of that of the body; subsequently, according to Döderlein, this percentage increases to 20, while the relative length of the tail is undergoing reduction, but again diminishes in the old to 16 % of the length of the body. The length of the snout is less in proportion to that of the body than in any among the preceding species of the genus, but in proportion to the breadth of the disk similar to the same measurement in the Starry Ray[b]. The least interorbital width of the forehead in this species too is somewhat more than 1/3 (about 36 %) of the length of the snout, and the longitudinal diameter of the eyes varies between about 3/4 and 2/3 of this breadth. The width of the spiracles, which are directed rather straight outwards, is in young specimens less, in old, according to Döderlein, 1/4 greater, than the longitudinal diameter of the eyes. The mouth and its dentition are subject to considerable alterations of growth. In the young the cleft of the mouth is much smaller than in Starry Rays of the same size, but the teeth are similar to those of the latter; in old specimens the mouth is broad, and the teeth are sharp and unguiform, both in females and males, while their number too shows considerable increase with age. In a young specimen about 15 cm. long we find only 34 longitudinal rows of teeth in the upper jaw, where Malm in older specimens counted 78. The internasal width is in our young specimens 71—72 % of the distance between either of the nostrils and the tip of the snout, but only 15—16 % of that between the mouth of the cloaca and the latter point.

Young specimens of the Sandy Ray too have only the dorsal side armed with spines, the ventral being perfectly smooth. In older specimens both the ventral side and the dorsal are more or less densely coated with spinulæ throughout the greater part of the surface; but certain patches, as, on the dorsal side, the hind margin of the pectoral fins, the anterior lobe and the base of the ventral fins together with an oblong patch further in, and the greater portion of the median line of the back and tail, and, on the ventral side, the outer part of the pectoral fins, the whole of the ventral fins, and the region between the latter pair, are smooth. Along the anterior margin of the pectoral fins — in old specimens both on the dorsal side and the ventral — as well as on the sides of the tail and at its extreme lateral margin — in young specimens, however, only to a line with the beginning of the first dorsal fin, where the lateral margins of the tail develop a broad dermal fold — are set rows of larger spinulæ, intermediate between spinulæ and aculei. The true aculei, which here too are grooved, though not so distinctly as in the Starry Ray, have a broad conical base and a compressed, recurved spine. They are set on the front of the snout, in a curved row on the supraorbital margin, in a triangular patch between the head and the scapular cartilage, one or two at each end of the latter cartilage, in a row on each side of the median dorsal line behind the scapular cartilage — sometimes, especially in old specimens, this row commences further back or even not before the tail — and in two to four more or less irregular series on the sides of the tail. The median line itself is smooth, with the exception that, owing to the irregularity prevalent in the distribution

[a] According to Döderlein's measurements the variations run between 83 and 97 %.

[b] In the Mediterranean *falsavela*, however, it is sometimes, according to Döderlein's measurements, only about 16—17 % of the breadth of the disk.

of the spines, an aculeus or two may sometimes be forced in even to the middle of the upper caudal surface.

By the coloration MOREAU distinguished between three varieties: *falsavela*, with plain, brownish or reddish gray (clay-coloured) dorsal side; *nævus*, with the base of each pectoral fin spotted with a large ocellus, the middle of which is black but crossed by rather broad, yellowish white streaks; *circularis*, with numerous, but smaller, symmetrically arranged, simple spots, light (cream-white) or dark, scattered on the dorsal side of the disk. The ventral side is white.

The Sandy Ray has an extensive geographical range, more southern and to the north more pelagic than that of the Starry Ray. Its true home in the Old World lies in the Mediterranean and the adjoining parts of the Atlantic, but it is frequently found even so far north as on the fishing-banks off the south-west of Norway, where MALM was the first to observe it among the take of fish at Jäderen. Even in the Skager Rack it has been met with, but only once, so far as is known. On the 12th of July, 1879, THEEL and FORSSTRAND took two specimens in a deep-sea trawl at a depth of 370 fathoms, off Arendal, on a bottom of fine, brown clay. One specimen was a male 33 cm. long and not yet arrived at maturity, the other a female 45 cm. in length. Round the coasts of Great Britain and Ireland the Sandy Ray would appear to be commoner (DAY), but in France it is stated to be rare (MOREAU). Yet, like the Starry Ray, it is apparently an inhabitant of the West Atlantic too, where MITCHILL'S[a] and STORER'S[b] *Raja ocellata* and *R. diaphanes* from the east coast of the United States can hardly be distinct in species from our Sandy Ray. As MOREAU has remarked, the Sandy Ray was certainly known to LACEPÈDE; but the name he conferred upon it was incorrect and has been so misused that it hardly deserves recognition. When the synonymy of the species has been fully elucidated, the point will be decided whether the systematic name employed in America has not most right to employment.

Where MALM first found the Sandy Ray, it had been taken on long-lines in company with all the other common Rays of Scandinavian waters, except the Starry Ray; and its manner of life is probably much the same as that of its congeners. As food, according to COUCH, it is little esteemed in England, where it is mostly used to bait lobster-pots and crab-pots. From spring till the end of autumn it may be found on the English coast in water of a moderate depth; during winter it lives farther from land.

Sectio II. **Rajæ læves, Skates.** *Snout long, tip of the snout acute-angled:* length of the snout from the tip to the transverse line through the body at the centre of the eyes more than half as long as this transverse line.

These Rays possess so-called ordinary aculei only at the eyes and along the spinal column and tail, no further ordinary aculei being scattered on the surface of the body. All have pointed teeth.

A: Ventral side of the body white, without spots. — **White Skates.**

These Skates have the two dorsal fins set close together, never with interjacent aculeus. Their under surface is entirely free from spots, they have ordinary aculei both on the back and the tail, and the lobate pupil-lid originating from the iris is absent. In size they are intermediate between the *Rajæ clavatæ* and the true *Rajæ læves*. They live at a great depth and seldom approach the coasts of Scandinavia. (FRIES.)

[a] Trans. Lit., Phil. Soc. N. Y., vol. I, p. 477.
[b] Mem. Amer. Acad. Arts, Sc., Boston, N. ser., vol. IX, p. 240, tab. XXXIX, fig. 1.

THE SHAGREEN SKATE (SW. GOKROCKAN).

RAJA FULLONICA.

Fig. 320 and Plate L, fig. 1.

Length of the snout about 12—14 % of that of the body or 20—24 % of the breadth of the disk. Distance between each nostril and the tip of the snout about 17 % of the said breadth or nearly twice (175—200 % of) the internasal width. Aculei grooved. No aculei in the median line of the back and tail.

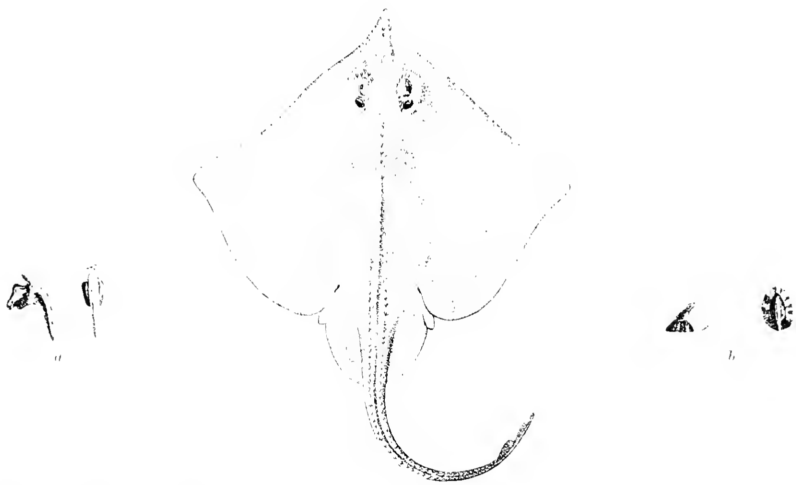

Fig. 320. Shagreen Skate (*Raja fullonica*), ♀. 1/8 nat. size. The Cattegat, July, 1835. B. FRIES. *a*, a tooth, magnified, lateral and outer aspects. *b*, a dermal aculeus.

Syn. *Raja* aspera nostras, the White Horse dicta, WILLUGHB., *Hist. Pisc.*, p. 78; RAY, *Synops. Meth. Pisc.*, p. 26. *Raja* toto dorso aculeato, duplici ordine aculeorum in cauda, simplicique ad oculos. ART., *Ichth.*, *Gen. Pisc.*, p. 72; *Syn. Pisc.*, p. 101. *Shagreen Ray*, PENN., *Brit. Zool.* (ed. 1776), vol. III, p. 77.

Raja Fullonica, LIN., *Syst. Nat.*, ed. X, tom. I, p. 231; RATHKE in ASCAN., *Icon. Rer. Nat.*, ad. tab. XLIII; FR., Vet. Akad. Handl. 1838, p. 150, tab. II, fig. 2, tab. III, figg. 5 et 9; MÜLL., HLE, *Plagiost.*, p. 145; KR., *Danm. Fisk.*, vol. III, p. 996; NILSS., *Skand. Fna, Fisk.*, p. 737; YARR., *Brit. Fish.*, ed. 2, vol. II, p. 578; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 467; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 217; 1879, No. 1, p. 106; N. Mag. Naturv. Chrnia, Bd 29 (1884), p. 119; MALM (*Leucoraja*), *Gbgs, Boh. Fna*, p. 609; WINTH. (*Raja*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 61; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 342, tab. CLXX; LILLJ., *Sv., Norg. Fisk.*, vol. III, p. 569.

Raja chagrinea, MONT., Mem. Wern. Nat. Hist. Soc., vol. II, p. 420, tab. XXI; PARN., ibid., vol. VII, p. 431, tab. XLI; COUCH, *Fish. Brit. Isl.*, vol. I, p. 117, tab. XXIX; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 401; DÖDERL., *Man. Ittiol. Medit.*, fasc. III, p. 172; CARUS, *Prodr. Fna Medit.*, vol. II, p. 521.

Raja aspera, FLMNG, *Brit. Anim.*, p. 172.

The ordinary dimensions of the Shagreen Skate, as it is brought home by the deep-sea fishermen of Bohuslän from the fishing-banks off Jutland and Norway, are a length of about 1 m. and a breadth of about 6 dm. At this size it has reached full sexual maturity. According to MOREAU its length varies between 8 and 12 dm.

The form of the disk is rhombic. The distance from the tip of the snout to the hind margin of the ventral fins is about equal to the greatest breadth of the body. The anterior side-margins of the disk are undulate, somewhat concave, so that the most prominent margin of the head falls short of the line between the tip of the snout and that of either pectoral fin.

The snout is prolongated in a securiform shape. The posterior side-margins of the disk are arcuate, with a slight inward curve near the tip of each pectoral fin. The ventral fins are conically pointed and rounded, rather long, their length, measured from the sacral prominence, being not much less than $^1/_3$ of the entire length of the tail, measured from the same point. The body as a whole is flat and not fleshy, its depth at the shoulder-girdle being only about 9 % of the greatest breadth of the disk. The tail is furnished, as in the preceding Rays except the Thornback, with two juxtaposited dorsal fins, often united at the base. The hind margin of the posterior lies half a fin-length from the tip of the tail, which bears above a low and almost semicircular caudal fin.

The length of the head to the occiput measures in specimens 1 m. long about 18 % of the length of the body or 30 % of the breadth of the disk. The length of the snout as stated above distinguishes the Shagreen Skate, as well as the following species, from the preceding forms of the genus, but the distinction is least marked in the Shagreen Skate, as appears from the relation between this length and the least interorbital width of the forehead. The latter is at least about 30—35 % of the length of the snout from the anterior margin of the eyes. The longitudinal diameter of the eyes is about half the interorbital width. The spiracles, which are almost transversely set, are of about the same size as the eyes. The mouth is broad and curved, powerfully armed with teeth. The form of the teeth is also highly characteristic, and among the other Scandinavian Rays there is none with whose dentition it can be confused. Each tooth (fig. 320, *a*) has a fairly long, unguiform crown, subulate at the tip, with somewhat compressed sides and without other indication of the ordinary basal rim than a very small intumescence on each side. The largest teeth are set in the middle of the jaws, and their size decreases towards the corners of the mouth. All these teeth are arranged in about 60 regular, longitudinal rows, which, in consequence of the length of the pointed crowns, the superimposed (imbricated) position thereof, and the fixed intervals between the rows, have a resemblance to thin ridges, fitting in between each other when the jaws are closed. The internasal width is about $^1/_5$—$^1/_3$ greater than the least interorbital width (120—133 %), somewhat more than half (55—60 %) of the distance between each nostril and the tip of the snout, and about 12 % of that between the tip of the snout and the anus.

Among all the Scandinavian Rays the present species has the most shagreened skin. The whole upper surface of the body is covered everywhere with dense, but very short spinulae, partly pointed with stellate base, partly granular and hardly distinguishable to the naked eye. On the snout, both above and below, throughout the anterior side-margins of the disk, and throughout the upper and under surfaces of the tail, these spinulae show a somewhat greater development, and with their pungent tip, recurved in a hamate form, they greatly resemble, on a small scale, the aculei proper. The ventral side too is strewn with spinulae, but more sparsely, large patches of smooth and naked skin being left on the pectoral and ventral fins, in the anal region, and at other points. The ordinary aculei have an expanded, stellate or grooved, laterally compressed, and flat base and a hamately recurved tip. Two short rows of small aculei, varying in number and size, are set on the rostral cartilage. In a semicircle around the inner margin of each orbit runs a row of larger, but unequal aculei, the middle ones, however, often absent or lost. The spinal column between the head and the scapular cartilage is followed by a series of aculei, 8—10 in number and not very large, and sometimes a row of still smaller ones skirts this series on each side; but often only vestiges of these last aculei remain in the form of small, worn protuberances occupying the said places. Two rows on the back begin just behind the scapular cartilage, the aculei being at first quite low, but increasing in size as they approach the tail, along which the rows proceed parallel to each other, on each side of the median line and nearer to this than to the side-margin of the tail. In these rows the aculei are very densely packed, sometimes, as it were, extruding one another. The largest aculei lie in front of the middle of the tail; further back their size again gradually decreases. On the spinal column itself, behind the scapular cartilage and in the caudal region, there is no row of aculei.

The dorsal side is of a plain yellowish gray, the ventral side of a translucent milky white, the muscles of the pectoral fins being visible, and the tips of the fins showing a bluish tinge. According to MONTAGU the back is of a plain grayish brown; but in one specimen he found a few black spots on this ground-colour.

The external differences of sex are confined, according to FRIES and MALM, to the ordinary cards of spines on the sides of the head and the outer parts of the pectoral fins in the male and to his pterygopodia.

The Shagreen Skate is stated to have been taken once on the coast of Sweden. Baron GYLLENSTJERNA received it, according to NILSSON, in October, 1819, from the fishing-village of Arild (Mount Kullen). But the specimen has disappeared, and with it the certainty that no confusion of the species has taken place. According to COLLETT a female $9^1/_2$ dm. long was caught in January, 1880, off the Onsö coast, at the entrance of Christiania Fjord and consequently on the confines of Sweden. Its favourite haunts in Scandinavian waters, however, are the rich fishing-banks off Southern Norway and the west of Jutland, where the water is from 50 to 120 fathoms deep. KRÖYER and COLLETT assign Trondhjem Fjord as the northern limit of its range[a], and to the south it occurs, according to GÜNTHER, off Madeira and, according to MOREAU, in the Mediterranean, where it is described, however, as rare. Like the other Rays it ascends nearer land in summer; in winter it is not taken, except where the fishermen follow it to the deep sea. It feeds on all kinds of fishes, such as Sharks and Codfishes, as well as on crustaceans and mussels[b]. The strong, pointed teeth in its jaws are suggestive of considerable voracity. As food it is little esteemed both in England (DAY) and France (BLANCHÈRE[c]).

The systematic name of the Shagreen Skate (*fullonica*, Lat. *fullo*, a fuller) has reference to the similarity between the spiny skin and the implements used in cleaning cloth and the like. It was adopted by LINNÆUS from RONDELET[d], but was not applied originally to this species. It is also probable that the Swedish name (*gökrocka* = Cuckoo Ray) was borrowed from England, though the latter name is ascribed by COUCH to the preceding species. In Norway, according to RATHKE, the Shagreen Skate is called *Næbskate* (Beaked Skate), a name which, as KRÖYER has remarked, is more appropriate to one or other of the following species. In Bohuslän FRIES also heard the name of *Godskrocka* (Jutland Ray).

(FRIES, SMITT.)

THE SHARP-NOSED SKATE (SW. HVITROCKAN OR BLAGARNSROCKAN)

RAJA LINTEA.

Fig. 321.

Length of the snout from the anterior margin of the eyes about 14—18 % of the length of the body or 24—29 % of the greatest breadth of the disk. Distance between each nostril and the tip of the snout about 21—25 % of the said breadth or more than twice (207—243 % of) the internasal width. Aculei faintly grooved. Both the upper median line of the tail and its lateral margins armed with rows of aculei. Second dorsal fin extended nearly to the tip of the tail. Caudal fin rudimentary. Ventral side white.

Syn. *Raja lævis, major* (p. p.), DUH., *Tr. Pêches*, part. II, sect. IX, p. 285.

Raja oxyrinchus (*Sharp-nosed Ray*), PENN., *Brit. Zool.* (ed. 1776), vol. III, p. 73; MONT., Mem. Wern. Nat. Hist. Soc., vol. II, p. 423; YARR., *Brit. Fish.*, ed. 1, vol. II, p. 424; ed. 2, vol. II, p. 556; COUCH (*Burton Skate*), *Fish. Brit. Isl.*, vol. I, p. 97, tab. XXI.

?*Raja alba*, LACEP., *Hist. Nat. Poiss.*, tom. V, p. 663, tab. 20, fig. 1 (♂ + *Raja marginata*, ibid.); MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 412; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 339, tab. CLXVIII; ♂ = *Raja* (*Laeviraja*) *bramante*, SASSI, vide CANESTR., Mem. Accad. Sc. Torino, ser. 2, tom. XXI (1865), p. 361, tab. I, figg. 2—5.

Raja Fullonica, NILSS., *Prodr. Ichth. Scand.*, p. 119; STORM, Norsk. Vid. Selsk. Skr., Trondhj., 1883, p. 47

Raja lintea, FR., Vet. Akad. Handl. 1838, p. 154; MÜLL., HLE, *Plagiost.*, p. 147; KR., *Danm. Fisk.*, vol. III, p. 1005; NILSS., *Skand. Fna. Fisk.*, p. 738; MALM, Öfvers. Vet. Akad. Förh. 1857, p. 193; GÜNTH., *Cat. Brit. Mus., Fish.*, vol. VIII, p. 466 (♂ + *Raja marginata*, p. 465); COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 217; 1882, No. 29, p. 4; MALM (*Leucoraja*), *Gbgs. Boh. Fna.* p. 611; LILLJ. (*Raja*), *Sv., Norg. Fisk.*, vol. III, p. 580.

Obs. That the *blagarnsrocka* of Bohuslän (the Norwegian *hvidskade*) is identical in species with the English *White Skate* (the French

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[a] STORM, who states (Norsk. Vid. Selsk. Skr. Trondhj. 1883, p. 47) that *Raja fullonica* is very commonly taken in Trondhjem Fjord, evidently referred here to the following species, for he says that "the middle row of caudal spines extends far forward on the back".

[b] Cf. OLSSON, *Om fiskarnes föda*, Lunds Univ. Årsskr., tom. VIII (1871).

[c] *La Pêche et les Poissons*, Dict. Gen., p. 666.

[d] *De Pisc.*, lib. XII, p. 356.

eau blanche), is extremely probable, though so large specimens have never been found in Scandinavia as further south, nor has the juvenile form (*Raja marginata*) referred by MOREAU to the said species been met with in Scandinavian waters. FRIES too was of this opinion, for he combined MONTAGU'S *Raja oxyrhynchus* and his own *Raja lintea*. In recent times (DUMERIL[a], GÜNTHER, and DAY) it has been proposed again to separate them; but the best descriptions (MOREAU, l. c. and DÖDERLEIN[b]) seem to favour the opinion that they are identical, if we bear in mind the significance within the genus of the alterations of growth and the external differences of sex.

Among the Sharp-nosed Skate, which were certainly not few in number, brought home by the fishermen of Bohuslän from the deep-sea fishery in the North Sea,

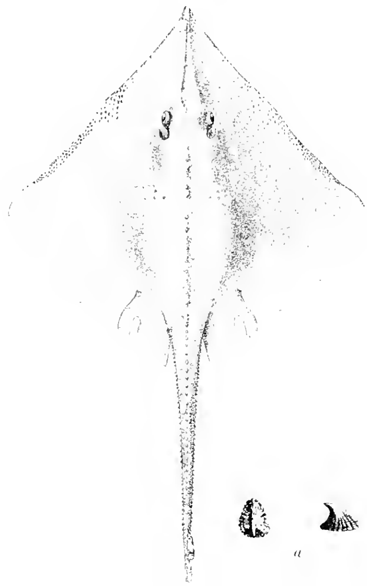


Fig. 321. Sharp-nosed Skate (*Raja lintea*), ♀, $\frac{1}{8}$ nat. size. The Cattegat, July, 1837. B. FRIES. From a stuffed specimen. *a*, an aculeus, after W. VON WRIGHT.

FRIES never came across specimens more than 9 or 10 dm. long; but none of the females he opened had fully developed ovaries, nor had the males full-sized pterygopodia[c]. "It is thus probable," wrote FRIES, "that these Skate attain a greater length before they are capable of reproduction, which is borne out by PENNANT'S statement that a specimen found by him measured 7 feet ($21\frac{1}{3}$ dm.)."

In form of body the Sharp-nosed Skate most nearly resembles the preceding species. The anterior lateral margins of the disk, however, show hardly so deep undulation or concavity[d], the most prominent side-margin of the head approaching close to the line from the tip of the snout to that of either pectoral fin. The ventral fins too are shorter, more truncate at the tip, rectilinear; their length from the sacral prominence being contained $3\frac{1}{2}$ times in the entire length of the tail. The two dorsal fins on the tail are closely juxtaposited, though sometimes without being confluent at the base, and the posterior is set so far back that the upper fin-margin projects beyond the tip of the tail, which is finless, save for a lobe formed by an incision in the hind margin of the second dorsal fin.

The length of the head in a female 9 dm. long measures nearly $\frac{1}{4}$ of that of the body or $\frac{2}{5}$ of the greatest breadth of the disk. The interorbital width (the least breadth of the cranial forehead) is $\frac{1}{4}$ of the length of the snout to the anterior margin of the eyes. The diameter of the transversely set spiracles is much less ($\frac{3}{5}$, according to KRØYER) than the longitudinal diameter of the eyes, which measures, according to KRØYER, $\frac{5}{7}$ of the interorbital width. The mouth is not so broad as in the Shagreen Skate, and the dentition too is feebler. The form of the teeth is not very characteristic. It almost exactly resembles that of the common Skate, with the exception that every tooth is comparatively smaller both in the area of the basal disk and the length of the cusp, and that the number of longitudinal rows is somewhat less, in the above-mentioned female 45[e]. The internasal width is much greater than the least interorbital width (150—175 % thereof), but at most somewhat less than half the distance between each nostril and the tip of the snout.

The Sharp-nosed Skate has the smoothest skin of all the Scandinavian species[f]. The ventral side is per-

[a] *Hist. Nat. Poiss.* (su. à BUFF.), tom. 1, p. 564, note.

[b] *Man. Ittiol. Medit.*, fasc. III, p. 165.

[c] In the male 1,125 mm. long and with pterygopodia 190 mm. in length described by MALM (*Gbgs. Boh. Fna*), these organs had not attained their full development, though nearly so. The largest female mentioned by MALM was nearly 12 dm. long. According to DÖDERLEIN the Mediterranean *Raja bramante* grows to a length of more than 2 m. According to DAY the White Skate of English waters sometimes weighs nearly 500 lbs.

[d] In this respect the descriptions and figures of the present species vary considerably. According to KRØYER the tip of the snout in a male is "strongly prolongated from the disk and of a considerable length."

[e] In a male KRØYER counted 48.

[f] Young specimens of the common Skate, however, are sometimes equally smooth.

fectly soft and smooth[a], without a sign of spinulæ, in ordinary cases even under the snout and tail, except at the extreme tip. The dorsal side is for the most part naked, if we except the edge of the anterior lateral margins of the disk, which is fringed with coarse, scattered spinulæ with stellate base, the rostral cartilage, where similar, but still more scattered spinulæ appear, the dorsal fins, and the tail. The latter is somewhat roughened with fine, very dense spines. These spines present the peculiarity of being distributed in two longitudinal bands, broad in front, narrowing behind, which extend between the aculei of the median and lateral rows, back to the sides of the base of the second dorsal fin, the outer margin of each band touching the lateral row of aculei, but the inner margin falling a little short of the median row, so that the spinal column itself, on which the aculei are situated, is covered between them with quite smooth skin. The ordinary aculei are the following: a) a few before and behind the eyes, b) a row along the back and the middle of the tail, though it should be observed that the aculei in the anterior part of this row are often worn, short and tuberous, here and there, or wanting at certain spots, c) 2 to 4 on each side of the spinal column above the scapular cartilage, and d) a row of smaller aculei on each side of the tail, occupying the extreme lateral margin, just above the membrane with which this is edged. The aculei have a singular and rather easily recognisable form. The base is a triangular cone, with compressed sides, sharp in front, truncate behind, and with a hollow and grooved or somewhat radiate surface, and from this rather elevated base there springs abruptly a very short cusp, usually directed obliquely backwards, but on one or two of the aculei at the side-margins of the tail antrorse. No aculeus is ever present between the two dorsal fins.

The coloration is above of a plain bluish gray, underneath of a pure milky white, with a grayish band along the middle of the tail and a spot of the same tint on each side of the anus. Sometimes a darker tinge appears on the margins of the disk, both above and below, being apparently a remnant of the juvenile dress which has given rise to the name of *marginata*.

The external differences of sex are the ordinary ones.

The haunts of the Sharp-nosed Skate are the same as those of the Shagreen Skate, but it is more frequently caught by the fisherman. It lives at the same considerable depth. Middle-aged individuals preponderate among the Sharp-nosed Skate taken on the Norwegian banks. In Bohuslän this species bears the names of *Spanjor* (Spaniard) and *Blagarnsrocka* (Canvas Skate), and is well known and distinguished from the others by every experienced fisherman. As we have already mentioned, our Sharp-nosed Skate is probably the same species as the French *Raie lisse et blanche*, which has been an article of trade between French and English fishermen for centuries, the former visiting the English coast to purchase this fish for transportation to their own country, where on account of its fleshiness it is more in demand than other Rays. (FRIES, SMITT.)

B: Ventral side of the body gray or grayish black, punctated with black dots and lines. — **True Skates.**

The two dorsal fins are separated, sometimes with, sometimes without interjacent aculei. The ventral side is of a dirty grayish or blackish colour, with numerous black pores, opening into curvilinear muciferous canals (Lorenzinian ampullæ and divisions of the lateral line). No ordinary aculei on the back, but only on the tail and sometimes at the eyes. These species attain a considerable size, live in very deep water, and are highly valued for their flesh. (FRIES.)

The relations between the three following species are very highly suggestive of the same close kinship as we have considered at length above, especially in the families of the Flounders and Salmons. These Skates compose a form-series in which the specific distinctions are more or less obvious expressions of the differences of age and sex. The most prominent specific characters depend on the prolongation and contraction of the anterior part of the body, especially the rostral region. In this respect one of the Scandinavian forms, the com-

[a] Sometimes, however, spines occur on the under surface of the snout; and in *Raja alba (bramante)* the anterior margins of the pectoral fins are also sometimes spinigerous underneath.

mon Skate, stands side by side with the most advanced stages of development in the species immediately preceding it. The course followed by its alterations of growth is such that, during the growth of the body from a length of 3 dm. to one of 15 dm., the length of the snout increases from about 16 to 18 % of that of the body, in exceptional cases exceeding the latter percentage, or from 24 to 26 % (sometimes 27 %) of the greatest breadth of the disk. In another of our species, the so-called *plogjernsrocka* (*Raja comer*) of FRIES, where the alterations of development, however, are scarcely known, these percentages for the length of the snout vary between about 20 and 24 in relation to the length of the body and between about 31 and 35 in relation to the breadth thereof. The first-mentioned alteration during growth of the proportion to the length of the body indeed depends in great part on another, which we have also observed above, namely the relative abbreviation of the tail with increasing age; but herewith is associated in the common Skate a difference of sex, which is expressed by the comparatively greater length of the abdominal region in the females than in the males. This is distinctly shown by the relations between the distances from the tip of the snout on the one hand of the mouth or nostrils, on the other of the cloacal aperture. The distances of the mouth and eyes from the tip of the snout are about equal in these Rays, and decrease in male specimens of the common Skate from about 53 to 38 % of the distance between the mouth and the cloacal aperture, whereas in the females these percentages diminish from about 51 to 27. The Long-nosed Skate represents in this respect the male characters of the common Skate; but in the former species, owing to the different prolongation of the snout, which is longest in the females, the sexual distinction has been reversed, the distance between the mouth and the tip of the snout being in adult males about 58—60 % of that between the former and the cloacal aperture, in the females about 75—80 % of the same. The males of the two species may consequently approximate so closely to each other in form of body that the limit between the species is difficult to fix. Furthermore PARNELL in Scotland, BONAPARTE in the Mediterranean, and COLLETT in Trondhjem Fjord have each distinguished an intermediate form to fill the gap between the lines of demarcation. This intermediate form has retained one of the juvenile characters of the common Skate, namely the aculei arming the supraorbital margin, which disappear in old specimens of the common Skate, and are wanting in the Long-nosed Skate. In Trondhjem Fjord this intermediate form has acquired a still darker (brownish black) ventral side; but even this peculiarity seems primordially to have been a sexual character, the males, according to STORM, being darker than the females. The more northern common Skate, with its more strongly marked female characters, thus represents an original form from which the two remaining species are descended.

THE COMMON SKATE (SW. SLÄTROCKAN).

RAJA BATIS.

Plate XLVIII.

Length of the snout from the anterior margin of the eyes about 14—18 % of the length of the body or 21—26 % of the greatest breadth of the disk. Distance between each nostril and the tip of the snout about 21 or 22 % of the said breadth and less than twice (180—140 % of) the internasal width. Least interorbital width more than 1/4 (about 30—42 %) of the length of the snout. Aculei without grooves (or with extremely faint ones). A row of aculei either in the upper median line of the tail or on each of its lateral margins, seldom simultaneously present on the former and the latter. The second dorsal fin ends at a distance from the tip of the tail measuring more than half its own base, and the tip of the tail is furnished above with a distinct caudal fin. Ventral side grayish or darker, dotted and streaked with black.

Syn. *Raja undulata sive cinerea*, RONDEL., *De Pisc.*, p. 346. *Raja lævis* (*Tepel*), SCHONEV., *Ichth. Slesv. Hols.*, p. 58. *Raja lævis undulata seu cinerea* RONDELETII, WILLUGHB., *Hist. Pisc.*, p. 69, tab. C, 5. *Raja* varia, dorso medio glabro, unico aculeorum ordine in cauda, ART., *Ichth.*, *Gen. Pisc.*, p. 73; *Syn. Pisc.*, p. 102. *Skata*, Raja (major et vulgaris) dorso non aculeato, OLAFS., *Reise Isl.*, pp. 359 et 987. *Skate* 1. *Rokke*, Raja clavata Auctt., STRÖM, *Søndm. Beskr.*, p. 309; cfr Trondhj. Selsk. Skr., vol. I, p. 148.

Raja batis, LIN., *Syst. Nat.*, ed. X, tom. I, p. 231; PENN. (*Skate*), *Brit. Zool.* (ed. 1776), vol. III, p. 72, tab. IX; BL., *Fisch. Deutschl.*, part. III, p. 54, tab. LXXIX; HOLLB.

(*Dasybatus* ex Blainv.), *Bohusl. Fisk.*, Gbgs Wett., Witt. Samh. N. Handl., part. III (1819), p. 21 cum 2 tabb.; Fab. (*Raja*), *Fisch. Isl.*, p. 33; Nilss., *Prodr. Ichthyol. Scand.*, p. 120; Yarr., *Brit. Fish.*, ed. 1, vol. II, p. 421; Fr., Vet. Akad. Handl. 1838, p. 158; Müll., Hle, *Plagiost.*, p. 146; Kr., *Danm. Fisk.*, vol. III, p. 978; Nilss., *Skand. Fna, Fisk.*, p. 739; Malm, Öfvers. Vet. Akad. Förh. 1857, p. 193; Gthr, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 463; Ltkn, Vid. Meddel. Naturh. For. Kbhvn 1873, p. 36; Coll., Forh. Vid. Selsk. Chnia 1874, Tillaegsh., p. 216; 1879, No. 1, p. 106; N. Mag. Naturv. Chnia, Bd 29, p. 119; Malm (*Laeviraja* ex Salv. et Bonap.), *Gbgs. Boh. Fna*, p. 615; Winth. (*Raja*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 60; Mor., *Hist. Nat. Poiss. Fr.*, tom. 1, p. 409; Mob., Heke, *Fisch. Osts.*, p. 156; Day, *Fish. Gt. Brit. Irel.*, vol. II, p. 336, tab. CLXVI; Lillj., *Sv., Norg. Fna, Fisk.*, vol. III, p. 584.

Raia gaimardi, Robert in Gaim., *Voy. Isl., Groenl., Zool., Poiss.*, tabb. 2 et 3; Dum., *Hist. Nat. Poiss.* (n. su. à Buff.), tom. I, p. 565.

Batis vulgaris, Couch, *Fish. Brit. Isl.*, vol. 1, p. 87, tab. XVIII.

Most of the common Skate taken in Bohuslän measure between 12 and 15 dm. in length, but at this size are hardly mature. On the south and west coasts of Norway Kroyer met with specimens 22—25 dm. long and rising 200 Norwegian pounds (100 kilo.) in weight.

The form of the body is rhombic, with the anterior side-margins somewhat undulate and more or less incurved, the posterior, on the other hand, very faintly rounded (convex), with a slight incurvature just behind the tip of each pectoral fin. The distance from the tip of the snout to the hindmost part of the posterior margin of the pectoral fins is about 74—84 % (as a rule about 77 %), and to the posterior margin of the ventral fins about 80—91 %, of the greatest breadth of the disk. The greatest thickness (the depth at the shoulder-girdle) is about 7 or 8 % of the greatest breadth.

The form and length of the head vary considerably, in proportion to the greater or less prolongation of the snout as mentioned above. The longitudinal diameter of the eyes is about $^1/_7$—$^1/_6$ of the length of the snout. The maximum diameter of the spiracles is about $^3/_5$—$^4/_7$ of that of the eyes. The internasal width measures about 57 (in young specimens, according to Kroyer, sometimes 55)—68 % of the distance between each nostril and the tip of the snout, which distance is about 88 (in young specimens, according to Kroyer, sometimes 91)—83 % of the length of the snout. The breadth of the mouth is about equal in young specimens to the internasal width, in older ones perceptibly greater, at least 112—114 % thereof. The jaw-teeth are comparatively small (fig. 322). On a neck-like, but low base is extended an almost nail-headed disk, the posterior part of which rises in a somewhat conical, retral tip, short in the females (fig. 323), longer in the males. Teeth of this form are distributed in fairly regular rows, denser in young individuals than in old, both along and across the jaws. The largest teeth, with the longest cusps, are set in the middle of the mouth,

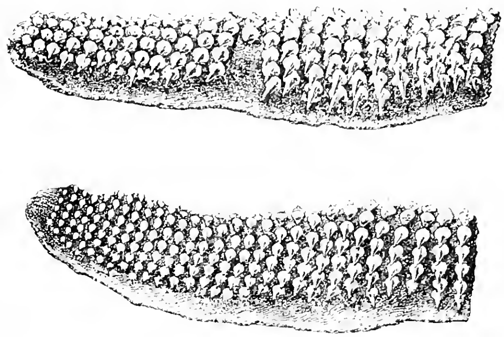


Fig. 322. Half of a jaw in a male (*A*) and a female (*B*) of the common Skate (*Raja batis*). Natural size. After Lütken.

the smallest, with hardly a sign of cusp, innermost at its corners. As a rule the longitudinal rows number some 40—50, the transverse 6—10. The various ages exhibit less difference in the number of the rows than in the form of the teeth, for in very small Skate there is scarcely an indication of the projecting cusps which are so prominent in older specimens, especially in the

Fig. 323. A tooth of *Raja batis*, ♀, magnified.

males; and the whole tooth thus acquires in the young a plane, lozenge-shaped appearance.

The spiny armature of the body consists in very young specimens merely of a restricted number of ordinary aculei, namely two before and one behind each eye and a row along the upper median line of the tail with one or two spines between the two dorsal fins. Of spinulae there is not a sign in these young specimens, either on the dorsal side or the ventral, the body being smooth on both sides. In middle-aged individuals both the upper and under surfaces of the body are roughened with spinulæ, which are, however, somewhat unevenly distributed, large and small patches of perfectly smooth skin occurring here and there. The spinulæ are also rather scattered, except on the under surface of the snout and around the inner orbital margins, where they are card-like. They do not extend to the hind margin of the pectoral fins, which is persistently smooth. In form these spinulæ are very pointed and fine, with a somewhat expanded, stellate base, the diameter of which is less, however, than the entire length of the spine, and which is scarcely distinguishable to the naked eye. Here and there they are worn and more granular, and their size is highly variable. In middle-aged specimens the orbital aculei are as a rule already worn down or missing. This is partly the case too with the median caudal row, of which there usually remain only one or two aculei and the marks of the rest. Each lateral margin of the tail, on the other hand, has developed by this age a row of aculei, which is also very variable, seldom symmetrical, and displays the peculiarity that most of its aculei are oftenest directed forwards. Full-grown females are rather densely covered with spinulæ throughout the dorsal side, except on the outermost parts of the hind margin of the pectoral fins, and on the posterior fold and anterior lobe of the ventral fins. The ventral surface of the snout is almost as densely armed with spinulæ as the dorsal side. At the middle of the body and on the tail, as well as on the inner parts of the hind lobe of the ventral fins, the ventral side is also spinigerous, but the spinulæ are more scattered and grow sparser and sparser outwards, until they disappear on the outer parts of the pectoral and ventral fins, the anterior lobe of the ventral fins being also naked. In adult males the spiny armature is as usual less developed.

The coloration of the dorsal side is yellowish gray or brown, with irregularly distributed and highly variable spots of lighter and darker tint. Young and middle-aged specimens frequently have one or two pairs of ocelli, varying in size, on the posterior and inner parts of the pectoral fins. One of our figures (Pl. XLVIII, fig. 2) represents a specimen from Gullmar Fjord with the dorsal side strewn everywhere with light spots (var. *guttata*). The ventral side is of a dirty grayish white or darker, chocolate-coloured, shading towards the hind margins of the disk into a grayish violet. It is also dotted and streaked, as we have mentioned above, with black, the apertures and opening ducts of the system of the lateral line being thus indicated. This black punctuation extends sometimes even to the anterior part of the back. Sometimes, however, the ventral side is so white — Baron CEDERSTRÖM has presented to the Royal Museum a specimen of this description, a male 1 m. long and not yet mature, from Strömstad — and the black punctuation so sparse and faint that the difference from the Sharp-nosed Skate in this respect is inconsiderable.

The common Skate is strictly a North Atlantic fish, its range extending from Norwegian Finmark and Iceland south to the Bay of Biscay. According to MOREAU and CARUS[a] it also occurs in the Mediterranean, being fairly common, especially off Cette and Riou; but neither GIGLIOLI[b] nor DODERLEIN[c] includes it among the list of Mediterranean fishes. The difficulty of fixing a specific limit between this species and the so-called Black-bellied Skate, which at least has a representative form in the Mediterranean, renders it impracticable to pass an opinion on this head without access to specimens. Our knowledge of the North American Rays is also too uncertain to decide the question whether the common Skate does not belong as well to the western parts of the North Atlantic. The waters round the British Isles and the fishing-banks off the south and middle of Norway are undoubtedly the most frequented haunts of the common Skate. It also enters in numbers the deep fjords and the island-belts of the west coast of Scandinavia. In Bohuslän it is commonly taken. In the Sound it penetrates at least to the neighbourhood of Landskrona, and through the Belts it makes its way, though rarely, at least to Travemünde Bay (MÖBIUS and HEINCKE). Its bathymetric range is also rather extensive. The older individuals are taken in Norway, according to LILLJEBORG, at depths sometimes amounting to 200 fathoms. But, like the other Rays, it ascends to higher levels during summer; and KRÖYER once saw 4 specimens, 12 to 15 dm. long, taken at the end of September in a stake-net off Gilleleje (the north coast of Zealand), in water probably not more than 4 fa-

[a] *Prodr. Faun. Medit.*, vol. II, p. 523.
[b] *Expos. intern. di Pesca*, Berlino 1880, Sez. Ital. Catal., p. 114.
[c] *Manuale Ittiol. Medit.*, l. c.

thoms deep, this being the maximum depth of an ordinary stake-net.

The common Skate seeks its food, like other Rays, among all kinds of marine animals, its size rendering it a still more dangerous enemy of the larger among them, such as Flatfishes, Codfishes, and large crustaceans. Even its congeners do not escape.

The breeding season of the common Skate occurs in spring. During summer, from May till September, it deposits its eggs, the shell of which, according to KRØYER, is of a handsome sea-green colour when fresh. While dredging in very deep water off the outermost islands in Bohuslän, FRIES secured the empty egg-shell of a Ray. It measured 32 cm. in length and rather more than 13½ cm. in breadth[a], and in all probability belonged to the common Skate.

The fairly plentiful occurrence of this species renders it of no little economical importance to man. The largest Skate are less esteemed, however, than those of medium size. When boiled fresh, Skate finds no great favour with the fishing population, who prefer either to keep it a day or two before eating or to score it with deep long slits, after which it is either salted or dried. Under the last-mentioned form it is often substituted for stockfish in their Christmas fare[b].

No special fishery can be said to be practised for the common Skate; but on his long-lines the fisherman usually leaves every fifth snood, the so-called Ray-snood, without float, so that it may sink to the bottom, where the bait, generally the head of a Herring, is more easily reached by the Skate.

(FRIES, SMITT.)

THE BLACK-BELLIED SKATE (SW. SVARTBUKSROCKAN[c]).

RAJA NIDROSIENSIS.

Figs. 293, A and 324.

Length of the snout from the anterior margin of the eyes (in adult specimens) about 19—22 % of the length of the body or 28 % (27—30 %) of the greatest breadth of the disk. Distance between each nostril and the tip of the snout about ¼ of the said breadth and more than twice the internasal width. Least interorbital width less than ¼ (24½—21 %) of the length of the snout. Females[d] with three rows of aculei on the tail, males with only one (that of the upper median line). Otherwise: aculei, dorsal fins, and caudal fin as in the common Skate. Ventral side so dark (blackish) that the black dots and streaks are indistinct.

Syn. ? *Raja Macrorynchus*, RAFIN., *Caratt. alc. n. gen.*, p. 15; BONAP. (*Laeviraja*), *Iconogr. Fau. Ital., Pesci*, tab. 151, fig. 2; GTHR (*Raja*), *Cat. Brit. Mus. Fish.*, vol. VIII, p. 468; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 405; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 338, tab. CLXVII.

? *Raia intermedia*, PARN., Mem. Wern. Nat. Hist. Soc., vol. VII, p. 429, tab. XL; RICH. in YARR., *Brit. Fish.*, ed. 3, vol. II, p. 557.

Raja nidrosiensis, COLL. apud STORM, N. Vid. Selsk. Skr. Trondhj. 1880, p. 80; COLL., Forh. Vid. Selsk. Chrnia 1881, No. 7; STORM, l. c. 1883, p. 47; COLL., N. Mag. Naturv. Chrnia, Bd 29, p. 121; LILLJ., *Sv., Norg. Fau. Fisk.*, vol. III, p. 576.

Of the Black-bellied Skate only large specimens, about 14—20 dm. long and 10—14 dm. broad, have hitherto been found. In form of body it is so similar to the common Skate that the longer snout can merely be adduced as a character which is generally distinctive of the Black-bellied Skate, but which — to judge by the course of development known to be followed by the other Rays — will probably lose its significance when information has been obtained of the earlier stages in the growth of this fish. The skeletons of the two species are also alike, apart from the length of the rostral region. The only difference worthy of remark in skeletons of about equal size seems to be that in the pectoral fins of the Black-bellied Skate the mesopterygium is bifid; but the number of the radialia applied to the two parts is the same (13) as that possessed by the undivided mesopterygium of the common Skate. The outer (anterior) lobe of the ventral fins also appears in the Black-bellied Skate to be longer in proportion to the posterior lobe; but to judge by COLLETT'S measure-

[a] In its present dried condition it measures, including the short horns, 24½ cm. in length and 8½ cm. in breadth.

[b] See p. 1107, note *f*.

[c] LILLJEBORG, l. c.

[d] According to COLLETT.

ments of these parts, the variations in this respect are equally great in the two species and overlap each other.

The spiny armature of the skin is generally weaker and on the dorsal side sparser than in the common Skate — sometimes it is entirely wanting — but on the ventral side it is more uniform and more extensive, except at the outer margins of the ventral fins and on the tail, which in some instances, however, has a strip of fine spinulæ along the middle of its under surface. The aculei of the young are persistent, at least in the males, on the orbital margins, and are also retained in both sexes on the upper median line of the tail, a few usually remaining as well between the two dorsal fins; but according to COLLETT only the females are furnished with a row of aculei on each lateral margin of the tail.

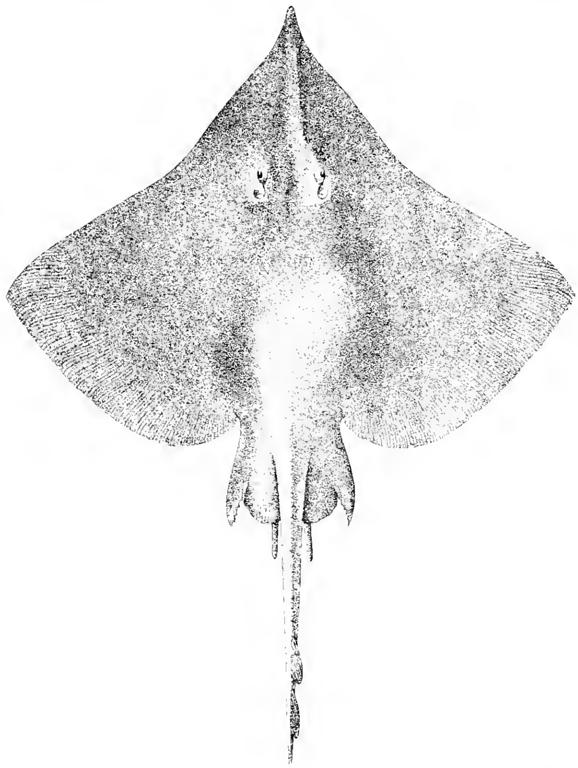


Fig. 324. Black-bellied Skate (*Raja nidrosiensis*), ♂, from Trondhjem Fjord, March 17, 1891. Conservator STORM. $^{1}/_{10}$ nat. size. The skeleton of this specimen is figured above, p. 1064.

In a male $14\frac{1}{4}$ dm. long the length of the head to the occiput measured 27·8 %, that of the snout from the anterior margin of the eyes 21 %, and the distance between the mouth and the tip of the snout 22·3 %, of the length of the body. The last-mentioned distance was 68 % of that between the mouth and the cloacal aperture, a percentage which, according to COLLETT's figure, amounts in a female 19 dm. long only to 56. The breadth of the mouth was 40 % and the internasal width 45·8 % of the length of the snout[a]. The jaw-teeth are similar to those of the common Skate both in number and form[b].

The coloration of the dorsal side, according to COLLETT, is of a dark grayish brown, and the ventral side is nearly brownish black, blackest in the middle[c]. The

[a] According to COLLETT's figure the last-mentioned percentage amounts in a female 19 dm. long hardly to 37; and the mouth seems to have been even narrower than that of the specimen described above.

[b] The distinction adduced by MOREAU between the dentitions of *Raja macrorhynchus* and *R. batis* evidently depends on differences of age and sex.

[c] According to CARUS *Raja macrorhynchus* is also dark brown (*fusca*) both above and underneath.

iris is bronze-coloured, the pupil shades into green and blue-black. The male Black-bellied Skate from Trondhjem Fjord presented by STORM to the Royal Museum in March, 1891, and the original of our figure, showed on the dorsal side about the same coloration as the Long-nosed Skate represented in Plate XLIX; the black skin of the ventral side had been for the most part chafed away during the railway-journey to Stockholm.

The Black-bellied Skate is hitherto known only from the deepest parts of Trondhjem Fjord, where STORM first distinguished it in 1880, among the fish taken at a depth of 150—300 fathoms. It is stated to be fairly common there. As mentioned above, however, there is scarcely any reason to regard it as distinct in species from the Scotch *Raja intermedia* and the Mediterranean *R. macrorhynchus*. Its manner of life, says STORM, is about the same as that of the other deep-sea Skates. It voraciously devours both large fishes and crustaceans. The fishes he most frequently found in its stomach were *Macrurus* and *Sebastes* as well as *Spinax niger* and *Pristiurus catulus*, and the crustaceans commonest among the contents were *Lithodes maja*, *Pasiphaë tarda*, and *Pandalus borealis*.

THE LONG-NOSED SKATE (SW. PLOGJERNSROCKAN).

RAJA OXYRHYNCHUS

Plate XLIX.

Length of the snout from the anterior margin of the eyes about 20—24 % ($24^1/_2$ %) of the length of the body or 31—35 % (36 %) of the greatest breadth of the disk. Distance between each nostril and the tip of the snout about 27—31 % of the said breadth and more than twice the internasal width. Least interorbital width less than $^1/_4$ of the length of the snout. Other essential characters as in the common Skate.

Syn. *Levraja mucosa, bucosa*, SALV., *Aquat. anim. hist.*, fol. 149, fig. 52. *Raia oxyrhynchos major*, WILLUGHB., *De Pisc.*, p. 71, tab. C, 4 (ex SALV.). *Raja* varia, tuberculis decemaculeatis in medio dorsi, ART., *Ichthyol.*, *Gen. Pisc.*, p. 72; *Syn. Pisc.*, p. 101.

Raja Oxyrinchus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 231; BONAP. (*Laeviraja*), *Iconogr. Fau Ital.*, tab. 151, fig. 1; GTHR (*Raja*), *Cat. Brit. Mus. Fish.*, vol. VIII, p. 469; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 403; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 341, tab. CLXIX; DODERL., *Man. Ittiol. Medit.*, fasc. III, p. 152.

Raja chagrinea, YARR., *Brit. Fish.*, ed. 1, vol. II, p. 414.

Raja Vomer, FR., Vet. Akad. Handl. 1838, p. 161; MÜLL., HLE, *Plagiost.*, p. 144 (+ *R. Salviani*, p. 143); KR., *Danm. Fisk.*, vol. III, p. 1011; NILSS. (*oxyrhinchus*?), *Skand. Fna, Fisk.*, p. 740; MALM, Öfvers. Vet. Akad. Förh. 1857, p. 193; RICH. in YARR., *Brit. Fish.*, ed. 3, vol. II, p. 548; GTHR, *Cat.*, l. c., p. 468; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 217; 1879, No. 1, p. 106; Nyt Mag. Naturv. Chrnia, Bd 29 (1884), p. 120; MALM, *Gbgs. Boh. Fna*, p. 617; STORM, Norsk. Vid. Selsk. Skr. Trondhj. 1880, p. 81; 1883, p. 46; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 598.

Raja mucronata, COUCH, *Corn. Fna*, p. 25; *Fish. Brit. Isl.*, vol. I, p. 93, tab. XIX; YARR., *Brit. Fish.*, ed. 2, vol. II, p. 550.

That this species also ranks among the largest Scandinavian forms of the genus and perhaps rivals the common Skate in size, appears from the fact that females measuring $1^1/_3$ m. are found that have not yet reached maturity. As a rule, however, the Long-nosed Skate is smaller than the common Skate, and the males are sometimes mature, as our figure shows, at a length of 124 cm. The largest females found by MALM among the take from the fishing-banks of Jäderen were 14 dm. long, and the largest males measured 137 cm.

The form of the body is highly characteristic of the Long-nosed Skate. Owing to the strong prolongation of the snout and its pointed or ploughshare-like form, the disk acquires the appearance of a sector of a circle, the two radii (the anterior side-margins of the disk) being undulate and incurved, so that the most prominent lateral margin of the head falls a good way short of the straight line from the tip of the snout to that of either pectoral fin. The posterior side-margins of the disk together form a handsome circular curve, the centre of which lies in the middle of the mouth aperture. The distance from the tip of the snout to the hindmost part of the posterior margin of the pectoral fins measured in two females about 83—84 % of the greatest breadth of the disk, in two males about 88—90 % of the same. The distance from the tip of the snout to the posterior margin of the ventral fins is very nearly the same as the greatest breadth of the disk (about 92—104 % thereof).

The length of the head to the occiput is about 28—30 % (according to LILLJEBORG sometimes $^1/_3$) of the length of the body. The longitudinal diameter of the eyes measures about $^1/_{10}$—$^1/_{12}$ of the length of the snout. The spiracles, the diameter of which is as usual variable, are of about the same size as the eyes. The internasal width is about 40—45 % of the distance between either nostril and the tip of the snout, which distance measures about 90 % of the length of the snout. The breadth of the mouth, even in old specimens, is perceptibly less than the internasal width. The dentition almost exactly resembles that of the common Skate. The only difference that might be adduced is that, on comparing specimens of equal size, the teeth of the Long-nosed Skate prove to be somewhat smaller, and the retral cusp ascends in a more conical form. The rows of teeth are nearly the same in number as those of the common Skate. The divergencies to be observed in this respect are most naturally regarded as the results of individual circumstances.

In middle-aged and large specimens the whole skin, both of the dorsal side and the ventral, is densely and almost uniformly covered with spinulæ of almost equal size, which have a stellately expanded base, fairly distinct to the naked eye, and consisting of 3—5 prostrate rays, each of a length nearly equal to the height of the spine. In the females no smooth gaps are left, except the circumanal region and the under side of the ventral fins and tail, which surface is partly naked. The rest of the skin is uniformly roughened throughout, even to the hind margins of the pectoral fins. In the males the smooth patches are rather more extensive. Around the eyes the spinulæ are somewhat coarser, and in young specimens, according to DÖDERLEIN, a well-developed aculeus is set at the preorbital margin.

The only other aculei possessed by this species consist of a row on each lateral margin of the tail. They are comparatively small, but of unequal size, pointed and compressed, with the base prolongated and as it were lobed. Their arrangement is not symmetrical, and their tips are directed indiscriminately forwards or backwards.

The coloration of the dorsal side is brownish gray or reddish brown, with sparse, light brown or even milk-white spots, scattered in curved rows or irregularly. The anterior side-margins and the spine-cards of the males are light gray. The under surface is coloured and marked as in the common Skate, but seems in general to be lighter.

The Scandinavian distribution of the Long-nosed Skate is probably the same as that of the common Skate, only that the former does not enter the Cattegat proper, though it no doubt approaches the Swedish coast in the Skager Rack. On the 14th of November, 1889, Mr. C. A. HANSSON secured in Koster Fjord, off Helsö, the male figured in our plate. The northern limit of the species apparently lies near Trondhjem, the southern limit off Madeira. The Long-nosed Skate is besides a rather common fish in the Mediterranean. Its bathymetric range appears to extend in Scandinavia between depths of about 70 and 150 fathoms.

In its manner of life the Long-nosed Skate resembles the common Skate. The same fishes are found in the stomach of both, and off our coasts they are taken on the same tackle (long-lines) and in company. With regard to the deposition of the ova GRIEG noted[a] that a female 129 cm. long, which was caught on the 18th of May, 11 miles west of Bergen, laid a fully ripe egg when drawn into the boat.

In Bohuslän the Long-nosed Skate is well known among the deep-sea fishermen and to the fish-dealers. It is there called, according to MALM, *rarnäbb* (Big Beak). It is taken less frequently by the Swedish fishermen than the common Skate; but according to STORM, JENSEN, and GRIEG it is common in Trondhjem Fjord and off Bergen.

As a food-fish it is considered inferior to the common Skate. (FRIES, SMITT.)

[a] Bergens Museums Aarbog 1892, p. XVIII.

PLAGIOSTOMI SELACHOIDEI[a].

Pectoral fins of ordinary form, situated behind or below the branchial apertures. Tail gradually contracted in unbroken continuity with the trunk. Anal fin present or wanting. One or two dorsal fins, the anterior generally belonging to the abdominal portion of the body.

Among the Sharks instances are indeed afforded of comparatively sluggish bottom-fishes: but this sub-order consists principally of the most powerful and enduring swimmers, which chase their prey in speedy pursuit and seize it with dexterous agility. Their form of body adapts itself to their manner of life. The quiet body and more pointed fins. Especially their caudal fin, the propeller of the body, is in general powerfully developed and, in contradistinction to that of the Rays, principally ventral (heterocercal).

The sensory organs of the Sharks are also adapted to the requirements of their predatory existence. The

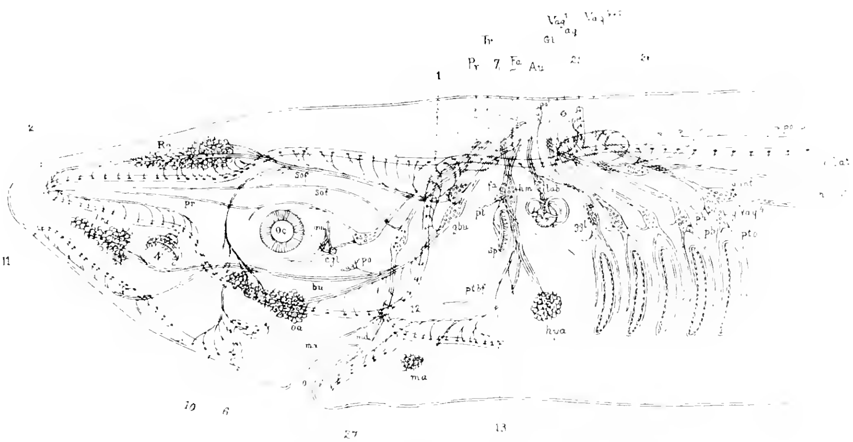


Fig. 325. Diagram showing the ramification of the cranial nerves and the system of the lateral line in the anterior part of a Greenland Shark (*Acanthorhinus carcharias*). After EWART.

aq, *aquæductus vestibuli;* *Au*, auditory nerve; *bu*, buccal branch of the facial nerve; *cgl*, ciliary ganglion; *Fa*, roots of the facial nerve; *fa*, facial nerve proper; *Gl*, glossopharyngeal nerve; *gbu*, ganglion of the buccal branch; *ggl*, ganglion of the glossopharyngeal nerve; *g. int*, ganglion of the intestinal branch of the *nervus vagus;* *g. Vag*[4], ganglion of the fourth branch of the *nervus vagus;* *hm*, ganglion of the hyomandibular branch of the facial nerve; *hya*, hyoid ampullæ; *lab*, labyrinth; *lra*, lateral ampulla of the snout; *ma*, mandibular ampullæ; *md*, mandibular branch of the trigeminal nerve; *mx*, maxillary branch of the trigeminal nerve; *N*, nasal cavity; *n. int*, intestinal branch of the *nervus vagus;* *n. lat*, lateral branch of the *nervus vagus;* *o*, mouth; *oa*, oral ampullæ; *Oc*, eye; *om*, oculomotor nerve; *pb*, last prebranchial division of the *nervus vagus;* *ph*, last pharyngeal branch of the *nervus vagus;* *pl*, palatine branch of the facial nerve; *po*, pit organs; *Pr* and *pr*, *nervus ophthalmicus profundus;* *ptb*, last postbranchial division of the *nervus vagus;* *ptbf*, postbranchial division of the facial nerve (running behind the spiracle); *Ro*, superior rostral ampullæ; *sof*, superficial ophthalmic branch of the facial nerve; *sot*, superficial ophthalmic branch of the trigeminal nerve; *sp*, spiracle; *Tr*, trigeminal nerve; *Vag*[1]—[5], first—fifth branches of the *nervus vagus;* *1*—*27*, canals of the system of the lateral line. The signification of these numerals is explained below fig. 308, see above, p. 1091.

and indolent Sharks have a more depressed body — anteriorly at least — and more rounded fins; the active and more distinctly raptatorial a more terete, fusiform system of the lateral line (see the explanation of fig. 325) consists of the same divisions as in the Rays, only that here the opercular (hyomandibular) canal

[a] From the Greek σέλαχος, a cartilaginous fish.

(12—13) does not extend beyond the branchial apertures, sometimes not even to them, and that the mandibular branch is continuous with this canal.

In Scandinavian waters Sharks are less common and consequently less known and feared than in more temperate or tropical seas. About one hundred and fifty species are recognised, but of these only eleven can be claimed for the Scandinavian fauna.

In the sketch given by HASSE[a] of the evolution of the Elasmobranchs one group, the *Palæonotidani*, in the present age most nearly represented by the *Notidanidæ*[b], a family foreign to Scandinavia, rank as the primordial type both of the Sharks and Rays. Externally this family is characterized by the possession of only one dorsal fin, but of six or seven gill-openings. The proofs of its primitive nature must be sought, however, in the structure of the spinal column, with its undifferentiated vertebræ. From the *Palæonotidani*, according to HASSE, three different evolutional series may be traced, with a calcified double-cone, more or less distinct and of varying development, in the centra of the vertebræ. Its development is most imperfect in the so-called *Cyclospondyli*, where it appears merely as a ring of calcification. Externally all these Sharks (the family *Spinacidæ*), with their typical form of body, may be recognised by their want of anal fin. In the other two evolutional series the double-cone (composed of two more or less deeply hollowed cones, confluent at the vertices) is generally developed to such a degree that the bodies of the vertebræ are fully amphicœlous; but in one of them — the so-called *Tectospondyli* — it consists of smooth, concentric layers of calcification, in the other — the so-called *Asterospondyli* — calcareous rays issue radially from the centrum. The *Tectospondyli* are without anal fin, and their series comprises both two Shark families foreign to the Scandinavian fauna, the Angel-fishes (*Rhinidæ*) and the Saw-Sharks (*Pristiophoridæ*), which are transitional even in their external form to the *Batoidei*, and the whole phalanx of the Rays. All the remaining Sharks — all furnished with anal fin and two dorsal fins — are *Asterospondyli*, and in this series the Plagiostomous type has attained its richest development, with the greatest wealth of families.

ASTEROSPONDYLI.

Sharks with anal fin and two dorsal fins.

Among the Scandinavian Sharks the families belonging to this series may be distinguished as follows:

A: First dorsal fin situated between the perpendiculars drawn through the pectoral and ventral fins.
- *a:* Eye with a nictitating membrane ... Fam. *Carchariidæ*.
- *b:* Eye without nictitating membrane ... „ *Lamnidæ*.

B: First dorsal fin situated above the ventral fins or behind the perpendicular drawn through these fins ... „ *Scylliidæ*.

FAM. CARCHARIIDÆ.

Two dorsal fins and one anal, the first dorsal opposite to the space between the pectoral and ventral fins. Eye with a nictitating membrane, which is drawn up from the lower part of the orbit. Spiracles obliterated or minute. The hindmost or even the penultimate gill-opening situated above the base of the pectoral fin.

According to GÜNTHER's definition[c] of this family it includes among its 60—70 species the true Hounds (*Musteli*) and their nearest relatives — with small, pointed or flat, more or less paved jaw-teeth — as well as the Hammerheads (*Sphyrnæ*), with their singular lateral production of the orbital and nasal regions. These two subfamilies are indeed strangers to the Scandinavian fauna, as far as we know at present, but approach very near to its limits, a species of each having been found on the Scotch coast, and one of these (*Mustelus vulgaris*)

[a] *Naturl. Syst. Elasmobr.*, Jena 1879, Allgem. Theil, pp. 35, cett.

[b] Two, perhaps three species of this family are inhabitants of the Mediterranean and the Atlantic; and one of these species, *Notidanus* (*Hexanchus*) *griseus*, is not so very rare on the English coast and has been met with so near the limits of the Scandinavian fauna as off the coast of Scotland.

[c] *Cat.*, vol. VIII, p. 353.

extending its wanderings up to the Shetland Islands. The third division, the subfamily *Carchariinæ*, is recognised by the normal development of its head and its large, triangular or subulate jaw-teeth, and to it belong most of the species within the family.

The two genera which occur in Scandinavian waters may be distinguished as follows:

A: Peduncle of the tail crossed by a transverse groove (a notch) above and below, just in front of the base of the caudal fin Genus *Carcharias*.

B: Contours of the tail uninterrupted (without notch) in front of the caudal fin .. *Galeorhinus*.

Obs. From Iceland Faber described[a] a species of Shark 7–9 ft. long, which he called *Squalus arcticus*. Nilsson assumed that so large a Shark, with the well-known roving proclivities of these fishes, could not occur off Iceland without paying at least an occasional visit to Norway; and on this ground *Squalus arcticus* was introduced into the Scandinavian fauna[b]. The elder Reinhardt showed, however, that, admitting the possibility of one or two slips of the pen or lapses of memory, Faber's description is most appropriate to *Isurus (Lamna) cornubicus*[c]. More recently Müller and Henle found in the Museums of Berlin and Leyden a species of Shark[d] which they assumed to be Faber's *Squalus arcticus*, and which they placed in their genus *Galeocerdo*, most nearly resembling *Galeorhinus*, but with a groove in front of the caudal fin. Kröyer also states[e] that he has examined two mandibles of *Galeocerdo arcticus* from Iceland. But Faber's description by no means coincides with that given by Müller and Henle of the last-mentioned species. Especial attention is due to the following points in Faber's description: "Schnauze verlängert, zugespitzt . . . Nasenöffnungen dicht vor den Augen . . . Schwanzflosse fast halbmondförmig." Nilsson too was probably justified in his assumption that, if so large a Shark had occurred regularly off the coast of Iceland, it ought also to have been met with in Norwegian waters. As this has not happened for more than sixty years since attention was first drawn to the possible occurrence of the species, we see no reason for noticing this species among the fishes of Scandinavia at greater length than we have done in the present note.

Genus CARCHARIAS.

Spiracles obliterated. A transverse groove in the superior and inferior margins of the tail just in front of the caudal fin. Valve of the spiral intestine longitudinally coiled.

The Sharks most commonly known as *man-eaters*, dreaded and detested with equal fervour by the sailor, belong to this genus. With their elongated form of body and their well-developed fins — especially the usually long and scythe-shaped pectorals — they are confirmed rovers and readily strike the eye, whether disporting themselves at the surface of the open sea or swimming in shallower water, sometimes close in shore. Their insatiate voracity renders them formidable pirates throughout their range in the tropical and temperate seas. The seaman that falls overboard, in most cases, no doubt, becomes their prey, and the incautious bather, even on a shelving coast, may meet with the same fate. Sailors therefore take a delight in tormenting these fishes in every conceivable manner when they have succeeded in getting them on board.

During his voyage to India Sundevall made the following notes with respect to the genus *Carcharias*: "These species are commonly seen slowly following the vessel in fine weather and light winds, especially when the salt meat for daily consumption is towed behind the ship, as is the general custom, in a sort of keg, to be soaked. The Shark is then seen cruising about, with dorsal fin projecting above the surface, and as soon as anything is thrown into the water, it is at once pounced upon by the fish. Bits of wood and other inedible substances are readily seized, but soon discarded. The Shark is consequently an easy catch, but the hook should be of a suitable thickness, the line strong and furnished with some iron links next the hook to prevent it from being bitten off. These fishes do not disdain any animal substance or filth. In securing any floating object, they open the jaws over it quite leisurely and raise the whole head above the surface, the mouth being situated on the ventral side; but upon objects that sink in the water they dart with great rapidity. In taking a baited hook, the Shark turns upon its side or completely over, with the belly upwards, as the snout would else come in contact with the line and push the bait away. When the wind is at all

[a] *Fisch. Isl.*, p. 17.

[b] *Prodr. Ichth. Scand.*, p. 115.

[c] Maanedskr. f. Lit., Kbhvn, Bd 7, p. 212 and Bd 9, p. 263.

[d] *Plagiost.*, p. 60, tab. 24.

[e] *Danm. Fisk.*, III, p. 933, note.

high, these Sharks are never seen, presumably because they are sluggish swimmers and cannot keep up with the vessel. In all their actions they greatly resemble a hungry dog or a wolf prowling in quest of food: hence the names of *chien de mer*, *grand chien bleu*, etc., which are conferred upon them in several languages. Most frequently these Sharks are attended by a little fish known among seamen as the *Pilot* (*Naucrates ductor*, see above p. 82, note *d*). This fish, which is about a foot long, presents a handsome appearance, being silvery blue with broad transverse bands of dark blue. Seafaring folk in general suppose that it guides the Shark to the prey in the hope of gaining its share thereof, and this belief has been supplemented by all kinds of romantic additions. CUVIER, who discerned the improbability of these fabulous narratives, was of the opinion that the companionship of the Shark and the Pilot-fish is merely fortuitous, each of them following the vessel. But this is not the case. The Pilot-fish really attends upon the Shark, but only to feed upon its excrements, as a few writers, ancient and modern, have correctly stated. I have often had the opportunity on tropical seas of carefully watching Sharks accompanied by one or two Pilot-fish, and have always made the same observation. The Pilot-fish keeps close to the body of the Shark, at the dorsal, pectoral, or ventral fins, but now and then quits his post to taste some floating object he has espied. Apparently, however, he seldom finds anything that tickles his palate, and soon returns to the Shark; but the moment the Shark passes any excrementitious matter, the Pilot promptly and eagerly makes off to secure the prize, and then returns to its former station, from which it refuses to be enticed for a long while, whereas, when it is hungry, it readily swims after any small object thrown into the water. I never succeeded in hooking a specimen. In the Bay of Bengal I had good opportunity of observing that large turtles are also attended by the same kind of Pilot-fish; and *Sucking-fishes* (*Echeneis*, see above, p. 89, note *a*) accompany both Sharks and turtles for the same reason as the Pilot, but always adhere firmly to the body of their host, till they see any morsel of food, when they vie with the Pilot-fish in agility, and, their errand accomplished, immediately return to attach themselves as before."

These Sharks are, however, not exclusively salt-water fishes. Some of them ascend the great rivers of the tropics, even beyond the tidal portion of their course. In Scandinavian waters they are strangers; but one species has strayed to our coasts.

THE BLUE SHARK (SW. BLÅHAJEN).

CARCHARIAS GLAUCUS.

Plate L, fig. 3.

Teeth serrated at the margins. Snout more or less conically prolongated to a length of about half that of the head. First dorsal fin nearer to the ventral fins than to the pectoral, beginning about half-way between the tip of the snout and the base of the caudal fin[a]. *Coloration above of a blackish or grayish blue, underneath white.*

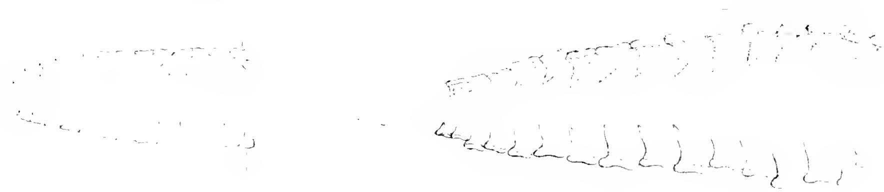
Syn. Γλαῦκος, ÆLIAN., *Anim. Nat.*, lib. I, cap. XVI, p. 22. *Galeus glaucus*, ROND., *De Pisc.*, p. 378; WILLUGHB., *Hist. Pisc.*, p. 49. *Squalus* fossula triangulari in extremo dorso, foraminibus nullis ad oculos, ART., *Ichth.*, *Gen.*, p. 69; *Syn.*, p. 98.

Squalus glaucus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 235; BL., *Naturg. Fisch. Deutschl.*, pt. III, p. 78, tab. LXXXVI; RETZ., *Fau. Suec. Lin.*, p. 306; BLVLLE (*Carcharinus*), Bull. Sc. Soc. Philom. Paris, 1816, p. 121 (+ *C. caeruleus*, ibid., cfr *Fne Franc.*, I, *Poiss.*, pp. 90—92); CUV. (subg. *Carcharias*), *Règn. Anim.*, ed. I, tom. II, p. 126; YARR., *Brit. Fish.*, ed. 1, vol. II, p. 381; ed. 2, vol. II, p. 498; BONAP., *Iconogr. Fna Ital.*, *Pesci*, tab. 133, fig. 2; MÜLL., HLE (*Carcharias*, subg. *Prionodon*), *Plagiost.*, p. 36, tab. 11 (+ *C. hirundaceus* ex VAL., p. 37); COUCH, *Fish. Brit. Isl.*, vol. I, p. 28, tab. VI; DUM., *Hist. Nat. Poiss.* (suit. à BUFF.), tom. I, p. 353; BARB. BOC., CAP., *Peix. Plagiost.*, p. 17; GTHR, *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 364; MOR., *Hist. Nat. Poiss.*, tom. I, p. 329; MÖB., HCKE, *Fisch. Osts.*, p. 150; JORD., GILB. (*Carcharinus*), Bull. U. S. Nat. Mus., No. 16, p. 22; DAY (*Carcharias*), *Fish. Gt. Brit.*, *Irel.*, vol II, p. 289, tab. CLII; COLL.,

[a] The distance between the beginning of the first dorsal fin and the upper transverse notches on the peduncle of the tail is in our young specimen 91 % of that between the same fin and the tip of the snout, which latter distance is equal to that between the anterior angle of the pectoral fin and the beginning of the anal fin. In older Blue Sharks the last-mentioned distance is even relatively somewhat greater.

N. Mag. Naturv., Bd 29 (1884), p. 116; Döderl., *Man. Ittiol. Medit.*, fasc. II, p. 42; Lillj., *Sv. Norg. Fisk.*, vol. III, p. 609.

In Plate L, fig. 3 we give a representation of a young Blue Shark, 41 cm. long, from the Indian Ocean. It was cut out of the belly of the mother-fish. The specimen is sufficiently developed and well preserved enough to give a better idea than a stuffed example of the appearance of the species. The Blue Shark, however, attains a considerable size, in ordinary instances a length of 2 to 3 or 4 m.[a], and the form varies during growth. The pectoral fins become considerably longer and narrower, their length being sometimes thrice their breadth. The relative size of the eyes diminishes from about $^1/_7$ to $^1/_{10}$ of the length of the head. The form of the jaw-teeth (fig. 326) is altered as shown in the figure; and the number of



A B

Fig. 326. Jaw-teeth of the right side in a young (*A*) and an adult (*B*) Blue Shark. $^1/_2$ nat. size. After Müller and Henle.

their transverse rows, one behind the other in each jaw, increases from 2 to 5.

In the tropical seas the Blue Shark is dispersed all round the globe. In Europe it is common in the Mediterranean and at least not rare on the south coasts of England and Ireland. Even in St. Andrews Bay (Scotland), according to McIntosh, it is not uncommon, and according to Couch it strays up to the Orkney Islands; but further to the north and east it is apparently but an occasional visitor. In November, 1883, Collett received a specimen 16 dm. long that had been taken at the very head of Christiania Fjord, and Blue Sharks have been caught in the westernmost parts of the Baltic. At the beginning of October, 1753, a specimen $3^1/_2$ m. long was taken in Travemünde Bay and described by Walbaum. During the previous year a specimen is said to have been caught off Kiel[b]. According to Couch the Blue Shark roves round the English coast during summer, but leaves those waters at the approach of winter.

Though the Blue Shark attracts most attention as it swims at the surface, it also descends to a considerable depth (at least about 100 m.), and here is perhaps its most congenial home. Light is apparently obnoxious to it, for at the surface and in the upper strata of the water, so long as the light is powerful, and when it is desirous of fixing a steady gaze on some object, it keeps drawing the nictitating membrane up and down over its eyes. In the Mediterranean the young make their appearance during May and June (Döderlein). Oppian celebrated in verse[d] the care devoted by the parents to their offspring. When any danger threatens, the mother (or, according to others, the father) opens its mouth for the young to take shelter in its pharynx[e] or even in its stomach. The fry are, however, soon capable of defending and feeding themselves, for they come into the world fully developed for leading an independent existence, and measuring, according to a note of van Beneden's[f], at least 60 cm.

The diet of the Blue Shark consists principally of fish of all kinds. In the stomach of a specimen 6 ft. long Couch found a large Picked Dog-fish and a Conger, both bitten right in two, and a Gurnard. In another he found four Mackerel, half a Garpike, and so many Herrings, quite whole, that the fisherman sold

[a] Lilljeborg states as much as $7^1/_2$ m.

[b] Cf. Bloch, l. c.

[c] Cf. Möbius and Heincke, l. c.

[d] *Halieuticorum* lib. 1. From the beginning of the third century, A. D.

[e] Cf. the method employed by the *Chromida* of preserving their eggs and fry in the branchial cavity. Agassiz, *A Journey in Brazil*, p. 222.

[f] *Poiss. Côtes Belg.*, p. 4; Mém. Acad. Roy. Belg., tom. XXXVIII (1871).

them for eighteenpence; and yet the Shark had been hungry enough to gorge the bait. To the fisherman the Blue Shark causes great annoyance, as it robs the long-lines of their bait, and cuts the line in two or twines the latter round its body, by rolling over and over, in such a complicated manner that the task of disentanglement is hopeless; and it plucks the fish out of the net and tears asunder the meshes.

The flesh of the Blue Shark is hard and has a nauseous smell, but it is eaten in Italy by the poor. The only other value of the fish consists in its oily liver and finely shagreened skin.

Genus GALEORHINUS.

Spiracles open, though small. Peduncle of the tail without transverse notch. Valve of the spiral intestine spirally coiled.

Both in form of body and manner of life the genus of the *Smooth Sharks* closely resembles the preceding one; but they do not attain the same dimensions as the man-eater Sharks, and the narratives related ever since PLINY's time of combats between divers and Smooth Sharks are probably based on a confusion with Blue Sharks, though the Tope is sometimes large enough to take a substantial mouthful from the body of a swimmer. The ground-colour of the body, though it does not distinguish them in the least from several man-eating Sharks, has given rise to the name of *Gray Sharks* (NILSSON in *Skand. Fauna*); but this name is more commonly applied to another genus, also occurring in the North Sea, namely *Notidanus*.

Only two species are known, one from Japan alone, the other cosmopolitan in the tropical and temperate seas.

THE TOPE (SW. HASTÖRJEN OR BETHAJEN).

GALEORHINUS GALEUS.

Plate L, fig. 2.

Inner margin of the teeth smooth, their outer margin obliquely notched, finely serrated, but with a coarser denticulation at the base. Snout in great part translucent and prolongated in a more or less flattened form to a length measuring about half that of the head. First dorsal fin at least about twice as large as the second and situated nearer to the pectoral fins than to the ventral, the distance between it and the tip of the snout being slightly more than $^2/_5$ of the length of the body to the beginning of the caudal fin. Beginning of the second dorsal fin somewhat further forward than that of the anal. Coloration above of a more or less light bluish gray, underneath white.

Fig. 327. Teeth of the upper and lower jaws in a Tope (*Galeorhinus galeus*) 13 dm. long, $^2/_3$ nat. size.

Syn. Γαλεὸς Κύων, Aristot., *De anim. hist.*, lib. VI, cap. XI. *Galeus canis*, Rondel., *De Pisc.*, p. 377. *Canis galeus*, Willughb., *Hist. Pisc.*, p. 51 (ex Salv.). *Squalus* naribus ori vicinis, foraminibus exiguis ad oculos, Art., *Ichthyol.*, *Gen.*, p. 68; *Syn.*, p. 97.

Squalus Galeus, Lin., *Syst. Nat.*, ed. X, tom. I, p. 234; Blnvlle (*Galeorhinus*), Bull. Sc. Soc. Philom. 1816, p. 121; Cuv. (subg. *Galeus*), *Regn. Anim.*, ed. 1, tom. II, p. 127; Nilss. (*Squalus*), *Prodr. Ichth. Scand.*, p. 115; Sundev., v. Wr., *Skand. Fisk.*, ed. 1, p. 185, tab. 45; Couch (*Toper*), *Fish. Brit. Isl.*, vol. I, p. 45, tab. IX; Jord., Gilb. (*Galeorhinus*), Bull. U. S. Nat. Mus., No. 16, p. 21; Coll., N. Mag. Naturv. Chrnia, Bd 29 (1884), p. 116.

Galeus vulgaris, Flmng, *Brit. Anim.*, p. 165; Yarr., *Brit. Fish.*, ed. 2, vol. II, p. 509; Kr., *Danm. Fisk.*, vol. III, p. 834; Coll., Forh. Vid. Selsk. Chrnia 1874, Tillegsh., p. 207; 1879, No. 1, p. 102; Day, *Fish. Gt. Brit. Irel.*, vol. II, p. 292, tab. CLIII; Lill., *Sv.*, *Norg. Fna*, *Fisk.*, vol. III, p. 612.

Galeus canis, Bonap., *Iconogr. Fna Ital.*, tom. III, *Pesci*, tab. 132, fig. 3; Müll., Hle, *Plagiost.*, p. 57; Nilss., *Skand. Fna*, *Fisk.*, p. 714; Barb. Boc., Cap., *Peix. Plagiost.*, p. 18; Gthr., *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 379; Winth., Naturh. Tidsk. Kbhvn, ser. 3, vol. XII, p. 56; Mor., *Hist. Nat. Poiss. Fr.*, tom. I, p. 317; Döderl., *Man. Ittiol. Medit.*, fasc. II, p. 36; Car., *Prodr. Fna Medit.*, vol. II, p. 509.

Galeus Linnei, Malm, *Gbgs. Boh. Fna*, p. 618.

The Tope, known in France as *le chien de mer* and in Italy as *la lamiola*, attains a length of about 2 m.[a] The form of the body is moderately elongated for a Shark, but varies rather considerably with age. Old individuals are more robust, with deeper body, than young. The greatest depth, just in front of the first dorsal fin, measures in the young about $^{1}/_{10}$—$^{1}/_{9}$, in the old sometimes $^{1}/_{7}$, of the length of the body. The least depth, just in front of the caudal fin, shows less alteration, measuring about $^{1}/_{30}$ (3·1—3·4 %) of the length of the body or 17—18 % of that of the head to the first gill-opening. The ordinary fusiform shape is laterally compressed in the anterior abdominal region, further back more terete or of a rounded quadrangular section, the dorsal margin being depressed, and the ventral almost plane. In front of the first dorsal fin, however, the back is bluntly sharpened (fastigiate or a so-called hog-back), which gives the section of the body in front of the pectoral fins an almost triangular form. Even the form of the head partakes in this modification, approaching in old specimens to that of a three-sided pyramid, but with a longitudinal swelling behind the eyes and a flattened snout, the lateral margins of which form a parabola. In younger specimens the head is flatter forward from the occiput, shallower, and behind the eyes of a more quadrangular section.

The length of the head to the first gill-opening is somewhat less than $^{1}/_{5}$ (18—19 %) of the length of the body. The length of the snout from the preorbital margin is about 46—48 %[b] of the length of the head. The eyes themselves are indeed round (with round iris), in the young with round, inferiorly acute-angled pupil, in old with elongated, slit-like pupil; but the orbits are oblong, their longitudinal diameter measuring in specimens $^{1}/_{2}$ m. long about 18—19 %, in specimens $1^{1}/_{3}$ m. long about 12—13 %, of the length of the head, the vertical diameter only $^{1}/_{2}$—$^{2}/_{3}$ of the longitudinal. The suborbital margin has been turned inwards to form the fold known as the nictitating membrane. The use of this membrane we have noticed in the Blue Shark. It is for the most part shagreened, like the skin of the body, but at the fold itself (below and at the corners of the eyes) naked and soft. The interorbital width is about $^{2}/_{5}$ of the length of the head. The spiracles behind the eyes are fairly large and distinct in young specimens; in old they are contracted into small, elongated slits and simultaneously removed farther from the eyes, the distance increasing from $^{1}/_{4}$ to $^{3}/_{4}$ of the longitudinal diameter of the orbit. Spiracular gills are wanting or are extremely vestigial, forming a row of 10—11 small papillæ, situated rather far in. The nostrils are somewhat obliquely set slits, directed inwards and backwards from the edge of the snout, on the under surface thereof, and their length is about equal to the vertical diameter of the orbits. Their anterior, overlapping margin is double, being divided into an outer (lower) and an inner (upper) lobe, and each of these lobes is furnished, about half-way or two-thirds of the way along the nostril, with a small, pointed, triangular flap (valvule). Their outer, somewhat expanded corner, which lies close to the edge of the snout, is separated from the tip thereof by a distance of about $^{7}/_{10}$ (72—68 %) of the length of the same. Their inner angle lies at a distance from the anterior margin of the mouth that is equal to the height of the gill-

[a] From Dublin Blake-Knox states (Zoologist, Dec. 1866, p. 509) that he has taken Tope, which are common there, as much as 7 ft. (21 dm.) long.

[b] According to Kroyer sometimes 52.

openings or about $^1/_4$ of the length of the head. The cleft of the mouth is horse-shoed. Its breadth is about equal to the postorbital length of the head. Both corners of the mouth are surrounded by an impressed fold of skin and are sharply defined, the distance from the tip of the snout to this posterior limit of the lips varying between about $^2/_3$ and $^3/_4$ (66—77 %) of the length of the head, and that from the anterior margin of the mouth to the same point being about 45 %[a] of the same length. The teeth are set so unevenly in 3 or 4 rows within one another that their number in one of these rows on each side was estimated by KRØYER at 7, by MÜLLER and HENLE at 17, the former having only counted the teeth exactly in a line with one another, omitting those close to (within) these at the intervening spaces. Both the upper and the lower jaws are furnished with a thick, but narrow fold (velum) behind the rows of teeth, with lobes answering to the dentition. The tongue is broad and fleshy, but flat. Of the five gill-openings on each side the last two are situated above the base of the pectoral fin.

The two dorsal fins are of rather similar form, but differ widely in size. Their form may be described as a triangle with the posterior corner raised above the base and strongly prolongated. The basal length of the second dorsal fin varies between about 63 and 53 % of that of the first, and the anterior margin of the former measures from about 58 to 48 % of that of the latter, which last-mentioned margin increases with age from about 8 to $9^1/_2$ % of the length of the body. The distance between the first dorsal fin and the tip of the snout is about $^1/_3$ (32—34 %), that between the second dorsal fin and the same point about $^2/_3$ (63—67 %), of the length of the body. The anal fin is similar to the second dorsal, but somewhat smaller[b] and situated a little further back[c]. The caudal fin resembles in form that of the Blue Shark, but is shorter, its length from the beginning of the inferior lobe to the extreme tip of the fin decreasing during growth from about 24 to $22^1/_2$ % of the length of the body. The inferior lobe is so deeply forked that it almost seems to consist of two fins, an anterior, prolongated forward so as to form a triangular lobe, behind shallow and of almost uniform depth, and a posterior, which is triangular, and together with the elongated shallow upper caudal lobe, gradually ascending behind, forms the extreme tip of the fin. The paired fins are triangular. The pectorals are of much the same form as the dorsals, but the posterior (inner) corner is only slightly prolongated. The distance between them and the tip of the snout measures about 23—22 %, their anterior margin about 13—15 %, of the length of the body. The ventral fins, which surround the anus, have the form of almost right-angled triangles with contiguous hypotenuses. These sides, which are about $^1/_4$ greater than the others, measure about 6—7 % of the length of the body. The distance from the beginning of the ventral fins to the tip of the snout is about 50—53 %, to the beginning of the pectoral fins about 27—30 %, of the length of the body.

The whole skin of the body — with the exception of triangular patches behind the cloacal region and the dorsal, the anal, and the pectoral fins — the surface of the fins, and the cavity of the mouth, are finely shagreened with small three-spined placoid scales, so small that, when stroked from in front, the body is smooth and slippery to the touch, but in the opposite direction feels harsh and rough.

The external difference of sex is that normal in the Sharks. In the young male represented in our figure the pterygopodia had not yet grown beyond the tips of the ventral fins.

The back, together with the dorsal and caudal fins and the upper surface of the paired fins, is of a steely gray, sometimes with a bronze lustre. The ventral side is white, sometimes with a nacreous lustre, or yellowish. The iris is white, with a narrow ring of cupreous lustre round the black pupil.

The Tope is known from the Atlantic, Pacific, and Indian Oceans. In the Atlantic it has been found from the Cape of Good Hope to the Orkneys and the neighbourhood of Bergen. In the Mediterranean and on the coasts of France, the south of England, and Ireland, it is common. In the North Sea it becomes less frequent of occurrence to the north; but even in the Cattegat it cannot be described as rare. North of Bergen it has never been met with; but in Christiania Fjord and on the coast of Bohuslän, as well as in Danish waters, it

[a] According to KRØYER sometimes 50.

[b] Base about 90—91 % of that of the second dorsal; anterior margin about 80—86 % of that of the second dorsal.

[c] Distance between the second dorsal and the tip of the snout about 98—99 % of that between the anal and the same point.

is frequently taken. In Liim Fjord a specimen was caught by FEDDERSEN off Struer in the summer of 1876. A female 15 dm. long was taken off Skummeslöf (Halland) in November, 1881, and forwarded to the Royal Museum by Mr. A. v. MOLLER. Another, not much inferior in size, was secured in the north of the Sound during January, 1835, and was described by SUNDEVALL in the former edition of the present work. It is otherwise usual that only young Tope are met with near land and enter the Sound (KRØYER and NILSSON), penetrating to the shallows round Saltholm (WINTHER). Older individuals generally confine themselves, except during the breeding season, to deeper water. Their haunts are soon learnt by the fisherman, who finds the snoods of his Haddock-lines torn off, and perhaps hauls in a Tope that has eventually been hooked, and in its desperate struggles has twisted the line round its body, in the same manner and with the same result as we have just related of the Blue Shark. A Tope 13 dm. long, which had been forwarded from Bohuslän to the Royal Museum, had in its stomach two Haddocks about 4 dm. long, each with a hook and a bit of the snood in the mouth. The great strength of the Tope appears from a statement made by two fishermen who were out fishing for Ling in September, 1887, about seven miles off Langesund. In 10 fathoms of water a Tope seized the bait, and the line being strong, he towed the boat behind him for half an hour. The fish was a metre long and weighed 55 kilo.

In summer, from June till September, the Tope gives birth to its young, about 20—40 being excluded from the female at a time, and these already about 4 dm. long. Through the winter the young stay near the coast, while the old retire to deep water, and according to YARRELL they reach their full size the following year; but no precise information on this head is forthcoming. COUCH says that on the English coast they are about 5 dm. long in January; but a Tope of this size was taken off the coast of Bohuslän by Mr. C. A. HANSSON in September.

The Tope does more harm than good to the fisherman. The oil extracted from its liver and the fine shagreen prepared from its skin hardly compensate the damage it causes. Its flesh is poor, but in spite of this it is eaten in many places. At the Danish fishing-villages, according to KRØYER, it is boiled fresh, or dried and sold in this condition at the markets of Northern Jutland. According to MOREAU it also finds consumers in the French departments bordering on the English Channel.

The Swedish name of *hastörje* (*ha*, *haj* = Shark) is derived, according to SUNDEVALL, either from the resemblance of the head to that of the Sturgeon (*stören*) or from the size of the fish (*stor* = great, large), Swedish fishermen meaning by *ha* or *haj*, when used without qualification, the Picked Dog-fish. Similarly they call the Tunny *Makrilstorje* (Great Mackerel). The name of *bethaj* (Bait-Shark) is conferred upon it in Bohuslän for its habit of stripping the long-lines and Haddock-lines of the bait.

FAM. LAMNIDÆ.

Two dorsal fins and one anal, the first dorsal opposite to the space between the pectoral and ventral fins. Eyes without nictitating membrane. Spiracles obliterated or minute. All the branchial apertures situated in front of the pectoral fins[a].

This family too contains large, not to say the largest Sharks, and has the same pelagic distribution as the preceding one, but is not so rich in forms. GÜNTHER includes in his *Catalogue* only 9 ascertained species. Most of these are characterized by large — one genus by exceedingly large — gill-openings. Some are formidable predatory fishes, with dentition as powerful as that of the preceding family or even more so; others — among them the largest Sharks — live on minute animals, and have extremely small teeth in proportion to the size of the body. These differences led GÜNTHER to divide the family into two subfamilies, which are represented in the Scandinavian fauna by the following three species:

[a] The last-mentioned character is adduced as being generally valid and distinct, and especially serviceable in cases where the presence or absence of a nictitating membrane cannot be controlled. Yet it happens, as in the Fox-Shark, that the character may easily lead to a misconception, the hindmost gill-opening approximating its lower end close to the beginning of the base of the pectoral fin, and being directed, as well as the penultimate opening, obliquely backwards and upwards above the said base.

A: Teeth large or middle-sized. The gill-openings extend only slightly, if at all, above the middle of the sides. — Subfamily *Lamninæ*.

a: Length of the caudal fin about half that of the body or even greater. Peduncle of the tail not keeled ... *Alopias vulpes*.

b: Length of the caudal fin much less than half that of the body. Sides of the peduncle of the tail furnished with a longitudinal carina in front of the caudal fin............ ... *Isurus cornubicus*.

B: Teeth extremely small, numerous, of a simple conical form. The gill-openings extend up the greater portion of the sides. — Subfamily *Selachinæ*....... *Cetorhinus maximus*.

GENUS ALOPIAS.

Caudal fin usually occupying more than half the length of the body. A transverse depression at its base above and below. No lateral carina on the tail. Teeth middle-sized, of a compressed triangular form, smooth-margined.

Of this genus, which possesses, in its so singularly elongated caudal fin, an unmistakable characteristic among all the Sharks, only one species is known. This is strictly a stranger to the Scandinavian fauna, but has been met with three or four times within the limits thereof.

THE FOX-SHARK (SW. RÄFHAJEN).

ALOPIAS VULPES.

Fig. 328.

Body, apart from the caudal fin, of a thick fusiform shape, almost clavate, the least depth being only slightly less or even more than half the greatest, which is contained about 4 times in the length of the body, excluding the caudal fin. Length of the short conical snout about $^1/_6$—$^1/_5$ of the interorbital width. Diameter of the eyes about half the length of the snout. Spiracles extremely small, situated in a groove exactly behind the eyes, from which they are separated by a distance equal to or half as great again as the diameter thereof. Gill-openings middle-sized (small, in comparison with those of the two following species). First dorsal fin situated about half-way between the tip of the snout and the base of the caudal fin, triangular, with the lower inferior corner but slightly prolongated. Second dorsal and anal very small, the former situated about two-thirds of the way between the first dorsal and the caudal and with its base in front of the perpendicular from the beginning of the anal fin. Pectoral and ventral fins rather large, especially the former, which are of a broad scythe-shape, their length being about $^1/_4$ of that of the body to the beginning of the caudal fin: ventral fins rather similar to the first dorsal. Caudal fin scythe-shaped, with a triangular flap near the tip of the inferior lobe. Coloration above slaty-gray, underneath white, these two colours being interspersed on the lower part of the sides.

Fig. 328. Fox-Shark (*Alopias vulpes*), $^1/_8$ nat. size. After TODD, in BROWN-GOODE.

Syn. Ἀλώπηξ, ARISTOT., *De Anim. Hist.*, lib. VI, capp. X et XI. *Singe de mer*, BEL., *Nat., Divers. Poiss.*, p. 88. *Vulpes*, RONDEL., *De Pisc.*, p. 387. *Squalus* cauda longiore quam ipsum corpus, ART., *Ichthyol.*, *Gen.*, p. 68; *Syn.*, pag. 96.

Squalus Vulpes, GMEL., *Syst. Nat. Lin.*, ed. XIII, tom. I, p. 1496; MITCH., Trans. Phil. Lit. Soc. N. York, vol. I (1815), p. 482; BLAINV. (*Carcharinus*), Bull. Sc. Soc. Philom. 1816, p. 121; CUV. (subg. *Carcharias*), *Règn. Anim.*, ed. 1, tom. II, p. 126; YARR., *Brit. Fish.*, ed. 1, vol. II, p. 379; BONAP. (*Alopias* ex RAFIN.), *Iconogr. Fau. Ital.*, *Pesci*, tab. 134, fig. 1; MÜLL., HLE (*Alopecias*), *Plagiost.*, p. 74; COUCH (*Carcharias*), *Hist. Fish. Brit. Isl.*, vol. I, p. 37, tab. VII; DUM. (*Alopias*), *Hist. Nat. Poiss.* (su. à BUFF.), tom. I, p. 421; BARB. BOC., CAP., *Peix. Plagiost.*, p. 14; GTHR (*Alopecias*), *Cat. Brit. Mus., Fish.*, vol. VIII, p. 393; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 208; 1879, No. 1, p. 102; MOR. (*Alopias*), *Hist. Nat. Poiss. Fr.*, tom. I, p. 287; DODERL., *Man. Ittiol. Medit.*, fasc. II, p. 52; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 300, tab. CLVII; PETERSEN, Vid. Meddel. Naturh. For. Kbhvn 1884, p. 160; DAY, *Fish. India* (Suppl.), p. 810; LILLJ., *Sv., Norg. Fau. Fisk.*, vol. III, p. 627; CAR., *Prodr. Faur Medit.*, vol. II, p. 507.

Alopias Macrourus, RAFIN., *Caratt. Alc. Nuov. Gen., Spec.*, p. 12.

The Fox-Shark attains a length of at least 5 m. (MOREAU) and a weight of 300 kilo. (DODERLEIN.) BUCKLAND cites[a] a specimen, taken by Mackerel-fishermen from Yarmouth, 44 dm. long, $17^1/_2$ dm. in girth, and weighing 500 lbs. ($226^3/_4$ kilo.), and another[b] measuring 45 dm., taken by Herring-fishermen from Folkestone.

Its geographical extension includes the Atlantic, Indian, and Pacific Oceans. Between the Cape of Good Hope and the Shetland Islands lies its Atlantic home, and in the Mediterranean it has been known time out of mind. Its comparatively large eyes suggest that it is more of a deep-sea fish than the other members of the family; but throughout its range it attracts attention at the surface in its pursuit of schooling fishes. The long caudal fin, which often projects out of the water on such occasions, has not only conferred upon the species its name, but has also given rise to the most fabulous accounts of its ravages. With its tail it lashes the waves and deals blows on the surface of the water that resound like a cannon-shot. Dolphins frightened by this noise have been seen to take to precipitate flight. It is quite credible that a whale may now and then have shown the same timidity. But from these observations, and owing to a confusion with the grampus (*Orca gladiator*), whose dorsal fin also appears above the surface, it has been concluded that the Fox-Shark is the relentless persecutor of whales and dolphins, though its dentition is far too weak for the achievements ascribed to it. "It is sometimes," says BUCKLAND, "called the 'thresher shark,' because it is said to inflict chastisement on the whale, though I can find no real authority for this being the case; nor can I see why the shark should flog the whale. The tail of the skate can, as I know to my cost, inflict severe wounds, and the tail of the sting-ray contains a dagger which is even more formidable still; I fancy, therefore, that the tail of the fox-shark is used by the owner as a weapon of defence, for if he chooses to use it, it would act like a waggoner's whip. Again, I think it just possible that, whereas we all know we can drive fish by long poles dashed suddenly into and about in the water, so the fox-shark may use his tail to splash about and drive the frightened herrings or mackerel into the position where they will be most handy for him to catch and swallow. I should imagine an unfrightened mackerel to be a difficult thing to catch when swimming at liberty in the sea. If, however, the fox-shark comes lashing about with his tail, he and his comrades would become confused, and while making up their minds what to do and where to go, they would suddenly find themselves going down the shark's throat. One thing is quite certain, his long tail would enable him to turn smartly round the corners and astonish unsuspecting natives."

In the stomach of a Fox-Shark 41 dm. long BUCKLAND found 27 Mackerel; and Herrings are devoured with equal avidity. Accordingly it happens often enough that the Fox-Shark gets entangled in the drift-nets shot for Mackerel and Herrings or in the tackle of the Pilchard-fisherman. On the other hand, it never takes a hook, which apparently proves that on the whole it is less rapacious than the other Sharks.

In the Mediterranean the Fox-Shark gives birth to its young during summer. In August DODERLEIN secured a young specimen 27 cm. long. During October BUCKLAND found in a large female from Folkestone an egg 76 mm. long and 63 mm. broad, on its backward passage through the oviduct, while the ovaries contained thousands of smaller eggs, from the size of a hazel-nut to that of a pin's head.

The Fox-Shark is, as we have mentioned, a stranger in Scandinavian waters. A female 429 cm. long was taken near Bergen on the 31st of August, 1868, and is described by LILLJEBORG. In Bunde-Fjord, about

[a] *Land and Water*, July 6, 1869, p. 608.

[b] *Nat. Hist. Brit. Fish.*, p. 221.

a league from Christiania, a specimen 16 dm. long was caught, according to COLLETT, on the 1st of February, 1878. PETERSEN cites a specimen "nearly 4 Danish ells ($8^3/_4$ ft.) long," that was cast ashore in December, 1886, off Tidsvilde on the north coast of Zealand. KRÖYER was besides informed on trustworthy authority that the Fox-Shark had once been met with on the west coast of Jutland.

The flesh of the Fox-Shark is "moderately good," says DÖDERLEIN, "though rather hard;" but at Cette it is sold, according to MOREAU, under the name of White Tunny (*Thon blanc*).

GENUS ISURUS.

Peduncle of the tail marked above and below with a transverse depression and furnished with a longitudinal carina on each side. Caudal fin crescent-shaped, its length much less than half that of the body. Teeth middle-sized, entire-margined, pointed, in adult specimens with[a] *or without*[b] *lateral cusps at the root.*

By its smooth-margined teeth, in the upper jaw too of a narrow triangular form or even subulately pointed, this genus is distinguished from *Carcharodon*, the most dreaded Shark of the Mediterranean and the tropics, often confounded with the Blue Sharks under the name of man-eater. In both these genera the spiracles, at least of adult specimens, are very minute or even obliterated.

In deference to the current rules of nomenclature the generic name of *Isurus*, coined by RAFINESQUE in 1810[c], must supersede the more generally employed *Lamna*, which was first proposed by CUVIER in 1817[d].

THE PORBEAGLE (SW. HABRANDEN).

ISURUS CORNUBICUS.

Plate LI, fig. 1.

Snout conically pointed, its length[e] *about $^3/_{10}$ (29—31 %) of that of the head (to the first gill-opening), which measures about $^1/_5$ (18—22 %) of that of the body. Teeth of a narrow triangular form, with a cusp on each side of the expanded root. Third tooth, counting from the middle, smaller than those beside it. Distance between the pectoral fins and the tip of the snout about $^4/_5$ (80—83 %) of that between the first dorsal fin and the same point. Coloration above slaty-gray, underneath white.*

Syn. *Porbeagle*, BORLASE, *Nat. Hist. Cornwall* (1758), p. 265, tab. 26, fig. 4. *Haae-Brand*, STRÖM, *Sondm. Beskr.*, part. I, p. 281. *Touille-Boeuf* ou *Loutre de mer*, DUH., *Tr. Pêches*, part. II, sect. IX, tab. XX, fig. 4. *Beaumaris Shark*, PENN., *Brit. Zool.*, ed. 1776, vol. III, p. 104, tab. XVII. *Le Nez*, BROUSSON., Mem. Acad. Sc. Paris 1780 (ed. 1784), p. 668. *Haabrand*, ASCAN., *Icon. Rer. Nat.*, tab. XXXI.

Squalus glaucus (*Haabrandsunge*), GUNNER., N. Vid. Selsk. Skr., Trondhj., vol. IV (Kbhvn, 1768), p. 1 (nom. erron.); STRÖM (*Haamar*), N. Saml. N. Vid. Selsk. Skr. Trondhj., vol. II (Kbhvn 1788), p. 335, cum tab.; RETZ., *Fna Suec. Lin.*, p. 307.

Squalus cornubicus, GMEL., *Syst. Nat. Lin.*, ed. XIII, tom. I, p. 1497; CUV. (subg. *Lamna*), *Regn. Anim.*, ed. 1, tom. II, p. 127; NILSS. (*Squalus*), *Prodr. Ichth. Scand.*, p. 116; ID., *Observ. Ichthyol.*, p. 13 (Disp. Lund, 1835); YARR., *Brit. Fish.*, ed. 1, vol. II, p. 384; BONAP. (*Lamna*), *Iconogr. Fna Ital.*, *Pesci*, tab. 134, fig. 2; SUNDEV., v. WR. (*Squalus*), *Skand. Fisk.*, ed. 1, p. 135, tab. 30; MÜLL., HLE (*Lamna*), *Plagiost.*, p. 67; GRAY (*Isurus*), *Cat. Chondropt. Fish. Brit. Mus.*, p. 58; KR. (*Lamna*), *Danm. Fisk.*, vol. III, p. 852; NILSS., *Skand. Fna, Fisk.*, p. 718; DUM., *Hist. Nat. Poiss.* (su. à BUFF.), tom. I, p. 405; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 389; v. BEN., *Poiss. Belg.*,

[a] Subgenus *Lamna*.

[b] " *Oxyrhina*

[c] *Caratt. Alc. Nuov. Gen., Spec.*, p. 11.

[d] *Regn. Anim.*, ed. 1, tom. II, p. 126.

[e] According to MALM this length, "measured along the surface" (not, as here, in a straight line), may amount to $^2/_5$ of that of the head.

p. 8 (Mem. Acad. Roy. Sc. Belg., tom. XXXVIII, 1871); Coll., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 208; Malm, *Gbgs. Boh. Fna*, p. 618; Mor., *Hist. Nat. Poiss. Fr.*, tom. I, p. 296; Doderl., *Man. Ittiol. Medit.*, fasc. II, p. 60; Mela, *Vert. Fenn.*, p. 365, tab. X; Möb., Heke, *Fisch. Osts.*, p. 151; Jord., Gilb., Bull. U. S. Nat. Mus., No. 16, p. 30; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 297, tab. CLVI; Storm, Norsk. Vid. Sels. Skr. 1883 (Trondhj. 1884), p. 44; Lilli., *Sv., Norg. Fna, Fisk.*, vol. III, p. 620; Car., *Prodr. Fna Medit.*, vol. II, p. 505

Squalus nasus, Walb., *Ichthyol. Art., Gen.*, p. 517

Squalus monensis, Shaw., *Gen. Zool.*, vol. V, p. 350; Cuv., l. c.; Yarr., l. c., p. 387.

(?) *Isurus Oxyrinchus*, Rafin., *Caratt. Alc. N. Gen. e Spec.*, p. 12, tab. XIII, fig. 1 (fide Doderl., figura tamen pessima fere potius ad *Isurum Spallanzanii* referenda).

due to the small, dense scales, which in a Porbeagle 13 dm. long are only $^1/_2$ mm. broad. On the upper parts of the body they are semicircular and thick, with 5 elevated, convex striæ, the ends of which project at the margin of the scale, forming rounded denticulations. On the under side of the body they have only 3 such ridges. On the fins they are set with equal denseness, but are smooth, as it were worn.

The head, like the body, is without prominent side-margins. The snout in front of the eyes and mouth is conical, its depth at the mouth being almost equal to its length. It is densely punctated (fig. 330) with

Fig. 329. Teeth of the upper and lower jaws in a Porbeagle (*Isurus cornubicus*) 213 cm long, $^1/_3$ nat. size; *a*, the first three pairs of teeth behind the gap (*diastema*) on the right side of the upper jaw, nat. size.

Squalus Selanonus, Leach, Mem. Wern. Nat. Hist. Soc., vol. II, p. 64, tab. II, fig. 2; Flmng (*Squ. selanoneus*), *Brit. Anim.*, p. 168 — *Selanonus Walkeri*, p. 169.

The Porbeagle ranks among the larger Sharks. Its ordinary length in Scandinavia, however, does not exceed $1^1/_2$—$2^1/_2$ m. In the Mediterranean it attains a length of at least 6 m.[a]

The body is almost terete, slightly compressed, rounded above and below, and pointed at each end. The greatest depth varies between about $^1/_5$ and $^1/_7$ of the length. The skin is everywhere rough as a file when stroked from behind, but not exactly rasping; in the opposite direction it is soft to the touch. This is distinct, impressed, muciferous dots, the mouths of Lorenzinian ampullæ, distributed in 6 broad, multiplex rows, which are separated by the same number of impunctate stripes, one in the median dorsal line, one vertically below this, and two on each side, all converging at the tip of the snout, which is also without punctures. Below the eye lies another row of similar dots. The eyes are round, closely bounded by the slightly oblong orbital margins. Their diameter is somewhat less than $^1/_3$ (27—31 %) of the length of the snout. In a dead specimen the pupil appeared to be somewhat oblong and obliquely set. There is no nictitating membrane. The nostrils are S-shaped and transversal, with

[a] Bonaparte even states "12 up to 20 or 24 feet," perhaps confounding the species with *Carcharodon Rondeletii*.

a very small flap (valvule) at the anterior margin. They lie so far in front of the perpendicular from the preorbital margin that the distance between them and the tip of the snout is about 80—90 % of that between the mouth and the same point, which latter distance is rather less than or sometimes equal to the length of the snout. The mouth is large, its breadth at the corners being somewhat more than $^1/_3$ of the length of the head. The cleft of the mouth is sharply curved, so that the lower jaw is rather long, and the distance from the corners of the mouth to the middle of the anterior margin of the upper jaw is about $^3/_{10}$ of the length of the head. Externally no dermal folds are visible on the jaws, for the small creases that lie above and below each corner of the mouth are concealed by

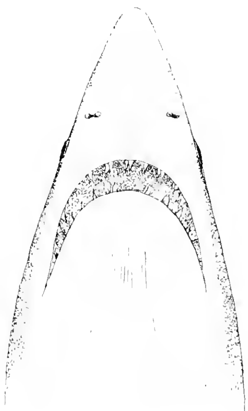


Fig. 330. Head of a Porbeagle (*Isurus cornubicus*) 213 cm. long, seen from below. $^1/_5$ nat. size.

the skin of the upper jaw. The teeth (fig. 329) are set in three rows. The anterior ones are the largest, measuring in a specimen 24 dm. long somewhat more than 12 mm. or $^1/_3$ of the diameter of the eyes. They are set rather far apart, of a narrow triangular form or conical, terete on the inner, but somewhat flattened on the outer side. The base of the broad root is emarginate, so that the tooth apparently has two fangs. In old specimens the root has a small conical cusp on each side; but this cusp is wanting in young specimens, sometimes even at a length of 9 dm. In both jaws we find at the extreme front a small gap, without middle tooth. The upper jaw has 14 or 15 (16) teeth in each row on either side, the number being alike both in young and old. The first two teeth are large, the third is rather small — and behind this lies a wide gap (*diastema*) the fourth and the following ones are again large, but gradually decrease in size, the hindmost teeth being comparatively minute. In the lower jaw there are 12 or 13 (14) teeth on each side. The gap at the extreme front is somewhat wider than in the upper jaw. The first and second teeth are the largest, the others decreasing in size behind. All the teeth are slightly recurved.

The spiracle of the Porbeagle is extremely small, resembling a hole pierced with a coarse pin. It lies exactly behind the eye, separated therefrom by a distance of twice the diameter thereof or somewhat more in large specimens. It is consequently situated rather further back than in most of the other Sharks, and has many times defied detection, being probably obliterated. All five branchial apertures lie in front of the pectoral fin, the lower end of the hindmost opening terminating close below the margin of this fin. This opening is, however, obliquely set, being considerably approximated below to the penultimate aperture. In the dermal fold that covers each opening, lie three parallel cartilaginous rays (radiating extrabranchial cartilages, see above), originating from the middle of each arch and extending to the edge of the opening.

The body itself is almost terete, with indistinct lateral line, which is best marked in dried skins. From the temporal region, above and behind the eyes, the line forms a slight curve above the gills and then proceeds in a straight direction to the lateral carinæ of the tail. These occupy, immediately in front of the caudal fin, one-fifth of the length of the body behind the head. They have an almost sharp, curved outer margin, and are so large that their breadth is $^2/_3$ of the greatest breadth of the body, and that the tail just in front of the caudal grooves is more than four times as broad as deep. The caudal grooves above and below are deep and clothed with finer scales than the rest of the skin.

The first dorsal fin is rather large, its base measuring about $^1/_9$, the length of its anterior margin $^1/_7$—$^1/_6$, and its height about $^1/_8$, of the entire length of the body. Its beginning lies at a distance from the tip of the snout measuring about 30—32 % of the length of the body. In form it resembles an almost equilateral triangle, with a large rounded incision above the elongated posterior angle. The posterior dorsal and the anal fins are almost similar in form and size, and lie opposite to each other — the former, however, a little further back, at a distance from the first dorsal measuring about 28—26 % of the length of the body. They are rather small, their bases measuring about $^1/_7$—$^1/_6$ of that of the first dorsal fin. Their anterior (upper) angle is rounded, the posterior acutely elongated. The distance between the anal fin and the tip of the snout is nearly $^2/_3$ of the length of the body. The superior lobe of the caudal fin, which is of the crescent-shaped form that characterizes most of the members of this family, measures about $^1/_4$ of the remaining length of the body, and is strongly curved in an upward direction, with a pointed and exceedingly small terminal lobe. The inferior lobe, on the other hand, is larger than in most of the other Sharks, at least somewhat more than half as long as the superior. The pectoral fins are from $1^1/_2$ times to nearly twice as long as the anterior margin of the first dorsal fin, and their length is rather more than $^1/_6$—$^1/_5$ of the entire length of the body or about equal to the distance from their base to the corner of the mouth. Their breadth is somewhat more than half their length. The ventral fins are small, with the outer angle obtuse and the posterior acute. Their length throughout the inner margin (the base together with the posterior lobe) is about $8^1/_2$ % of the length of the body. They are set a little behind the middle of the body.

Besides the pterygopodia of the males — which in a specimen $22^1/_4$ dm. long were 247 mm. in length and 25 mm. in diameter — SUNDEVALL remarked that it appeared to him as if another external sexual character were expressed in the form of the second dorsal and the anal fins, which seemed to have the posterior tip much more elongated in the males than in the females.

The coloration is above of a blue-black gray, underneath white, the posterior angles of the dorsal fins being also whitish. The iris is dark brown.

The Porbeagle is somewhat variable in form. In a number of cases, both male and female, the body is rather slender (greatest depth $^1/_7$—$^1/_6$ of the entire length), the dorsal fin comparatively high and rectilinear, the snout short and narrow (length of the snout in adult specimens about $^1/_5$ of the distance between its tip and the pectoral fins), the inferior caudal lobe $^2/_3$ as long as the superior, or even more, and the hindmost gill-opening distinctly oblique. This form is apparently the commoner. Other specimens present the appearance shown in our figure (Plate LI, fig. 1). They are thicker (greatest depth up to $^1/_5$ of the entire length), with somewhat larger head and thicker, longer snout (length of the snout up to $^1/_4$ of the distance between its tip and the pectoral fins), with the inferior caudal lobe little more than half as long as the superior, and with the hindmost gill-opening somewhat less oblique. This latter form seems in general to be characteristic of youth. Our figure was drawn in Bohuslän from a young specimen $13^1/_3$ dm. long. But that this form has representatives even among full-grown Porbeagles, seems probable from the descriptions given by the authors cited above (in the synonymy) of *Squalus monensis*, whereof YARRELL mentions a specimen 29 dm. long.

The remaining alterations of growth consist principally in the relative reduction with age of the snout and eyes and the furnishing of the teeth with basal cusps, which are wanting in the smallest specimens, but in Porbeagles 13 dm. long are already quite distinct.

The Porbeagle is the only one among the large Sharks that appears with any frequency in the south of the Cattegat; but it is far from common on the coasts of Sweden. It occasionally makes its way through the Sound into the Baltic, and it has been met with, according to MELA, even in the vicinity of Åland. Along the Norwegian coast it occurs up to Finmark, where it is found rather often, according to COLLETT, except to the extreme north. Its ordinary name in Norway, as in Bohuslän, is *Habrand;* but it is said to be sometimes coupled with the Greenland Shark under the name of *Hamar*. As it had no Danish name, KRØYER called it *Sillhaj* (Herring Shark). The Porbeagle is dispersed throughout the North Sea, though it is not so common there as on the west coasts of the United Kingdom and France; and its greatest development seems to be attained in the Mediterranean. On the other side of the Atlantic it has been found off the east coast of the United States; and according to MÜLLER and HENLE's determination of the jaws sent by BÜRGER from Japan to the Museum of Leyden, the Porbeagle also occurs in the Pacific off the Japanese coasts. HAAST includes the species among the fishes of New Zealand.

The appearance of the Porbeagle is even more repulsive than that of other Sharks. It emits an extremely disagreeable, fetid smell, and the surface of the body, which is yielding and at several spots flabby, acquires a dirty look from the secretion of tough mucus. This is especially copious at all the orifices, and it was this uncleanness, which is shared by the whole phalanx, that suggested the ancient name of *Squalus*[a]. Furthermore, the profile of the Porbeagle indicates far more stupidity in combination with ravenousness than that of other Sharks. The Porbeagle is said to be a more rapid swimmer than most of them, a statement apparently borne out by the powerful caudal fin and the keeled, robust tail, which in nearly all fishes is the principal organ of locomotion.

The food of the Porbeagle consists chiefly of fishes and Cephalopods. The Herring-shoals in particular suffer greatly from its depredations; and several Porbeagles often join company in the chase. Like the preceding species these Sharks too sometimes become entangled in Herring or Pilchard nets. Deep-sea lines do not escape their ravages (THOMPSON and DAY); and many a narrative relates how the Porbeagle dashes up to secure the Whiting, Cod, or other fish which the fisherman has hooked.

Of the breeding of the Porbeagle not much is known. The young are considerably developed at birth. The fœtus described by GUNNERUS, which was taken out of the mother-fish in summer, measured "nearly three-quarters of a Zealand ell" (47 cm.) in length. SUNDEVALL examined a young specimen 74 cm. long, and found that every external trace of the navel, which is situated in the Sharks between the pectoral fins, had disappeared. Hence he concluded that the length of the young at birth must be between these two dimensions. In a female cited by PENNANT only two fœtuses were found.

The Porbeagle is not much sought after by Scandinavian fishermen, for the liver is small and lean, with a scanty yield of oil, and it is only for this sake that the large Sharks are taken. By accident, however, or in the absence of better fish, the Porbeagle is caught by the Norwegian Shark-fishermen. In the south of the Cattegat and in the Sound it is scarcely ever taken except when it entangles itself in the nets set for other fishes. The skin is fairly well adapted for the polishing of articles of fine workmanship, in wood or horn for instance, and it is also applied to this purpose. The hard scales withstand a considerable amount of wear.

The flesh of this species, like that of many other Sharks, has a disagreeable smell, and it is hardly eaten in Sweden; but in Italy and Spain it enjoys a better reputation.

(SUNDEVALL, SMITT.)

GENUS CETORHINUS[b].

Teeth numerous, small, conical. Branchial arches furnished with baleen-like, fine, long, and dense gill-rakers. Anterior gill-openings extended across the greater part of the sides of the body. Tail with transverse grooves in front of the caudal fin and with the sides longitudinally carinated. Caudal fin crescent-shaped.

The genus of the Basking Shark occupies within the Lamnoid family a position analogous to that of the Hounds in the preceding family; but in the Basking Shark, the solitary species of the genus, the reduction of the jaw-teeth has advanced still further, these organs having scarcely retained any function, at least in the capacity of Shark-teeth. The genus consequently does not belong to those commonly known as predatory fishes; but it contains the most gigantic piscine forms. As we have mentioned above, it shares with another genus of huge fishes (*Rhinodon*) a manner of life similar to that of the large whales. Notwithstanding its own great size, it lives exclusively on minute creatures, which it strains off from the seawater by means of its gill-rakers. This manner of procuring food calls for a wide mouth and a capacious pharynx, with room for the filtering apparatus; and herewith is connected the great width of the branchial arches and apertures. In the remaining characters we easily recognise a form akin to the Porbeagle. The most important external difference to be found on comparison is that in the Basking Shark the second dorsal fin stands entirely in front of the perpendicular from the beginning of the anal fin or nearly so.

The name of *Cetorhinus* means *Whale-Shark*, and has reference in the first place to the dimensions of

[a] From the Latin *squalor*, *filth*.

[b] BLNVLLE, Bull. Soc. Philom. Paris, 1816, p. 121.

THE BASKING SHARK (SW. BRUGDEN).

CETORHINUS MAXIMUS.

Fig. 331.

Form of the head in old specimens fairly normal, with short, bluntly pointed, conical snout, in the young (up to a length of 3—5 m.) contracted in front of the mouth into a semicylindrical, inferiorly flat forepart (orbitorostral portion), with dorsally pointed tip of the snout. The small spiracles situated high up, just behind the perpendicular from the corners of the mouth or further back, sometimes about half-way between the eyes and the top of the first gill-opening. Coloration above of a brownish or bluish black, underneath lighter, shading into white. The soft snout, with its numerous pores, reddish.

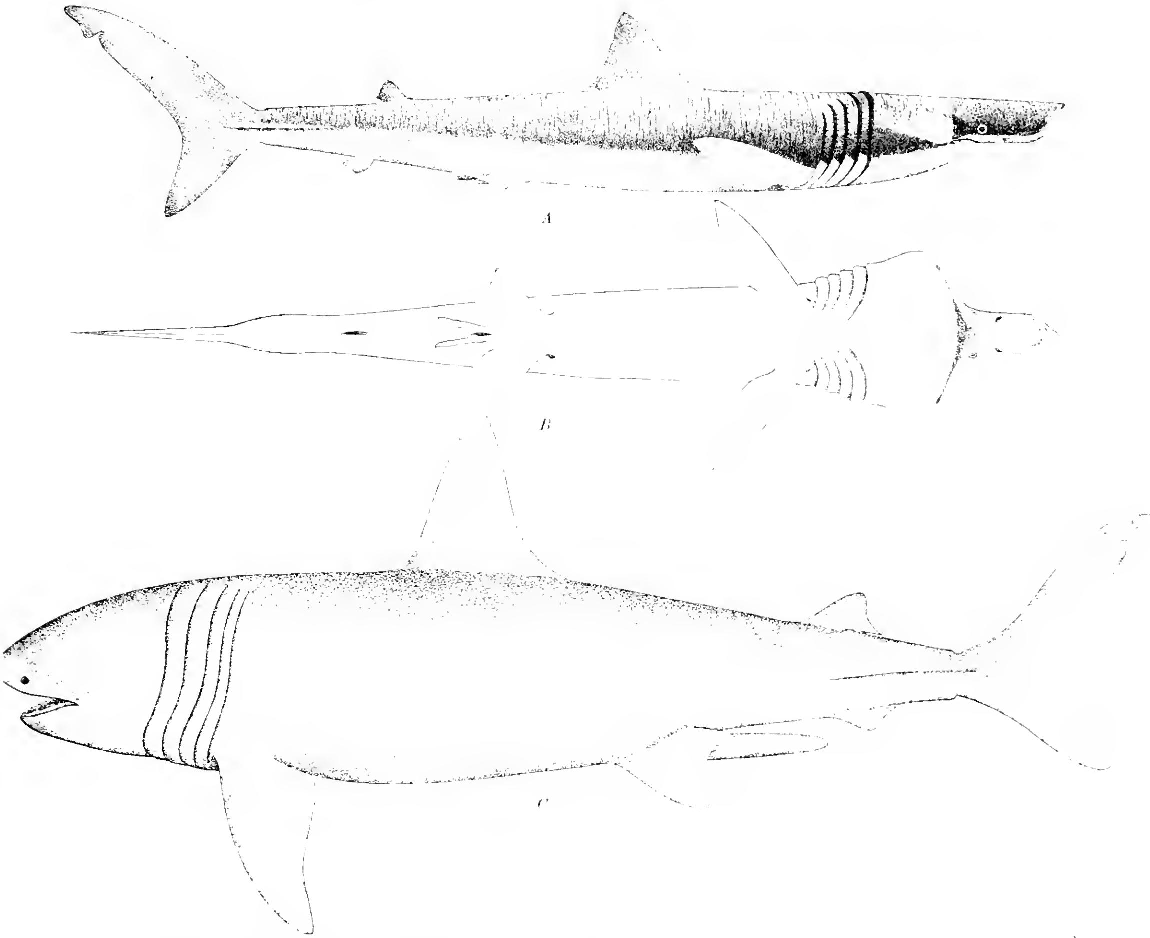


Fig. 331. The Basking Shark (*Cetorhinus maximus*): *A* and *B*, a young specimen in the Museum of Genoa University, after PAVESI, 1/13 nat. size; *C*, the specimen described by BLAINVILLE (*Squale pèlerin*, Nov. 21, 1810, Dieppe), about 1/34 nat. size, after TURTON's copy of BLAINVILLE's figure.

Syn. *Brygde*, STRÖM, *Sondm. Beskr.*, pt. I, p. 273. *Beinhaakall*, OLAFS., *Reis. Isl.*, p. 988.

Squalus maximus, GUNNER., Trondhj. Selsk. Skr., vol. III, p. 33, tab. II; vol. IV, p. 14, tab. IV, fig. 1; LIN., *Syst. Nat.*, ed. XII, tom. I, p. 400; PENN. (*Basking shark*), *Brit. Zool.*, vol. III (ed. 1776), p. 89, tab. XIII; (?) FABR., *Fna Groenl.*, p. 130; MITCH., Trans. Litt., Phil. Soc., N. York, vol. I, p. 486; CUV. (subg. *Selache*), *Regn. Anim.*, ed. 1, tom. II, p. 129; FAB., *Fisch. Isl.*, p. 20; NILSS. (*Squalus*), *Prodr. Ichthyol. Scand.*, p. 111; YARR. (*Selachus*), *Brit. Fish.*, ed. 1, vol. II, p. 396; MÜLL., HLE (*Selache*), *Plagiost.*, pp. 71 et 191; DEK. (*Selachus*), Zool. N. York, pt. III, p. 357, tab. 63, fig. 208; KR. (*Selache*), *Danm. Fisk.*, vol. III, p. 932; NILSS., *Skand. Fna, Fisk.*, p. 720; COUCH, *Fish. Brit. Isl.*, vol. I, p. 60, tab. XIV (+ *Polyprosopus Rashleighanus*, p. 67 + *Polypr. macer*, p. 68, tab. XV et vol. IV, p. 421, tab. XV*); DUM., *Hist. Nat. Poiss.* (su. à BUFF.), tom. I, p. 413, tab. 3, fig. 18; STOR. (*Selachus*), Mem. Amer. Acad. Arts, Sc., n. ser., vol. IX, p. 229, tab XXXVII, fig. 3; GTHR (*Selache*), *Cat. Brit. Mus., Fish.*, vol. VIII, p. 394; STRP (*Selachus*), Overs. D. Vid. Selsk. Forh. 1873, p. 47, tab. II; PAV., Ann. Mus. Civ. Genova, vol. VI (1874), p. 5, tabb. I—III; vol. XII (1878), p. 348, tab. III; COLL. (*Selache*), Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 209; (*Selachus*) ibid. 1879, No. 1, p. 103; GERV., P et H. (*Squalus* 1. *Cetorhinus*), *Journ. Zool.*, tom. V (1876), p. 319; LTKN (*Selachus*), Vid. Meddel. Naturh. For. Kbhvn 1879—80, p. 62; MOR. (*Selache*), *Hist. Nat. Poiss. Fr.*, tom. I, p. 305; DODERL., *Man. Ittiol. Medit.*, fasc. II, p. 70; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 303, tab. CLVIII, fig. 1; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 633.

Squalus Gunnerianus, BLNVLLE, *Journ. Phys.*, tom. LXXI (1810), p. 256, tab. II (+ *Squ. pelegrinus* + *Squ. Homianus*, p. 257); ID., *Squ. Pélerin*, Ann. Mus. D'Hist. Nat., tom. XVIII (1811), p. 88, tab. 6; ID., *Cetorhinus Gunneri* + *Cet. Peregrinus* + *Cet. Shavianus* + *Cet. Homianus* (?), Bull. Sc. Soc. Philom. 1816, p. 121.

Squalus isodus, MACRI, Att. Accad. R. Sc. Borbon., Nap., vol. I (1819), p. 55, tab. I, fig. 1; tab. II, fig. 2 (+ *Squ. rostratus*, p. 76, tab. 1, fig. 2). *Squalus* (*Cetorhinus*) *rostratus*, CORNISH, Zoologist, vol. XXVIII (1870), p. 2259.

Squalus elephas, LESUEUR, Journ. Acad. Nat. Hist. Philad., tom. II (1882), p. 343.

The Basking Shark attains a length of at least about 13 or 15 m. Larger specimens are cited; but the accounts of these do not admit of satisfactory verification. GUNNERUS states, for instance, that specimens have been met with measuring 16 fathoms (30 m.) in length and 3 fathoms ($5\frac{1}{2}$ m.) in breadth. A specimen of this size would yield over 28 hectolitres of liver; and according to a statement in COLLETT a Basking Shark was harpooned in West Fjord about 1868 that contained 23 *tunnor* (27 hectolitres) of liver. NILSSON was informed by the fishermen on the west coast of Norway with whom he conversed in 1826, that they harpooned Basking Sharks every year considerably more than 40 ft. (12 m.) long, and that the liver of each fish filled 10—12 *tunnor*. The largest Basking Sharks they had seen, had yielded 14 *tunnor* of liver.

Apart from the above-mentioned characters, the Basking Shark in form of body rather closely resembles a Porbeagle, being of a terete, fusiform shape, on the back rather flat, behind with some lateral compression, though broadened by the lateral carinæ of the tail, which render the breadth of this part greater than the depth. The greatest depth of the body measures in young specimens, according to PAVESI, about 10—12 % of its length, in old, according to BLAINVILLE, about 18 %, according to DODERLEIN as much as 22 %, of the same.

The different form of the head in the young and old we have remarked above. The alteration is essentially due to the position of the cleft of the mouth, which in the young is transverse, as in the Rays, in the old curved, as in other Sharks. The corners of the mouth, which during youth are directed straight outwards, form the rounded protuberances on the sides of the head behind the eyes. In the jaws the recurved, conical, but sharp-edged, pointed teeth are set in 4—7 transverse rows, but are so small that they "are often concealed by the gums and accumulated filth" (GUNNERUS). In a Basking Shark 39 dm. long they are 3 mm. high, according to LILLJEBORG. STORER counted 1,400 teeth in the lower jaw. The nostrils lie on the under surface of the snout, but close to either side-margin, much nearer to the eyes than to the tip of the snout. The relative length both of the snout and the entire head is considerably greater in the young than in the old. In the former, according to PAVESI, the length of the snout is about $\frac{1}{10}$ or $\frac{1}{13}$ of that of the body, in the latter $\frac{1}{30}$ of the same or less. The length of the head to the first gill-opening is in the former about $\frac{1}{4}$—$\frac{1}{5}$, in the latter at most less than $\frac{1}{6}$, of the length of the body*. The eyes, which are round and small, undergo, as usual, the same alteration of growth. According to PAVESI the diameter of the orbit in the young is about $\frac{1}{6}$ of the breadth of the head at the base of the snout; according to STORER this diameter measures in an older specimen $\frac{1}{8}$ of the interorbital width. The gill-openings extend across so considerable a portion of the sides (the throat) that the distance between the tops of the first pair is only twice

* According to STORER the length of the head in a specimen $9\frac{1}{4}$ m. long was 15·7 % of that of the body.

the diameter of the orbits, between those of the second pair three times the same diameter, of the third pair five times, of the fourth pair seven times, and of the fifth pair nine times, in each case according to STORER'S measurements. The gill-rakers (fig. 332) have claimed a special chapter in literature. They are long and fine, apparently corneous, transversal setæ, uniserial on the first and last branchial arches, biserial on the others. Even GUNNERUS described them[a] as forming a kind of strainer; and a very characteristic indication of their structure is his opinion that it was by clinging to them that the prophet Jonah escaped being engulfed in the maw of his captor — a Basking Shark, not a whale, being the monster that swallowed this remarkable man. In 1867[b], without knowing what the objects were or whence they had come, but guided by their microscopical texture, HANNOVER determined some dry fragments of these gill-rakers, preserved in the Museums of Copenhagen, Kiel, and Christiania, as a kind of squamous or spinous growth belonging to some Ray. The same texture, answering to that of dentine, was detected by v. BENEDEN in 1871[c] in similar substances from the Antwerp Crag, and he assigned them to a Ray otherwise unknown, which he called *Hannovera aurata*. STEENSTRUP (l. c.) and, after him, GERVAIS (P. and H., l. c.) have since maintained both that these gill-rakers afford one of the most important characters of the genus *Cetorhinus*, and that v. BENEDEN'S find carries the existence of the genus back at least to the Tertiary epoch.

The fins are very like those of the Porbeagle; but their outer (posterior) margin is less incurved. The first dorsal begins at a distance from the tip of the snout measuring about 40—36 %, and its base occupies about 10—9½ %, of the length of the body. Its height sometimes measures, according to STORER, 14½ % of the length of the body. The distance between the two dorsal fins is about 18½—19 % of the said length. The second dorsal and the anal fins are about ⅓ as large as the first dorsal. The superior caudal lobe measures about 19—21 % of the length of the body, and the inferior lobe is about ⅔ as long. The median breadth of the caudal fin, from the upper transverse groove, is about equal to the length of the base of the first dorsal. A little within the tip the under margin of the superior lobe has the same notch as in the Porbeagle. The pectoral fins are rather more than twice as long as broad. Their length is about 18 % of that of the body. The ventral fins, according to PAVESI'S figures, are obliquely quadrangular. Their length is about the same as the breadth of the pectorals. The preabdominal length is about equal to the distance between the beginnings of the two dorsal fins.

The thick skin is armed with sharp and strong spines — small in comparison to the size of the body.

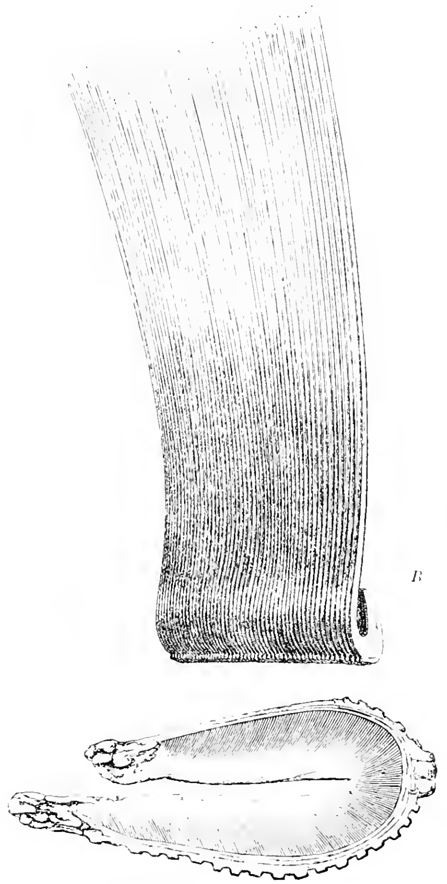


Fig. 332. Gill-rakers of the Basking Shark. *A*, an excised branchial arch, on a reduced scale, after E. PERCEVAL WRIGHT (*Nature*, vol. XIV (1876), p. 313); *B*, part of a row of gill-rakers, nat. size, after HANNOVER and STEENSTRUP.

[a] . . . "fine, stiff, lustrous black strings, resembling bristles or horse-hair, all with one end attached to and hanging over one side of a round, cartilaginous arch, of a thumb's thickness".

[b] D. Vid. Sels. Math. Natur. Skr., 5:te Række, Bd VII, p. 489.

[c] Bull. Acad. Roy. Belg., ser. 2, tom. XXXI, p. 504, pl. II, fig. 16.

but large enough to draw blood from the finger, if incautiously handled — gathered in patches or series, with interstices between, that give the body an appearance like that of elephant-hide. Hence the name conferred upon the species by LESUEUR.

The Basking Shark is a pelagic fish of the North Atlantic[a], whose manner of life calls to mind in many ways that of the whales, which it also rivals in size. A line between North Africa and Virginia forms the southern limit of its geographical range, so far as this has been investigated up to the present time; and the species roves northwards to Iceland and the extreme north of Norway, even to Varanger Fjord, principally, no doubt, within the area of the Gulf Stream. At all events it does not appear to be, strictly speaking, an arctic fish; and the old accounts from Greenland of an immensely large Shark, which was said to devour dolphins (especially whitefish), rorquals, and humpbacks, whereon FABRICIUS based his statement[b] that the Basking Shark occurred on the coast of Greenland, have been assigned by LÜTKEN (l. c.) to the category of fables. The comparatively small eyes and the firm, thick skin are in themselves sufficient to suggest that the Basking Shark is no deep-sea fish, properly so called; and the probability that its life is passed in the upper levels of the ocean is further increased by the nature of the food to which it is evidently referred. As yet, it is true, we know but little of the bathymetric distribution in the open sea of those minute creatures — chiefly lower crustaceans, in general so-called *Entomostraca*, and the larvae or even the eggs of fishes and invertebrates — which compose the diet both of the large whales and the Basking Shark. Investigations into the biological conditions at various depths in the high seas, vigorously pursued as they have been since first instituted by the Swedish expedition in 1869 on board the corvette *Josephine*[c], have still much left to teach us. But we already know that the supply of animal food of this kind in the upper strata of the open sea is plentiful at depths varying with the changes of the weather or the set of the currents, and that it fluctuates at different seasons of the year. Guided hereby, the Basking Shark too probably shifts its quarters. The course taken by the Gulf Stream affords an explanation why the Basking Shark is found more frequently off the north of Norway than on the south coast and has never been met with in the Skager Rack or Cattegat. In the North Sea it is rarer than on the west and south coasts of Great Britain and Ireland. On the west coast of France and in Portuguese waters it has been taken once or twice. It penetrates into the Mediterranean through the Straits of Gibraltar (DODERLEIN). On the east coast of North America it occurs in the same manner as on this side of the Atlantic.

The Basking Shark is a peaceable and sluggish creature, harmless to man or other animals of any magnitude, and asserting its presence only by roving in quest of food at the surface, sometimes with snout above the water. When it accelerates its pace, cleaving the waves with the projecting dorsal and caudal fins, and when it swims in a company of several, one behind another, it presents an appearance that may well have dictated an occasional contribution to the history of the great sea-serpent. Or the same phenomenon may be suggested to the imagination by a sight of this fish as it lies during calm weather in repose at the surface, often with the belly upwards, and as the waves lap its rotund body. The name of Basking Shark was conferred upon it by PENNANT in exchange for the older name of *Sun-fish* employed on the Irish and Welsh coasts, an allusion to its habit of lying motionless at the surface, as if basking in the sun. Yet extremes meet, even in the temperament of the Basking Shark; and it has sometimes been seen to leap several feet out of the water.

In spring the Basking Shark approaches the Irish coast. Whether this is done for purposes of propagation, is unknown. PENNANT found in a female a fœtus about 3 dm. long; but he does not state the time of year. On the west coast of Ireland, about 100 miles west of Clew Bay, is a bank long celebrated for its Basking Shark fishery. Off Tory Island too (N. W. coast of Ireland) companies of 60 to 100 Basking Sharks have been seen. In certain years they are commoner; during others they perhaps do not put in an appearance. From this locality they seem to migrate northwards along the west coast of Scotland.

[a] BROWN-GOODE indeed states (*Fisher., Fisher. Industr. U. S.*, sect. I, p. 669) that the Basking Shark is not unfrequently harpooned by whalers on the Pacific coast, where a specimen of this species was examined at Monterey (California) by JORDAN and GILBERT; but in their *Synopsis of the Fishes of North America* the latter writers do not mention a word about this.

[b] *Fna Groenl.*, p. 130.

[c] See SMITT: *De senaste årens undersökningar om hafsfaunans gräns mot djupet*, in the periodical *Framtiden* for 1870, p. 345.

"The Basking Shark fishery," writes NILSSON from notes taken about seventy years ago, "commences on the west coast of Norway about the middle of August. The boats used are about 18—20 ells (107—119 dm.) long, carry all the tackle requisite for the fishery, and are manned by a crew of four. These boats cruise along the coast, and the Shark generally appears in their wake and comes close to the boat, but is sometimes found lying still at the surface. One of the crew then takes the harpoon, which is furnished with a long shaft (a pole), and plunges it with all his might into the fish. The others lend a helping hand, 'but the moment the bone is touched, he plunges to the bottom.' The harpoon-line, which is about 14—15 score fathoms (530—565 m.) long, and which lies coiled up (*kveilet*) and clear, runs out so rapidly that water must be poured on the bulwark to prevent it from catching fire. On reaching the bottom the Basking Shark swims along until exhausted, towing the boat out to sea. Sometimes, if lean, it can hold out for twenty-four hours; if fat, it gives in after three or four hours. When it is tired out, they haul it up alongside the boat, and with a long knife cut the tail in front of the caudal fin, not quite off, for, if so treated, it would stave in the boat with lashes of the maimed limb; they leave a part of the fin hanging fast. Afterwards they stab it to death with lances; then turn it belly upwards in the water, and lash it fast to the mast. Now one of the fishermen takes a long knife and cuts out a great piece at the fore end of the liver, whereupon he inserts his arm and severs all the bands and ties of the liver. Finally he cuts open the belly with a single slit, when the liver comes out and floats on the water like a bolster; but at the same moment the water rushes into the belly of the fish, and the lashings must be cut loose with haste, or the boat will sink." This fishery was commenced, according to GUNNERUS, at the middle of the eighteenth century, and was still practised, according to NILSSON, in 1820—1830; but it has now been abandoned as a special occupation, and for the last forty years the Basking Shark has been spoken of in Norway almost as a rarity.

The Basking Shark is most sought after for its liver, which yields an excellent oil; but according to GUNNERUS the poor at least were accustomed in his time to cut *rákling* and *raf*[a] from the flesh of the Basking Shark. The outer skin is used for polishing purposes; and the thick true skin is manufactured into saddles and shoe-soles.

The Norwegian name of the Basking Shark is pronounced both *brugde* and *brygde*. OLAFSEN cites from Iceland the names of *Ryner* and *Beinhaakal* (Bony Greenland Shark), the latter having reference to the greater firmness which its skeleton displays than that of the Greenland Shark and of the smaller Sharks. In England too it is known as the Bone Shark.

FAM. SCYLLIIDÆ.

Two dorsal fins and one anal, the first dorsal situated above the ventral fins or behind the perpendicular therefrom: none of them with spine. Eyes without nictitating membrane. Spiracles open, comparatively large.

Sharks of rather considerable dimensions and sometimes dangerous to man[b] are indeed not wanting within the present family, but most of the 25 species are middle-sized or small. By GÜNTHER the Scyllioids are distributed among 7 genera. From the preceding Sharks they differ both in form of body and manner of life. Instead of pelagic rovers we here meet for the most part with bottom-fishes and littoral species of nocturnal habits, hiding themselves by day among seaweeds, on the sand or under rocks, where they lurk for prey. The fins are consequently of a more rounded or truncate form. The tail too is straighter, running in a line with the trunk, and without any marked upward curvature of the caudal fin, the tip of which forms a diphycercal lobe, in most cases not very obliquely cut, the anterior part of the lower caudal lobe being similar in shape to the anal fin. Another character of fairly general validity in this family is the great development of the nostrils, which is frequently so advanced that these apertures are confluent, as in the Rays, with the

[a] See above, p. 415.

[b] The Australian *Wobbegong* (*Crossorhinus*), see HILL in TENISON-WOODS, *Fish and Fisheries of N. S. Wales*, p. 94.

mouth, being separated from each other and covered within by a sometimes continuous nasal valvule. The mouth too of some forms is set very far forward, close to the tip of the snout, and fringed with dermal flaps. None of these Sharks gives birth, so far as is known, to living young.

Within the Scandinavian fauna three species have been observed, belonging to two very similar genera:

A: Dorsal margin along the beginning of the caudal fin armed with spines ... *Pristiurus catulus.*

B: Dorsal margin without special spiny armature.

a: Inner posterior corners of the ventral fins acutely prolongated, in the males coalescent with each other . *Scylliorhinus canicula.*

b: Inner posterior corners of the ventral fins obtuse, in the males separated from each other .... *Scylliorhinus stellaris.*

Obs. DE FILIPPI and VERANI[a] have described from the Mediterranean a *Scyllium acanthonotum*, distinguished by a row of spines on each side of the back, extending from the middle of the head nearly to the end of the first dorsal fin. Of the *species*, however, they had seen only a young individual with vitelline capsule attached. GÜNTHER[b] was of the opinion that this young specimen belonged to one of the above-mentioned *Scylliorhini*; GIGLIOLI[c] referred it to *Pristiurus*. The correct explanation may be left to the future; but it seems likely that the spiny armature is a character of youth which disappears entirely in *Scylliorhinus*, partially in *Pristiurus*.

GENUS **PRISTIURUS**[d].

Nostrils so remote from each other and from the mouth that the distance between their inner angles is perceptibly greater than that between either of them and the mouth, somewhat greater than their length, and about equal to the distance between their outer angles and the orbital margin. Distance between the mouth and the tip of the snout greater than the postorbital length of the head (to the first branchial aperture). Anterior part of the upper caudal margin (fig. 333, *a*) *armed on each side with a row of retral serrated spines.*

This genus contains only one species, which is more nearly approximated by the situation and delimitation of the nostrils to the preceding genus than is the case with the succeeding one. It also has a more finely shagreened skin than *Scylliorhinus*. In these Sharks, as we have seen in numerous Teleosts, e. g. the Gobies and Salmons, the scales of the tail are larger than those on the anterior part of the trunk. Here we also find that the placoid scales of the tail approach more and more to the form of the jaw-teeth, least so, however, in *Pristiurus*. Besides the above-mentioned characters this genus displays the peculiarity that the tip of the tail is bent downwards, whereas in the following genus it is straighter. The egg-capsules of *Pristiurus* (fig. 333) are distinguished by the absence of horns at the extremity directed backwards in the uterus, which end is rounded by the incurvature of the corners and incised at the tip, while the horns at the other end, one at each corner, are as short as in the egg-shells of the Rays.

a

Fig. 333. Egg-capsule of the Black-mouthed Dog-fish (*Pristiurus catulus*) from the fishing-bank of Jäderen. Nat. size. *a*, a part of the upper edge of the caudal fin in a Black-mouthed Dog-fish 67 cm. long, superior aspect, × 5 to show the serrated spines and the scale-rows on the dorsal margin between them.

[a] Mem. R. Accad. Sc. Torino, ser. 2, tom. XVIII (1859), p. 193, tab., fig. 2.
[b] *Cat. Brit. Mus., Fish.*, vol. VIII, p. 403.
[c] Espos. Intern. Pesca Berlin 1880, Sez. Ital., p. 112.
[d] BONAP., *Fna Ital., Pesci*. Established as a subgenus of *Scyllium*.

THE BLACK-MOUTHED DOG-FISH (SW. HAGALEN).

PRISTIURUS CATULUS.

Plate LI, fig. 2.

Coloration above of a reddish or brownish gray, with spots darker than the ground-colour but with a lighter border, and varying in size and form, usually larger, quadrangular or rounded, next the back, smaller down the sides. Dorsal fins behind, the other unpaired fins at the base more or less cinereous, at the tops darker. Pectoral and ventral fins of the same colour as the back or sides, but immaculate, paling outwards. Ventral side white. Mouth and pharynx, as well as the branchial cavity and peritoneum, black. Iris light blue.

Syn. *Haa-Girle*, STRÖM, *Sondm. Beskriv.*, part. 1, p. 283.

Squalus Catulus (*Haae-Galen*), GUNNER., Trondh. Selsk. Skr., vol. II, p. 235; ASCAN. (*Rodhaae*), *Icon. Rer. Nat.*, tab. XXXVIII; RISSO, *Ichth. Nice*, p. 30 (p. p.; feminam *Scylliorhini caniculæ* credidit); LILLJ. (*Pristiurus*), *Sv., Norg. Fna, Fisk.*, vol. III, p. 657.

Galeus melastomus, RAFIN., *Caratteri N. Gen., N. Sp.*, p. 13; YARR., *Brit. Fish.*, vol. II, ed. 1, p. 375 (*Scyllium*), ed. 2, p. 495 (*Pristiurus*); BONAP. (*Pristiurus melanostomus*), *Fna Ital., Pesci*, tab. 131, fig. 3; MÜLL., HLE, *Plagiost.*, p. 15, tab. 7; LOWE, *Fish. Madeira*, p. 93, tab. XIV; KR. (*Scyllium melastomum*), *Danm. Fisk.*, vol. III, p. 832; GTHR (*Pristiurus melanostomus*), *Cat. Brit. Mus., Fish.*, vol. VIII, p. 406; COLL., Forh. Vid. Sels. Chrnia 1874, Tillaegsh., p. 211; N. Mag. Naturv., Bd 29 (1884), p 117; MALM, *Gbgs, Boh. Fna*, p. 623; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 58; MOR., *Hist. Nat. Poiss. Fr.*, tom. 1, p. 284; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 314, tab. CLX, fig. 1; STORM, N. Vid. Sels. Skr. 1883, Trondhj., p. 43.

Scyllium Artedi, RISSO, *Eur. Mérid.*, tom. III, p. 117; BARB. BOC., CAP. (*Pristiurus*), *Peix. Plagiost.*, p. 11.

Squalus annulatus, NILSS., *Prodr. Ichthyol. Scand.*, p. 114; (*Scyllium*), *Skand. Fna, Fisk.*, p. 713.

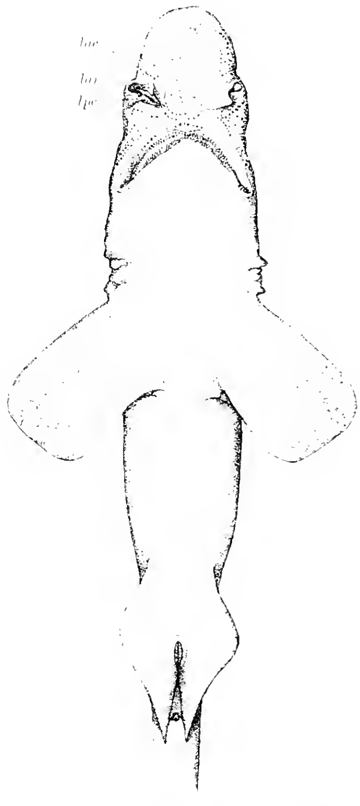


Fig. 334. Ventral side of a Black-mouthed Dog-fish (*Pristiurus catulus*), ♀, from the fishing-bank of Jaderen. Nat. size. The anterior outer lobe (*lae*) of the right nostril is raised to show the anterior inner (*iai*) and the posterior outer (*lpe*) lobes.

The Black-mouthed Dog-fish attains according to STORM a length of 80 cm., according to MOREAU of 90 cm.; but it is commonly smaller. Our specimens from Scandinavia measure between 33 and 68 cm. The largest are females. The body is of the elongated Shark-form, with flattened snout, more terete, though somewhat depressed head, behind which the vertical section is more or less triangular (hog-backed), and more or less compressed tail, almost flattened on the sides, the depth just in front of the caudal fin being about twice the thickness. The greatest depth, at the pectoral fins, is in the males about 9 %, in the females about $10^1/_2$ %, of the length of the body. The greatest breadth falls within the head, just in front of the first branchial aperture, and varies, as usual, with the distension of the jaws and branchial apertures, being somewhat less or greater than the greatest depth. The least depth of the tail, just in front of the caudal fin, is about $4-4^1/_2$ % of the length of the body.

The head occupies about 17 ($17^1/_2$)—15 (14·8) % of the length of the body, and differs essentially from that of the following genus in the length of the snout, which measures nearly half ($49^1/_2$—46 %) of that of the head. The snout is translucent, and its skin is pierced with numerous ampullar orifices, arranged above in series so as to form oblong patches on each side of the median line, below in the manner illustrated in fig. 334. The nostrils, which are directed obliquely inwards and backwards from the edge of the snout, have the anterior overlapping margin double (cf. above, on the Tope), and the outer lobe (*lae*) has a pointed triangular flap, the base of which is continued inwards, the inner (*lai*) an obtuse, more or less rounded flap, belonging to the outer part of the nostril. Exactly opposite the last-mentioned flap there projects a more deep-seated, more tubercular lobe (*lpe*) from the posterior margin of the nostril. In this manner the nostril is incompletely divided, as that of the Rays, into an outer (anterior) and an inner (a posterior) part; but the latter is not confluent either with the nostril of the opposite side or with the mouth. The distance between the inner ends of the two nostrils is somewhat more than $^1/_3$ (in the younger among our specimens about 36 %, in the older about $34^1/_2$ %) of the length of the snout; and the distance from either of these ends to the mouth varies between $^3/_5$ and $^3/_4$ of the former distance. The orbits are oblong, the vertical diameter being about $^2/_5$ of the longitudinal or even less, and the longitudinal diameter measuring about half the length of the snout, somewhat more or less, or about $^2/_3$ of the interorbital width. Exactly behind the orbits — at a distance from them rather greater than their length — lie the spiracles, whose diameter is about $^1/_4$ of that of the former. The mouth is semicircular, the lower jaw being somewhat more pointed than the upper, and is so situated that the anterior margin of the upper jaw lies in a line with the preorbital margin or a little behind the perpendicular therefrom, the tip of the lower jaw almost below the centre of the eyes. Lips are wanting, but the corners of the mouth are elevated and posteriorly bounded by a rather deep semicircular groove. The teeth are pointed, with one or two lateral denticulations on each side of the main cusp. They are set in a quincunx of three—five series, which gives them the appearance of being distributed in some thirty longitudinal rows running obliquely backwards and outwards across the jaws. The tongue is fleshy and flat, as in most of the Sharks. The gill-openings are middle-sized, the hindmost being set above the beginning of the pectoral fin.

The dorsal fins are characterized, as in the following genus, by their similarity to each other both in form and size; but in these fins, as in the other unpaired fins, it should be observed that the forward extension of the anterior margin varies in different individuals, the measurement of the basal length being thus rendered uncertain. The distance from the tip of the snout to the first dorsal fin is about 45 ($44^1/_2$—$47^1/_2$) %, to the second about 63 (62—64) %, of the length of the body; the interval between the two fins measures between 13 and 14 % of the said length. Their form is obliquely quadrilateral, with the posterior corner almost rectangular. The length of their base varies between 4 and $4^1/_2$ % (sometimes nearly 5 %), and their height between 5 and $6^1/_2$ %, of the length of the body. The first dorsal fin lies opposite to the anterior part of the space between the ventral and anal fins, the second to the posterior part of the anal fin. The last-mentioned fin, which has an unmistakable resemblance to the anterior part of the lower caudal lobe (an obliquely trapezoidal form, gradually attenuated behind, with pointed infero-posterior corner and slightly concave under margin), is here distinguished by its length — about 15—16 % of that of the body, and in the females 4 times or less, in the males up to 5 times the greatest height of the fin. The distance between the tip of the snout and the beginning of the anal fin measures in full grown females perceptibly more than $^1/_2$ (about 54 %), in males and young females about $^1/_2$ or less (49—51 %), of the length of the body. The caudal fin is expanded at the end, obliquely truncate, with somewhat rounded corners. Its length from the beginning of the anterior lobe is more than $^1/_4$ ($27^1/_2$ to nearly 33 %) of the length of the body.

The pectoral fins are broad, obliquely truncate, with rounded corners. Their length at the anterior margin varies between 10 and $12^1/_2$ %, their base between $6^1/_2$ and 8 %, of the length of the body. The ventral fins are quadrangular, low but long, with the posterior corner pointed. Their base is longer than that of the pectorals — in the females about $8^1/_2$ %, in the males about 9 %, of the length of the body — but their height (breadth) is only about $^1/_3$ or $^3/_8$ of the length of the base.

The lateral line is quite distinct, from the very temples, and at first runs about half as far from the dorsal margin as from the ventral, but on the tail at about the middle of the sides, until it reaches the anterior part of the caudal fin, where it bends downwards in a loop to the lower third of the depth of the body.

The Black-mouthed Dog-fish is most known in the Mediterranean and on the coasts of Portugal and Norway, this being probably due to the circumstances that it generally lives at a depth of about 100—250 fthms., and that fisheries at this depth are most developed in the said localities. But it also roves into higher strata, being met with, though seldom, in the North Sea, and penetrating in the Skager Rack and Cattegat into 40 fathoms of water (MALM) off Bohuslän and in Christiania Fjord, or even, as once happened, in March, 1847, according to NILSSON, into the Sound off Raa. LOWE has described it from Madeira; according to COLLETT it has been found off Tromsö. It thus has a wide geographical range in the North Atlantic.

The food of the Black-mouthed Dog-fish consists of fish and crustaceans. It takes the ordinary bait of deep-sea lines. During spring and summer the female deposits her singular eggs (fig. 333), two at a time, as described by GUNNERUS. The life of this species is otherwise little known; but where it is taken in any number, the flesh is considered eatable.

GENUS SCYLLIORHINUS[a].

Nostrils approximated behind to the mouth or even meeting the anterior margin of the upper jaw, the distance between which margin and the tip of the snout is less than the postorbital length of the head. Upper edge of the caudal fin without prominent serrations.

As has been hinted above, the difference from the preceding genus is rather inconsiderable. The most important distinction consists in the advancement of the mouth and the more or less marked prolongation of the nostrils back towards the mouth cavity. Consequently we also find in the genus *Scylliorhinus* that the tip of the lower jaw is in a line with or even in front of the preorbital margin. The genus is indeed without serrations at the upper edge of the caudal fin, though these may sometimes be traced in the difference between the large spiny scales in the upper rows on each side and the smaller and smoother ones in the median dorsal line at the said spot; but it has a compensation for them in the stronger development of the spiny scales on each side of the body above and behind the anal fin, which almost exactly resemble jaw-teeth. These scales literally form a rasp, which the fish uses as a defensive weapon.

To the characteristics of the genus also belongs the form of the egg-capsules (fig. 335). These are similar to those of the Rays, oblong, rectangular, and flattened, but with one half thicker than the other. At each corner they are furnished with a long (measuring sometimes half a metre) filamentous appendage. When the first pair of these tendrils emerge from the cloaca, the female coils them round a branch of seaweed or coral, where the egg is left hanging. Two eggs, as a rule, become simultaneously ripe for exclusion, one in each uterus; and the female deposits them

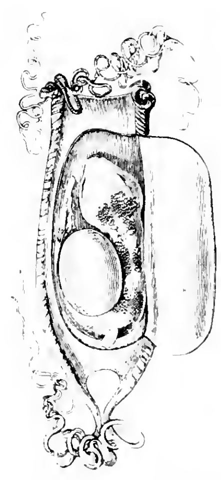


Fig. 335. Egg of Nurse Hound (*Scylliorhinus stellaris*), cut open to show the enclosed foetus, and with the posterior (the first excluded) end turned downwards. Nat. size. After MOREAU, who further states that the ova of this species differ from those of the Rough Hound in that the thickened side-margins are transversely striped.

[a] Σκύλιον in ARISTOTLE, elsewhere σκύλαξ (*canicula* in GAZA), whelp.

in pairs, at certain intervals. In the course of a month a female Nurse Hound has been seen to lay 18 eggs. The eggs deposited early in April were hatched at the beginning of December (COSTE, Comptes Rendus, January 21, 1867).

The systematic name of the genus, *Scylliorhinus*, was coined by BLAINVILLE in 1816 and must be recognised, as JORDAN and GILBERT[a] have proposed, in deference to the accepted laws of nomenclature, although the Cuvierian name of *Scyllium* has hitherto been in general use. The Swedish name of *Rödhajar* (Red Sharks) is originally a Danish rendering, introduced by KRØYER, of the French *Roussettes*, an allusion to the red coloration prevalent in the family, which characteristic is further distinguished by its maculation from the plainer dress of other Sharks. NILSSON called these Sharks *doggfiskar*, an adaptation of the English word.

Of the genus 8 or 9 species are known from tropical and temperate seas.

THE NURSE HOUND.

SCYLLIORHINUS STELLARIS.

Fig. 336.

Nasal valvules separated exactly in front of the mouth by a space equal in width to the height of the hindmost gill-opening. Length of the head about 19—17 % of that of the body and greater than the distance between the anterior margins of the two dorsal fins. Distance between the pectoral fins and the tip of the snout at least $^2/_5$ of that between the first dorsal and the same point. Distance between the ventral fins and the tip of the snout somewhat greater than that between the first dorsal and the eyes: their inner posterior corners obtuse, scarcely elongated behind. Length of the base of the anal fin greater than or at least equal to the distance between the two dorsal fins. Length of the caudal fin from the beginning of the inferior lobe more than $^1/_4$ of the length of the body. Greatest depth of the body about 10—12 %[b], least depth, in front of the caudal fin, about $4^1/_2$—5 %, of the length of the body. Coloration above grayish brown, sometimes shading into yellow or red, below white. Back, sides, and fins, the paired ones even underneath, strewn with comparatively large roundish spots — some (more constant) blue-black, others (sometimes indistinct or wanting) whitish — about equal in size to the gill-openings, smaller on the head and the forepart of the back.

Syn. *Galeus stellaris minor*, BELON., *Nat., Divers Poiss.*, p. 65. *Canicula saxatilis*, RONDEL., *De Pisc.*, p. 383. *Catulus maximus*, WILLUGHB., *Hist. Pisc.*, p. 63; RAY, *Synops. Method. Pisc.*, p. 22. *Squalus* cinereus, pinnis ventralibus discretis, ART., *Ichthyol.*, *Gen. Pisc.*, p. 69; *Syn. Pisc.*, p. 97.

Squalus stellaris, LIN., *Syst. Nat.*, ed. X, tom. I, p. 235; FLMNG (*Scyllium*), *Brit. Anim.*, p. 165; BONAP., *Iconogr. Fna Ital., Pesci*, tab. 131, fig. 2; THOMPS., *Nat. Hist. Irel.*, vol. IV, p. 247; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 402; MALM., Öfvers. Vet. Akad. Förh. 1875, No. 10, p. 33; *Gbgs, Boh. Fna*, p. 622; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 652; CAR., *Prodr. Fna Medit.*, vol. II, p. 508.

Squalus canicula, BRUNN. (nec LIN.), *Ichthyol. Massil.*, p. 4; BL. (p. p.), *Naturg. Ausl. Fisch.*, part. I, p. 16, tab. CXII.

Squalus (Scyllium) catulus (+ *Sq. stellaris*), CUV., *Règn. Anim.*, ed. 1, tom. II, p. 124; YARR. (*Scyllium catulus*, nec LIN.), *Brit. Fish.*, ed. 1, vol. II, p. 373; ed. 2, vol. II, p. 493; MÜLL., HLE, *Plagiost.*, p. 9, tab. 7; DÜMER., *Hist. Nat. Poiss.* (su. à BUFF.), tom. I, p. 316; BARB. BOC., CAP., *Peix. Plagiost. Portug.*, p. 11; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 280; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 312.

Nurse Hound, COUCH, *Fish. Brit. Isl.*, vol. I, p. 11, tab. 1.

The Nurse Hound attains a length of at least $12^1/_2$ dm. (BOCAGE and CAPELLO: according to DAY 15 dm.); but so large specimens appear to be rare. As a rule the length varies between about 5 and 7 dm. It is strictly a Mediterranean fish, dispersed in the Atlantic to Ireland and England. Sometimes it strays north to the Orkney and Shetland Islands; and

[a] Bull. U. S. Nat. Mus., No. 16, p. 869.

[b] Sometimes, according to DÖDERLEIN (*Man. Ittiol. Medit.*, fasc. II, p. 23), about 14 %.

on a single occasion it has been met with in Scandinavian waters. In November, 1875, MALM received a female 622 mm. long that had been taken on a Haddock-line north-west of Hallö, in the central portion of the island-belt of Bohuslän. The favourite haunts of the Nurse Hound are the deepest algal zones or lower levels, on a stony or rocky bottom; its coloration too indicates that it does not usually frequent the region of the green algae, even if the females repair thither, as THOMPSON states, to attach their egg-capsules to *Laminariæ*. Its food is, no doubt, the ordinary diet of the small Sharks, consisting principally of invertebrates, but also of fishes. As mentioned above, it takes the bait of long-lines set for Haddock.

From April to September ripe egg-capsules have been found in the uterine dilatations of the female. The development of the fœtus in the egg after deposition is said to take nine months.

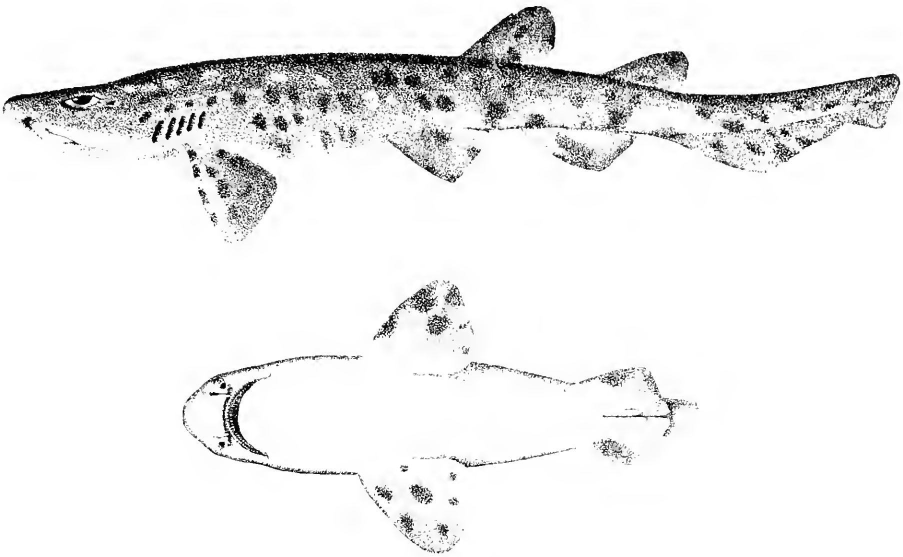


Fig. 336. Nurse Hound (*Scylliorhinus stellaris*), ♂, $^1/_2$ nat. size. From Nice, GIGLIOLI.

The skin of the Nurse Hound is considered to be one of the best polishers — it bites marble and iron — and after being smoothed it is employed in covering the hilts of sabres and small-swords. Its flesh is eaten freely by the poor of Southern Europe. In Scandinavia its only value is that of rarity.

THE ROUGH HOUND.

SCYLLIORHINUS CANICULA.

Plate LI, fig. 4.

Nasal valvules in front of the mouth almost confluent, forming a broad dermal fold interrupted only for a very short distance at the middle. Length of the head about $12^1/_2$—$13^1/_2$ % of that of the body and less than the distance between the anterior margins of the two dorsal fins. Distance between the pectoral fins and the tip of the snout about $^1/_3$ (31—37 %) of that between the first dorsal and the same point. Distance between the ventral fins and the tip of the snout about $^4/_5$ (77—83 %) of that between the first dorsal and the same point and less than that between the latter fin and the eyes. Inner posterior corner of the ventral fins acutely elongated, the two fins coalescent behind in the males. Length of the base of the anal fin about $^3/_4$—$^4/_5$ (71—83 %) of the distance between the two dorsal fins. Length of the caudal fin from the beginning of the inferior lobe less than $^1/_4$ (21—24 %) of the length of the body. Greatest depth of the body about $8^1/_2$—11 %, least depth, in front of the caudal fin, about 3—$3^3/_4$ %, of the length of the body. Coloration above russet, on the sides grayish yellow, paling downwards towards the white ventral side. Fins more or less reddish. Body more or less densely strewn above and on the sides, as well as the fins (the paired ones only on the upper surface), with roundish brown spots, densest but smallest on the head and back, more scattered but larger (though not so large as the gill-openings) on the sides of the body and the fins.

Syn. *Galeus stellaris major*, BELON., *Nat., Div. Poiss.*, p. 64. *Canicula Aristotelis*, RONDEL., *De Pisc.*, p. 380. *Catulus major vulgaris* (♀ adult.) + *Catulus minor* (juv. et ♂), WILLUGHB., *Hist. Pisc.*, pp. 62 et 64. *Catulus* major vulgaris + *C.* minor vulgaris, RAY, *Syn. Meth. Pisc.*, p. 22. *Squalus* ex rufo varius. Pinna ani medio inter anum et caudam pinnatam + *Squ.* dorso vario; Pinnis ventralibus concretis, ART., *Ichthyol., Gen. Pisc.*, pp. 68 et 69; *Syn. Pisc.*, p. 97. *Spotted Dog Fish* + *Lesser Spotted Dog Fish*, PENN., *Brit. Zool.*, vol. III (ed. 1776), pp. 99 et 101, tab. XIX.

Squalus Canicula, LIN., *Syst. Nat.*, ed. X, tom. I. p. 234; GMEL., ed. XIII, p. 1490; RETZ., *Fna Suec. Lin.*, p. 305; BLAINV. (*Scylliorhinus*), Bull. Sc. Soc. Philom. 1816, p. 121; CUV. (*Scyllium*, subg.), *Regn. Anim.*, ed. 1, tom. II, p. 124; NILSS., *Prodr. Ichthyol. Scand.*, p. 113; BONAP. (*Scyllium*), *Iconogr. Fna Ital.*, tab. 131, fig. 1; MÜLL., HLE, *Plagiost.*, p. 6, tab. 7; KR., *Danm. Fisk.*, vol. III, p. 814; NILSS., *Skand. Fna, Fisk.*, p. 710; THOMPS., *Nat. Hist. Irel.*, vol. IV, p. 247; DUM., *Hist. Nat. Poiss.* (su. à BUFF.), tom. I, p. 315; BARB. BOC., CAP., *Peix. Plagiost. Port.*, p. 11; FEDDERS., Tidsskr. Fisk. Kbhvn, Aarg. 2 (1868), p. 123; Aarg. 4 (1870), p. 339; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 402; V. BEN., *Poiss. Belg.* (Mém. Acad. Sc. Belg., tom. XXXVIII), p. 3; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 210; 1879, No. 1, p. 104; N. Mag. Naturv. Chrnia, Bd. 29, p. 116; MALM, Öfvers. Vet. Akad. Förh. 1875, No. 10, p. 33; *Gbgs. Boh. Fna*, p. 619; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 57; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 278; DODERL., *Man. Ittiol. Medit.*, fasc. II, p. 24; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 309, tab. CLIX, fig. 1; PETERSEN, Vid. Meddel. Naturh. For. Kbhvn 1884, p. 160; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 645; CAR., *Prodr. Fna Medit.*, vol II, p. 508.

Squalus Catulus, LIN., l. c., p. 235; BRÜNN., *Ichth. Massil.*, p. 5; BL., *Naturg. Ausl. Fisch.*, pt. 1, p. 21, tab. CXIV; DONOV., *Brit. Fish.*, tab. LV; BLAINV. (*Scylliorhinus*), *Fne Franç., Poiss.*, p. 69, tab. 17, fig. 1 (+ var. *Sc. Canicula*, p. 71).

Rough Hound, COUCH, *Hist. Fish. Brit. Isl.*, vol. I, p. 14, tab. II.

Obs. WILLUGHBY and RAY regarded the male and female as distinct species. ARTEDI and LINNÆUS were hardly more than copyists of their predecessors; but GMELIN, RETZIUS, and BLAINVILLE paved the way for a correct apprehension of the case. At present there need be no risk of ambiguity in dropping the Linnæan name of *Catulus* here and applying it instead, as GUNNERUS has done, to the Black-mouthed Dog-fish.

The Rough Hound never quite attains the maximum size of the preceding species. The largest specimens on record were about 1 m. long ($10^1/_2$ dm. according to DAY). The ordinary length of both species is, however, the same, 5—7 dm. In the terete form of the body, anteriorly somewhat depressed, and broadest at the posterior part of the head, they are also much alike; but the Rough Hound approaches nearer to the Black-mouthed Dog-fish in the usually greater elongation of the body and the anterior compression of the back.

The difference in the form and delimitation of the nostrils (fig. 337) shows that the Rough Hound comes still nearer to those members of the family which are yet more singularly equipped in this respect. Not only is the outer lobe (*lae*) at the anterior margin of each nostril expanded forwards and prolongated inwards, so close to the corresponding lobe of the other side that an almost continuous nasal valvule is produced, not unlike that of the Rays — the posterior margin of the nostril is also furnished internally in both species with a dermal lobe, which in the Nurse Hound, however, is simple and thin, projecting like a leaf into the backward narial groove, but here develops into two barbel-like processes, one of them (above the dotted line from *lpi*) jutting into the said groove, the other (below the dotted line from *lpi*) directed backwards and laid within the mouth, outside the margin of the upper jaw. The lower jaw is furnished in both species, but in the Nurse Hound only behind, in the Rough Hound throughout the greater part of its length, with a pendent labial fold; and the skin on the margin of the upper jaw swells towards the corners of the mouth in a labial form.

As a compensation for the absent nictitating membrane these Sharks possess the faculty of raising the lower eyelid so high that the orbits become shut; and NILSSON as well as MALM has described how the Rough Hound can close the pupil by contracting the iris, till the latter leaves open only a narrow longitudinal slit, dilated at each end.

The fins of the Rough Hound are most like those of the Black-mouthed Dog-fish; but the dorsals are set somewhat further back, the first beginning about half-way along the body, the second just behind the second third thereof, and the anal and caudal fins are shorter, the base of the former measuring only about 9—10 % of the length of the body.

The shagreened skin is fairly alike in both the Roussettes, but generally rougher in the Nurse Hound.

The Rough Hound has about the same geographical range as the Nurse Hound, but is somewhat more addicted to northern rovings. On the English coast it is far commoner than the latter, and it is considered to be one of the commonest Sharks in British waters. In Scandinavia it is indeed scarce, but not among the rarest fishes, for it has repeatedly been met with on the west coast of Norway, south of Bergen, and in the Cattegat — even in the Sound, between Malmö and Helsingborg, one specimen has been taken (LILLJEBORG). Off Mount Kullen, according to NILSSON, it is familiar enough to bear a special name (*Haskarfving*); and at Agger, on the west coast of Jutland, it is known, according to FEDDERSEN, as the *Tudhaj* (Toad Shark). The original of our figure (Plate LI, fig. 4) is also from the west coast of Jutland, and was presented to the Royal Museum in November, 1889, by Mr. FREDERICKSEN, a Copenhagen merchant.

The Rough Hound prefers a sandy bottom with its growth of seaweed, as indicated by the reddish colouration the fish generally displays. When it lives on a clayey bottom, the body has a different ground-colour, darker (grayish or blackish) with still darker spots (THOMPSON). In its reproduction, temperament, and general habits, this species resembles the preceding one. Both have something of the serpent about them, as

Fig. 337. Ventral side of a Rough Hound (*Scylliorhinus canicula*), ♂, from Messina, 6—10 fthms., stony bottom, Feb. 5, 1891, C. BOVALLIUS. 1/2 nat. size. The anterior outer lobe (*lae*) of the right nostril is raised to show the anterior inner (*lai*), the posterior outer (*lpe*), and the posterior inner (*lpi*) lobes.

they sway their whole body in sinuous movements; and both are gregarious, each species by itself, as they chase schooling fishes. To the Herring and Pilchard they are dangerous enemies, and they cause the fisherman trouble by tangling and tearing his nets. The long-line fishermen too complain of them. In the Eng-fish Channel it has happened[a] that fishermen who had shot long-lines for Cod have found a Rough Hound on almost every hook; and the hooked Cod had been devoured down to the head and a bit of the backbone. The Rough Hound eats, besides fish, both crustaceans and mollusks, seeming to be especially fond of whelks (*Buccinum undatum*) and lugworms (*Arenicola*).

As human food the Rough Hound also finds consumers among the fishing population and the poor. In Scandinavia it is far too rare to possess any economical importance. Not so in France and the rest of Southern Europe. Its skin is used in polishing various substances. Its hard flesh and musky odour are disagreeable, but the latter is said to be removed by boiling. The liver, which is described as having an abominable taste, is considered poisonous. One Doctor SAUVAGE of Montpellier related in 1745 that a family who had eaten the liver of this fish were overpowered by heavy drowsiness, from which they first recovered on the third day, and which was attended with a skin disease, causing the whole epidermis to peel off in fragments.

CYCLOSPONDYLI.

Sharks with two dorsal fins, but no anal.

HASSE has shown[b] that the Sharks whose external character is expressed in the absence of an anal fin[c], in their internal characters stand lowest, next the Cow-Sharks (*Notidanidæ*) — which indeed have an anal fin, but only one dorsal — and nearest to the primordial forms common to the Sharks and Rays. A comparison between our two figures 296 and 297 (see above, pp. 1068—69) shows the great difference in the structure of the spinal column between a Cyclospondylous and an Asterospondylous Shark. In the former the vertebræ are far less differentiated. The bodies of the vertebræ form a continuous canal, only imperfectly coarctated by the constrictions answering to the middle parts of fully developed vertebræ. Frequently, though irregularly, so-called diplospondylism occurs, two pairs of apophyses (two neurals and two interneurals), or at least two pairs of foramina for spinal nerves on each side, appearing in a single vertebra. The basal parts of the dorsal fins also exhibit a lower grade of differentiation; but in compensation most of the *Cyclospondyli* are equipped at the anterior margin of each dorsal fin with a spine (ichthyodorulite), which in the species our figure (296) represents, however, is considerably reduced, not projecting above the skin.

All the *Cyclospondyli* have open and rather large spiracles. Their eyes are without nictitating membrane. All their gill-openings lie in front of the pectoral fins. Their caudal fin is generally less heterocercal than that of other Sharks. Most of them are characterized by the singular form of the jaw-teeth. One genus (*Acanthorhinus*) differs from all the other known Sharks in having the duodenum furnished at its commencement with a pair of cæcal appendages[d]. The great majority of them are known to be viviparous; but one species of the genus just mentioned, the Greenland Shark, has been suspected in recent times to form an exception to this rule[e].

HASSE has divided the *Cyclospondyli* into three families: *Læmargi*[f], without externally visible dorsal

[a] BREHM, *Thierleben*, 2:te Aufl., Abth. 3, Bd 2, p. 377.

[b] *Naturl. Syst. Elasmobr.*, Allgem. Th. p. 41; Besond. Th., p. 55.

[c] *Squales anhypoptériens* MOREAU, *Hist. Nat. Poiss. Fr.*, tom. I, pp. 276 and 340.

[d] This observation may be traced even in GUNNERUS (Trondhj. Selsk. Skr., vol. II, pl. X, fig. 2), but is unnoticed in the text.

[e] See LÜTKEN, Vid. Meddel. Naturh. For. Kbhvn 1879—80, p. 56. A female Greenland Shark 23 dm. long was taken in the North Sea during January, 1891, and presented by Mr. FREDERICKSEN of Copenhagen to the Royal Museum. The oviducts lay, as TURNER (Journ. Anat., Physiol., vol. XII [1877—78], p. 604) also found them, extended from the diaphragm to the cloaca, straight and thin-walled, gradually expanding in the hindmost part alone to the thickness of a goose-quill, and here with somewhat stouter walls than in front, but without any special dilatation whatever throughout their extent. From this circumstance it is, however, impossible to decide with certainty the appearance presented by the oviducts after the act of copulation and the development within them of the impregnated eggs.

[f] Containing the genera *Acanthorhinus*, *Isistius*, *Euprotomicrus*, and *Scymnus*.

fin-spines; *Echinorhini*[a] with the first dorsal fin opposite to the ventrals and with large dermal spines, similar to the aculei of the Rays, but without dorsal fin-spines; and *Spinacidæ*[b], with externally prominent spine before each dorsal fin. Two of these families are represented in the Scandinavian fauna.

A: At the anterior margin of each dorsal fin a more or less prominent spine. — Fam. *Spinacidæ*.

a: Distance between each nostril and the tip of the snout considerably more than half of that between the former and the mouth ... *Squalus acanthias*.

b: Distance between each nostril and the tip of the snout less than half of that between the former and the mouth ... *Etmopterus spinax*.

B: No externally prominent dorsal fin-spines. — Fam. *Scymnidæ* ... *Acanthorhinus carcharias*.

FAM. SPINACIDÆ.

Skin uniformly shagreened. First dorsal fin set half-way between the perpendiculars from the pectorals and ventrals or further forward. At the anterior margin of each dorsal fin a more or less prominent spine.

The intermediate position between the Cow-Sharks (*Notidanidæ*) and the Roussettes (*Scylliidæ*) occupied in many respects by the *Cyclospondyli*, is especially manifested in the form of the jaw-teeth. The primitive Notidanidan type is characterized partly by the difference of the teeth in both jaws — longer (broader) and coarser, like serrate disks, in the mandible — partly by the obliquity in the growth of the denticulations, especially in the lateral teeth of the lower jaw, with the tips of all the denticles directed outwards (towards the corners of the mouth) and with the innermost (or one of the innermost) denticles largest, so that the others evidently answer to accessory cusps. In most of the *Cyclospondyli*, and especially within the present family, this difference between the jaws, as well as the obliquity of the teeth, has persisted — only one genus, the Greenlandic and North American *Centroscyllium*, has teeth similar in both jaws and resembling those of the Roussettes — or the obliquity has advanced yet further, the original inner edge of the largest denticle being turned entirely aside and having become an incisive upper edge; and this form of dentition may finally develop not only in the lower jaw but also in the upper. The differences in the dentition besides afford the best distinctive characters between the 5 genera into which the family of the Spur-Sharks has been divided, together including about 20 known species.

GENUS SQUALUS.

Teeth of the upper and lower jaws almost similar in form, obliquely shaped incisors. Nostrils middle-sized, their width much less than the distance from the tip of the snout to the middle of a transverse line crossing their anterior margins. Pectoral fins triangular (following the ordinary Shark type), with the outer posterior margin concave. Dorsal fin-spines without lateral grooves.

In the works of most recent writers the Linnæan generic name of *Squalus* has been dropped entirely, or applied, as in BONAPARTE, to the Blue Sharks, as representing the highest development of the Shark type. JORDAN and GILBERT, however, have advanced the opinion[c], previously maintained by RAFINESQUE[d], that, when he employed this generic name, LINNÆUS had first in view the species which is commonest in Scandinavian waters, and which he ranged first in his systematic enumeration of the Sharks.

Among the Sharks destitute of anal fin the genus *Squalus* is the most differentiated or, so to say, mo-

[a] Containing a solitary species, *Echinorhinus spinosus*, from the Atlantic between the North Sea and the Cape of Good Hope and from the Mediterranean.

[b] Containing the genera *Centrophorus*, *Centrina*, *Centroscyllium*, *Squalus*, and *Etmopterus*.

[c] Bull. U. S. Nat. Mus., No. 16, p. 16.

[d] *Caratt. N. Gen., Spec.*, p. 13.

dernized, most nearly resembling in external form the preceding Sharks. This is best shown by the character drawn from the shape of the pectoral fins, and might also be expressed by the relative dimensions of these fins, but for the fact that the alterations of growth within the genus approximate the fry, or at least the almost viable fœtuses, too nearly to the following genera. The same remark essentially applies to the form and dimensions of the two dorsal fins. How closely the genus *Squalus* is allied, however, to the remaining genera of the family, appears from the rank long assigned to a Mediterranean form, the so-called *Squalus uyato* of RAFINESQUE (l. c.), as an independent species of this genus, until BELLOTTI and DODERLEIN[a] discovered it to be a young form of *Centrophorus granulosus*, an inhabitant of the neighbouring parts of the Atlantic[b]. Even between the two species left within the genus *Squalus* after this elimination there would appear to obtain some developmental relation, one of them (*Squalus Blainvillei*) representing in its characters the juvenile and male characters of the other.

THE PICKED DOG-FISH (SW. PIGGHAJEN).

SQUALUS ACANTHIAS.

Plate LII, figs. 1 and 2.

Distance between each pectoral fin and the tip of the snout at most about $^2/_3$ (67—58 %) of that between the first dorsal and the same point. The ventral fins begin half-way along the body or somewhat further back.

Syn. Ἀκανθίας γαλεός, ARISTOT., *Zool.*, lib. VI, cap. X (= *Mustellus spinax*, GAZA). *Galeus acanthias*, RONDEL., *De Pisc.*, p. 373. *Canis Acanthias*, GAZÆ *spinax*, SCHONEV., *Ichthyol. Slesv. Hols.*, p. 29. *Squalus* pinna Ani nulla, ambitu corporis subrotundo, ART., *Ichthyol.*, *Gen. Pisc.*, p. 66; *Syn. Pisc.*, p. 94; *Spec. Pisc.*, p. 102; LIN., *Fna Suec.*, ed. I, p. 100; It. Wgoth., p. 174; *Mus. Adolph. Frid.*, part. I, p. 53 (*Hundfisk*). *Haae*, STRÖM, *Sondm. Beskr.*, part. I, p. 280. *Haafur*, OLAFS., *Reise Isl.*, part. I, p. 359; part. II, p. 989.

Squalus Acanthias, LIN., *Syst. Nat.*, ed. X, tom. I, p. 233; BL., *Naturg. Fisch. Deutschl.*, part. III, p. 74, tabb. 75 (fig. 1) et 85; RETZ., *Fna Suec. Lin.*, p. 305; BLNVLLE (*Acanthorhinus*), Bull. Sc. Soc. Philom. 1816, p. 121; CUV. (*Spinax*, subg.), *Règn. Anim.*, ed. 1, tom. II, p. 130; NILSS. (*Squalus*), *Prodr. Ichthyol. Scand.*, p. 117; BONAP. (*Spinax*), *Iconogr. Fna Ital.*, tab. 139; SUNDEV., v. WR. (*Squalus*), *Skand. Fisk.*, ed. 1, p. 187, tab. 46; JORD., GILB., Bull. U. S. Nat. Mus., No. 16, p. 16; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 665.

Picked Dog Fish, PENN., *Brit. Zool.* (ed. 1776), vol. III, p. 88; YARR., *Brit. Fish.*, ed. 1, vol. II, p. 400; COUCH, *Fish. Brit. Isl.*, vol. I, p. 49, tab. XI.

Squalus fernandinus, MOLINA, *Chili*, p. 229; GUICHEN. (*Spinax*) in GAY, *Chile*, Zool., tom. II, p. 365.

Acanthias vulgaris, RISSO, *Eur. Mérid.*, tom. 3, p. 131; MÜLL., HLE, *Plagiost.*, p. 83; SCHLEG. in SIEB., *Fna Japon.*, *Poiss.*, p. 304, tab. CXXXV; KR., *Danm. Fisk.*, vol. III, p. 868; NILSS., *Skand. Fna, Fisk.*, p. 731; DUM., *Hist. Nat. Poiss.* (nouv. su. à Buff.), tom. I, p. 437; BARB. BOC., CAP., *Peix. Plagiost. Port.*, p. 21; GTHR. *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 418; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 211; 1879, No. 1, p. 104; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 58; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 342; DODERL., *Man. Ittiol. Medit.*, fasc. II, p. 86; MÖB., HCKE, *Fisch. Osts.*, p. 152; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 315, tab. CLX, fig. 2; STORM, N. Vid. Sels. Skr. Trondhj. 1884, p. 45; CAR., *Prodr. Fnæ Medit.*, vol. II, p. 503.

Acanthias americanus, STOR., Mem. Amer. Acad. Arts, Sc., vol. II, p. 506; vol. IX, p. 232, tab. XXXVIII, fig. 1.

Acanthias Linnæi, MALM, *Gbgs*, *Boh. Fna*, p. 624.

The Picked Dog-fish belongs to the smaller Sharks. According to DAY it attains a length of 12 dm. on the English coast; but in Scandinavia it does not exceed, so far as we know, one of about 9 dm.[c] New-born fry with obliterated navel measure about 22—25 cm. In the external form of the body the Picked Dog-fish is not unlike the Tope, but it is usually rather more elongated. The greatest depth of the body, just in front of the first dorsal fin, varies irregularly between about 9 and 11 % (according to KROYER sometimes 8 or 12 %) of its length, the least depth between 2 and $2^1/_2$ % (according to KROYER sometimes nearly 3 %) of the same. The latter depth measures between about 13 %

[a] *Man. Ittiol. Medit.*, fasc. II, p. 118, Nota.

[b] This might besides be taken for granted partly from RAFINESQUE's description of the teeth of the upper jaw (*denti minuti ed acuti*), partly from BARBOZA DU BOCAGE's and CAPELLO's figures of old and young specimens of *Centrophorus granulosus*.

[c] The Vega Expedition brought home a male $9^1/_2$ dm. long from Behring Island.

(according to KRØYER 16—17 %) of the length of the head to the first gill-opening. Like the Tope, the Picked Dog-fish has an almost terete body, but the anterior part of the trunk is of the so-called hog-backed form, with a rounded triangular section. Behind the body is slightly compressed, the breadth being about equal to the depth, and the section almost quadrangular, though rounded (convex) above and laterally sharpened below by a dermal carina, running on each side behind the perpendicular from the second dorsal fin and some way out above the beginning of the inferior caudal lobe. The sides of the tail are, however, without true median carina, nor are there any caudal grooves, though a trace thereof may sometimes be found above, at the dorsal margin, in front of the caudal fin. The head, in particular the translucent snout, is depressed, behind somewhat broader than the trunk, with breadth about equal to the depth of the latter, and with parabolically pointed snout.

The length of the head to the first branchial aperture varies between 17 (in the nearly viable fœtus 18) and 15 % of the length of the body. The length of the snout to the eyes measures about $^2/_5$ (40—44 %) of the length of the head. Both the eyes and the orbits are oblong, the latter most so, the vertical diameter of the eyes being always more than $^1/_2$ (53—70 %), that of the orbits sometimes $^1/_3$ (41—33 %[a]), of the longitudinal diameter. This measures in the case of the latter, which are besides sharply pointed at each end, about 30[b]—20 % of the length of the head. The pupil is either round, but acute-angled below, or transversely oblong. Behind the eyes, but higher (further in) than these, lie the rather large spiracles, their diameter being only slightly less than or even equal to the vertical diameter of the orbits, from which they are separated by a distance of the same magnitude. Their anterior margin is folded double, the fold being sometimes so deep as to give them the appearance of being really double. The interorbital width is generally about equal to the length of the snout, somewhat greater or less, usually the latter. The prone nostrils are set about half-way along the snout, but the distance from the mouth to the transverse line drawn through their posterior margins is greater in the young than that from the tip of the snout to the transverse line drawn through their anterior margins. In the old the said distances are about equal, the tip of the snout in front of the nostrils being even relatively prolongated with age. The nostrils are, as usual, obliquely transversal, with a small pointed valvule at the middle of the anterior margin. Their width is about $^1/_6$ of the distance between them. The mouth is less curved than in most other Sharks, with deep folds around the corners. The distance from the tip of the snout to the anterior margin of the mouth is about $^1/_2$, to the corners thereof about 60—70 %, of the length of the head. The teeth are densely set, without gaps or unpaired median tooth. They are merely attached to the skin, as in all the Plagiostoms, not to the cartilage, and are consequently mobile. The first two rows of teeth stand upright, apart from the rest, the inner row leaning backwards; the remaining 3 or 4 rows have the cusps turned inwards (backwards), covered by the transverse fold (velum) in the

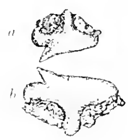


Fig. 338. One of the right teeth of the upper jaw (*a*) and the lower jaw (*b*) in the Picked Dog-fish (*Squalus acanthias*), anterior aspect. × 5.

front part of each jaw. The last-mentioned rows are, however, erected in the old, where the anterior rows have disappeared. Each tooth (fig. 338) is small — in an adult fish only about 2 mm. high — flat and sharp-edged, with a deep jag in the outer (posterior) margin, under the keen, laterally directed cusp. They have the same form in both jaws, but are somewhat larger in the lower than in the upper. In front they have a basal cusp running into the gum, and reminding us of the median ridge and the shaft with which the dermal scales are furnished. In a young female SUNDEVALL counted 26 teeth in each transverse row above and 22 below. The tongue is not free, and consists merely of a skin investing the rather large hyoid cartilage, which occupies almost the whole mandibular arch. The branchial apertures are comparatively small, the middle ones smallest, the hindmost opening somewhat larger than the first, the height of which is about $^1/_3$ to $^1/_2$ greater than the vertical diameter of the orbits.

[a] According to KRØYER down to 28 %.

[b] In a nearly viable foetus rather more than $^1/_3$.

The two dorsal fins in their relative position to each other resemble those of the Tope; but their form approaches more nearly to the square, and each of them is furnished at the anterior margin with a fairly stout and strong spine. As a rule the second dorsal fin is perceptibly smaller than the first, about $^3/_4$ as large; but its spine is the larger, being even higher than the fin itself, whereas the spine of the first dorsal extends only about half-way up the anterior margin thereof. The spines are pointed, somewhat curved, and triangular in section, with the whole posterior surface concave, but with rather convex side-margins. The first dorsal fin commences at about the end of the first third of the length of the body, the second dorsal at the termination of the second third thereof, somewhat further forward in the adult males than in the females, and further back in the young of both sexes than in the old. The length of the base of the first dorsal is about equal to the interorbital width. The base of the second dorsal measures about $^1/_5$—$^3/_4$ of that of the first. The caudal fin is distinguished partly by the

a *b*

Fig. 339. A scale of the Picked Dog-fish (*Squalus acanthias*), seen from above (from without, *a*, with the retral tip directed upwards in the figure) and from the side (*b*, with the retral tip turned to the right of the figure). About 37 times the natural size.

slight upward curvature of the tip of the tail within the fin, partly by the greater relative breadth of the upper lobe than in the preceding Sharks and the absence of incision in the hind part of the inferior margin of the fin. The length of the upper anterior margin of the fin is in the males somewhat more, in the females somewhat less, than $^1/_5$ of the length of the body. The lower anterior margin is about half as long as the upper or a little longer.

The pectoral fins indeed approach to the more spatulate form they exhibit in the following Sharks, but they remind us of the preceding species in the marked prolongation of the posterior inner corner, the hind margin being thus rendered concave. The distance between them and the tip of the snout is about $^1/_5$ of the length of the body, and in the males about $^2/_3$, in the females about $^4/_5$, of that between the first dorsal fin and the same point. The length of their anterior margin measures about 80—95 % of that of the head — relatively less in the young — and the breadth of their base about 34—40 % of their length. The ventral fins are obliquely lozenge-shaped, or resemble an obtuse-angled triangle, when the fins are laid back, in which case the base is continued, without a break, by the inner posterior margin. The distance between them and the tip of the snout in the males is about 50—52 %, in the females about 53—54 %, of the length of the body. Their base together with their inner posterior margin measures about 9 or 10 %, their anterior margin about 5 or 6 %, of the length of the body. In adult males the distally flattened pterygopodia project far beyond the ventral fins, and are furnished on the upper surface with a broad dermal groove, in which two spines are concealed, the one long and hamately curved at the tip, the other, which is visible in our figure (Pl. LII, fig. 1), pointed, grooved, and serrated.

The skin is uniformly shagreened with scales of a singular form (fig. 339), elevated on a terete shaft, at the top of which they are rectangularly bent and expanded behind in a three-pointed foliate form, with the middle point longest and most powerfully strengthened by a median ridge, passing into the anterior margin of the shaft, on whose sides the lateral ridges are also continued.

The coloration is above grayish brown, more or less dark, shading down the sides into violet, with a few small, roundish, whitish spots set in a row along the anterior half of the lateral line and in another row along the back, which latter series is much sparser, but is continued in very young specimens back to the tail. The belly is pale and whitish, but finely punctated with dark dots. After death the colour of the back soon fades and becomes more grayish, but it may be better preserved by depositing the specimen at once in strong spirit.

The external difference of sex may be traced in unborn fœtuses 18 cm. long. The males among these have fairly distinct pterygopodia, which are, however, only half as long as the inner margins of the ventral fins. These young specimens are almost similar in form and coloration to the adult individuals, only that the tip of the snout is somewhat shorter, the distance between the nostrils and the extreme tip of the snout being only about $^2/_3$ of that between them and the mouth, and that the dorsal fin-spines are short. The posterior of these spines measures only $^2/_3$ of the height of the fin, and the naked tip of each spine projects only a very little way above the skin. The breadth of the caudal and pectoral fins is also rather greater in proportion to their length. Somewhat smaller fetuses, 15—16 cm. long, with the large vitelline sac still attached in the form of a pear 7 cm. long, with a stalk measuring $2^1/_2$ cm., have a deep groove, like a seam, along the under surface of the snout. Their fin-spines are so short that the tips have not emerged from their scaly dermal envelope, which occupies, however, as great a portion of the fin-margin as in adult specimens. In the males only quite indistinct rudiments of the pterygopodia, not yet protruding from the skin, are visible. The coloration is fully developed. The young are not born until the yolk has been entirely absorbed, and may then have attained a length, as mentioned above, of 25 cm.

The Picked Dog-fish has a very extensive geographical range. In the North Atlantic this includes the most northerly parts of Europe, Iceland, and the east coast of the United States, as well as the west coast of Europe and the Mediterranean. To the south the species has been found off the Cape of Good Hope, the Mascarene Isles (DUMERIL), and on the coast of Australia (RICHARDSON and GÜNTHER). In the Pacific it is also known from Chili (MOLINA), Japan (SCHLEGEL), and Behring Island (the Vega Expedition). It is consequently to be regarded, we may almost say, as a cosmopolite. Throughout the west coast of Scandinavia it is common, and it penetrates, though more rarely, into the Baltic to the east coast of Rügen (MÖBIUS and HEINCKE) and to the north-east of Scania (WALLENGREN[a]).

In Scania, Bohuslän, and everywhere in Norway the Picked Dog-fish is called *Ha* (*Haa*). In Sweden the name is written *haj*, probably from some German or Dutch dialect. Other, less usual names are: *Piggha* or *Hafisk*, in Iceland *Hafr* or *Haafur*, on the Faroe Islands *Haarur*, in Scania *Hakatt* or *Hafskatt*. The name of *ha* (Shark) seems to have been everywhere applied among the Gothic nations by preference to this species, the commonest Shark; and the other forms have been distinguished by the addition of some suffix, as *Habrand* (the Porbeagle), *Hastörje* (the Tope), *Hamär*, *Hakäring*, or *Håkal* (the Greenland Shark).

The Picked Dog-fish has its constant habitat on a soft and oozy bottom, but, like most of the Sharks, is a confirmed rover. It swims in shoals, and is exceedingly voracious. Its food consists both of lower marine animals and of fishes, especially those of gregarious habits, such as Clupeoids, Garpike, and even Cod or Haddocks, which it bites in two with ease, though they be not much thinner than itself. When Picked Dog-fish appear in shoals, they are a great nuisance to the fisherman, for they plunder and damage nets set for other fishes, make off with hooked fish or get caught themselves instead, a poor exchange, and often bite off the snood above the hook, which is thus lost. They are said to be most numerous early in spring, when they approach the coast in enormous shoals, whose multitude, it is alleged, rivals that of the Herring. A boat's crew, it is stated, can then take several boat-loads in a day. From Norway SUNDEVALL was told that the Herring-shoals are sometimes hemmed in near shore by Picked Dog-fish, which keep watch outside. They are as plentiful on the English coast as in Norway, but in Bohuslän they do not seem to occur in quite so great numbers, when the Herring is not there. STRÖM, in his description of Söndmöre, says that they withdraw from the shallows at the beginning of April, shortly after the Cod have come in, after which very many are hooked, about Whitsuntide, in the deep fjords. On the coast of Bohuslän they are again taken towards autumn, first on hand-lines and Haddock-lines, thus in somewhat deeper water, during August and September, when the catch is said to consist almost exclusively of males, and later on, in October, when they are said often to penetrate far up the fjords and to remain there until the frost sets in. During winter they are not met with on the said coast, except when the Herring is there, possibly because they are not sought after in the deep water where they pass this season.

ARISTOTLE stated that on the coast of Greece this fish copulates in August and brings forth its young from May till August. The case is apparently as a rule the same in Scandinavian waters. EKSTRÖM concluded from his observations in Bohuslän that the breeding is performed in shoals during August or September in rather deep water. According to many corroborative statements the young are born most plentifully at the end of April and the beginning of May and afterwards, in less number, throughout the summer. W. v. WRIGHT states that during spring the females assemble in large companies near land, in small pools

[a] Öfvers. Vet. Akad. Förh. 1866, No. 1, p. 5.

3—6 fthms. deep, which are known in Bohuslän as *haljor*, and are then taken in the seine, without the catch of a single male. When drawn into the boat at this time of year, they often give birth to young ones, the probable origin of the assertion that young fish 15—17 dm. long swim in shoals together with their elders on predatory excursions. The Swedish fishermen declare that the fry never accompany the old, but live by themselves in shallow water. There they keep to the bottom, and are often taken on hand-lines during autumn. As they are never caught in numbers at the same time, it would appear that they do not gather in shoals, but lead a more solitary life. Each female seems to bring forth only about 10 young — in Ireland THOMPSON was told that the number is always odd — and the fishermen state that the female seldom contains more than 5 or 6 "*full-grown*" young at a time. SUNDEVALL found all the young taken out of the same female to be exactly similar in size and development, whence he concluded that they are probably born shortly after one another. As we have mentioned above, the new-born fry are 22—25 cm. long. Those taken in autumn are hardly any larger, and even in January a few specimens of about the same size are now and then caught. These are probably born late in the year, and THOMPSON states from Ireland[a] that even at Christmas-time he found a female Picked Dog-fish with 9 nearly mature fœtuses (5 male and 4 female) in the oviducts.

The flesh of the Picked Dog-fish is quite white and free from the disagreeable smell with which the larger Sharks are tainted. It is said to be fairly palatable, and it is eaten in Bohuslän both fresh, either boiled or fried, and cured, either salted or dried, in the last case usually after lyeing[b]. So too in Norway, where it is, however, not much esteemed. In Scotland and in Southern Europe the Picked Dog-fish is also frequently used for food. In a dried state it is a marketable commodity. If left uncooked for some days in summer, it begins to give off a rather powerful and exceedingly pure ammoniacal vapour, without any perceptible putrid smell, such as that usually emitted by decaying flesh. The caudal fin, which is a common article of trade in the island-belt of Bohuslän, under the name of *ha-rump*, is used by cabinet-makers in polishing wood and metal. In many localities the eggs are made into pancakes. The liver is boiled down into oil, and gives a fair yield. (SUNDEVALL, SMITT.)

GENUS ETMOPTERUS.

Teeth of the upper jaw symmetrical in form, multicuspid; those of the lower jaw obliquely shaped incisors. Nostrils large, their width being greater than the distance from the tip of the snout to the middle of a transverse line crossing their anterior margins. Pectoral fins orally spatulate. Dorsal fin-spines with lateral grooves.

It is true that RAFINESQUE[c], when he established this genus in 1810, based it partly on an erroneous observation — that it possessed only three branchial apertures — partly on a fortuitous character — that its dorsal fins were split at the margin[d]. But no ambiguity is thereby involved, and the current rules of nomenclature therefore demand that his name for the genus should supersede the generally adopted, but younger name of *Spinax*, which CUVIER[e] and, after him, BONAPARTE, in accordance with an unfortunate practice, borrowed from the Linnæan specific name.

GÜNTHER indeed recognises three species of this genus, one from Europe, another from Madeira and the West Indies, and a third[f] from the southern coast of South America; but the distinction between them is apparently rather dubious, and the former two are identified with each other by DUMERIL.

[a] *Nat. Hist. Irel.*, vol. IV, p. 254.

[b] See above, p. 1107, note *f*.

[c] *Caratt. N. Gen., Spec.*, p. 14.

[d] Hence the generic name (Gr. ἠθμός, *strainer* and πτερόν, *wing, fin*), which ought strictly to be written *Ethmopterus*. Still we retain here the orthography of its author.

[e] *Regn. Anim.*, ed. I, tom. II, p. 129 (1817).

[f] *Spinax granulosus*, *Shore Fishes*, Rep. Challeng. Exped., Zool., 6, p. 19, tab. II, fig. *C*.

THE SAGRE (SW. BLÅKAXAN).

ETMOPTERUS SPINAX

Plate LI, fig. 3.

Skin shagreened with curved, setiform spines, expanding into three or four arms at the base. Coloration above blackish blue, underneath coal-black.

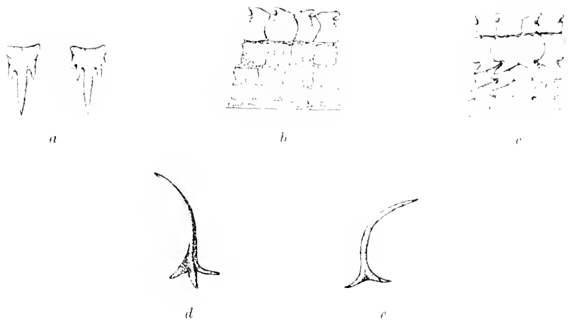


Fig. 340. Teeth and scales of the Sagre (*Etmopterus spinax*). *a*, two teeth from the upper jaw; *b*, the four middle, longitudinal rows of mandibular teeth, removed from the jaw and seen from in front, the descending compensatory teeth being visible through the mucous membrane; *c*, the same rows of teeth, seen from behind (from within): *a*—*c*, from a female 42 cm. long, × 1; *d* and *e*, scales, anterior and lateral aspects, × about 45.

Syn. *Galeus Acanthias seu spinax fuscus*, WILLUGHB., *Hist. Pisc.*, p. 57. *Squalus* pinna ani carens; naribus in extremo rostro, ART., *Ichthyol.*, *Gen. Pisc.*, p. 67; *Syn. Pisc.*, p. 95.

Squalus Spinax, LIN., *Syst. Nat.*, ed. X, tom I, p. 233; MARTIN, Vet. Akad. Handl. 1761, p. 227; LIN., *Fna Suec.*, ed. 2, p. 107; GUNN. (*Sorthaaen*), Trondhj. Sels. Skr., vol. II (1763), p. 313, tab. VIII; ASCAN. (*Blaataske*), *Icon. Rer. Nat.*, tab. XXXVII; RETZ., *Fna Suec. Lin.*, p. 305; RISSO, *Ichth. Nice*, p. 41; ID. (*Acanthias*), *Eur. Mer.*, tom. III, p. 132; NILSS., *Prodr. Ichthyol. Scand.*, p. 118.

Etmopterus aculeatus, RAFIN., *Car. N. Gen., Spec.*, p. 14, tab. XIII, fig. 3.

Spinax niger, CLOQUET, Dict. Sc. Natur., T. I (Suppl.), p. 93; AGASS., *Poiss. Foss.*, tom. III, pp. 61, 93, tabb. *A*, fig. 3; *B*, figg. 4, 5; BONAP., *Iconogr. Fna Ital.*, *Pesci*, tab. 141; MÜLL., HLE, *Plagiost.*, p. 86; KR., *Danm. Fisk.*, vol. III, p. 893; NILSS., *Skand. Fna, Fisk.*, p. 729; DUM., *Hist. Nat. Poiss.* (N. su. a BUFF.), tom. I, p. 441, tab. 4, figg. 13 et 14; GÜNTH. *Cat. Brit. Mus., Fish.*, vol. VIII, p. 424; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillaegsh., p. 212; 1879, No. 1, p. 104; GIGL., Espos. intern. pesca Berlino 1880, Sez. Ital., Cat., p. 113; MOR., *Hist. Nat. Poiss. Fr.*, tom. I, p. 348; DÖDERL., *Man. Ittiol. Medit.*, fasc. II, p. 96; STORM, N. Vid. Selsk. Skr. Trondhj. 1883, p. 44; CAR., *Prodr. Fnæ Medit.*, vol. II, p. 504.

Spinax Gunneri, RHDT, Overs. D. Vid. Selsk. Forh. 1824—27, p. XVI; COLL., N. Mag. Naturv. Chrnia, Bd 29 (1884), p. 117; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 673.

Acanthidium pusillum, LOWE, *Fish. Mad.*, p. 37, tab. VI.

Spinax Linnei, MALM, *Gbgs. Boh. Fna*, p. 626.

The Sagre is the smallest European Shark. It would scarcely appear to attain a length of half a metre: GUNNERUS's largest specimen was "somewhat more than half an ell in length" (between 30 and 40 cm.), and the largest female obtained by STORM from Trondhjem Fjord was 47 cm. long. The body is of a terete, fusiform shape, with rather indistinct hog-back[a], flatly convex on the forepart of the back and on the belly, somewhat flattened at the middle of the sides, deepest at the first dorsal fin, and gradually passing forwards from this point into the flatly depressed snout, though with a depression at the occiput, between the spiracles, and a corresponding swelling below, at the lower jaw and the hyoid bone. The peduncle of the

[a] In old females, with belly distended by ova or fœtuses, the hog-backed form (rounded triangular section) of the body is more pronounced.

tail is of a rounded quadrangular section, and is more or less deeply impressed in the median line above and below. Where the body is shallowest, just in front of the caudal fin, the breadth (thickness) is about $^3/_4$ of the depth. The greatest depth measures about $13^1/_2$ (♀)—$11^1/_2$ (♂) %, and the least depth about $2^1/_2$—3 %, of the length of the body. The greatest breadth occurs in the head, just in front of the gill-openings, and is

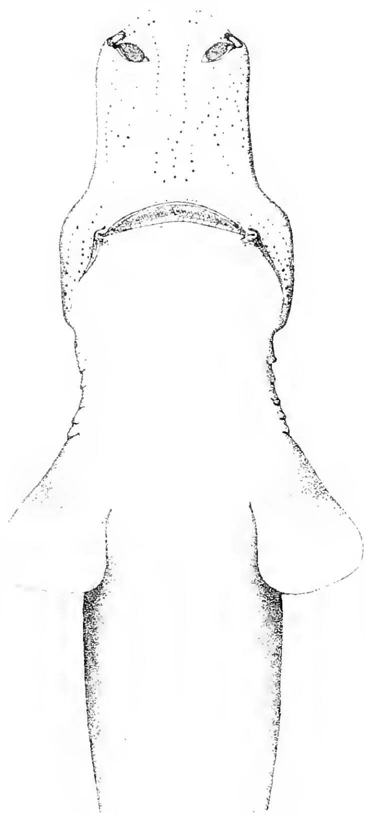


Fig. 341. Anterior part of the ventral side in a Sagre (*Etmopterus spinax*), ♂, 4 dm long, from Strömstad Fjord. Nat. size.

about 11—9 % of the length of the body. Across the gill-openings, on the other hand, the body is somewhat contracted, forming, as it were, a neck.

The length of the head to the first branchial aperture measures in full-grown specimens about $17^1/_2$—17 %[a] of the length of the body. Above the head is almost flat, underneath convex. Between the eyes the forehead is coursed by a longitudinal groove on each side of a terete median carina, which forks behind into two divergent branches. The interorbital width (including the dermal rim of the supraorbital margins) is about 45 %, and the length of the elongated, anteriorly and posteriorly pointed orbits about 34 %, of the length of the head. The eyes themselves are also elongated, the height of the iris being about $^2/_3$ of its length, which is nearly $^1/_5$ of that of the head. The length of the snout is about equal to that of the orbits, and in form the snout differs considerably from that of the preceding species, advancing with uniform breadth, until it is abruptly rounded off at the nostrils to a very blunt tip. The nostrils (fig. 341) are apparently double on each side, the small, pointed nasal valvules, one from the anterior margin, one from the posterior, laying their tips together, so that each nostril seems to consist of a circular aperture, situated at the very margin of the snout, and a proximal, oblong opening, directed obliquely backwards and inwards. Their entire breadth (both apertures) is about equal to the distance between their inner extremities, but only $^1/_3$ of that between the latter and the middle of the margin of the upper jaw, which margin lies below the posterior margin of the eyes, about half-way along the head. At the middle of the under surface of the snout is a longitudinal concavity which calls to mind the groove present at the same point in fœtuses of the preceding species. Among the pores belonging to the system of the lateral line on the snout, a double row on each side of the median groove underneath and a similar series on the upper surface, in a loop above the nostrils, are especially prominent. At an angle to the last-mentioned series a row crooks over each eye and is continued back towards the occiput. The broad mouth is slightly curved, its breadth being about $^3/_7$ of the length of the head, or somewhat greater than the distance between the nostrils and the upper jaw. The thin corners of the mouth are each surrounded by a deep groove, which is continued backwards by a slit narrowing to a point. The upper jaw is armed with 3 or 4 transverse rows of tricuspid or quinquecuspid teeth, with the median cusp largest, one row close behind the other. The lower jaw contains only one row of simultaneously functioning teeth, essentially similar to those of the preceding species, and forming, as there, a serrated cutting-edge;

[a] According to LILLJEBORG 16 %; according to KRØYER sometimes $15^1/_2$ %.

but behind (within) this row lie two or three rows of compensatory teeth, directed inwards and downwards. Thick dermal folds form, as usual, transverse curtains and cover the inner rows of teeth both in the upper jaw and the lower. The tongue is broad and flat. On opening the mouth, we can see from within straight through the large spiracles, which here, as in the preceding species, have the anterior margin double. Here too they lie obliquely behind and above (within) the posterior ends of the orbits, so far inwards that the distance between them is only about $^4/_5$ of the inter-orbital width, and so far back that their distance from the tip of the snout measures somewhat more than $^2/_3$ of the length of the head. Their width is about half the external diameter of the iris. The gill-openings are still smaller than in the Picked Dog-fish. They are scarcely larger than the spiracles, or even smaller than these. The last three are often set so close together that at a casual glance one may fail to distinguish between them, this being the probable explanation of RAFINESQUE's above-mentioned mistake.

All the fins are extremely thin at the outer margin, without scaly covering, and more or less transparent. They are consequently torn in most cases at the said margin, and they are seldom seen so entire as in our figure, which is drawn from a newly caught specimen in a good state of preservation.

The dorsal fins are distinguished by the posterior being considerably larger than the anterior and having about twice as large a spine. The first dorsal fin commences at the end of the first third of the body, the second somewhat before the end of the second third thereof. The form of the first dorsal calls to mind that of the adipose fin in the Salmonoids, the second is more typically a Shark fin, with concave outer posterior margin. The caudal fin, as a whole, is sickle-shaped, with the usual sinuses in the under margin only subindicated. The laterally compressed tip of the tail forms a slight upward curve within it. From the beginning of the upper lobe the caudal fin measures rather more than $^1/_5$, from that of the lower lobe rather less than $^1/_4$, of the entire length of the body.

The insertion of the obtusely rounded pectoral fins commences at a distance from the tip of the snout measuring somewhat more than $^1/_5$ of the length of the body. Their length is about 8—$8^1/_2$ % of that of the body or 43—54 % of that of the head; and the breadth of their base is about 52—56 % of their length. The ventral fins are elongated, with the outer angle strongly rounded. Their insertion, which measures about $8^1/_2$—$9^1/_4$ % of the length of the body, begins at a distance from the tip of the snout answering to about 54—56 % of the said length. The pterygopodia of the fully mature males — figured by DUMERIL, l. c., Pl. 1, fig. 13 — have before the tip three curved and pointed spines, two of which — the outermost being mobile — are set at the outer margin of the cleft on the upper side of these organs, the third being hidden in the skin near the top of the inner tegumentary margin of the cleft. The cloacal aperture occupies about the posterior half of the space between the ventral fins.

The scaly armature we have already noticed. The lateral line is sometimes quite distinct, marked by a black punctuation, and following a rather straight course, near the back, until it comes within the region of the caudal fin, where it crooks downwards to follow the inferior margin of the tip of the tail and pass straight out over the fin itself.

The coloration is distinguished from that of the preceding Sharks first and foremost by its being darkest on the ventral side; and from this black colour a stripe ascends on each side behind the ventral fins and expands both forwards, above the said fins, and backwards on the sides of the tail. Another similar stripe runs up before the beginning of the inferior caudal lobe and spreads along the lower part of the tip of the tail. The termination of the lateral line is also marked by a fine, coal-black streak along the under margin of the tip of the tail. The blackish blue colour of the back and sides acquires along the middle of the latter a more or less distinct silvery band, due to the grayish lustre of the setiform scales. The iris has a greenish metallic lustre; the pupil is green. The dorsal fin-spines and the teeth, as well as the outer parts of the eyes, are conspicuously marked by their white colour.

The Sagre is strictly a deep-sea fish, and it consequently shares with several other fishes[a] the peculiarity of having been found in widely separated localities without being discovered in the interjacent regions. Thus it was first described by WILLUGHBY from the Mediterranean, where it was already known — more than three hundred years ago — to the Genoese fisher-

[a] See for example above, p. 155, on the Blue-mouth.

men under the above name. It is certainly not very rare in the Mediterranean, for in 1879 GIGLIOLI took 40 specimens on one occasion from depths of 800—1,000 m. The stated occurrence of the Sagre on the coast of Portugal is doubted by BARBOZA and CAPELLO; but in the Bay of Biscay it is found, though seldom, according to LAFONT (in MOREAU). On the coasts of the United Kingdom and in the North Sea it has not yet been met with; but on the Norwegian coast it is common, occurring northwards at least to the 70th degree of latitude. In Trondhjem Fjord, according to STORM, is is one of the most usual catches on deep-sea lines. But it also ascends into comparatively shallow water, and the original of our figure, a male, was taken in November, 1881, on a Cod-line, at a depth of 40—50 fthms. in Strömstad Fjord. In Christiania Fjord, according to COLLETT, it is common. As mentioned above, it can hardly be distinct in species from *Acanthidium pusillum*, a Madeiran fish described by LOWE, which also lives, according to GÜNTHER, in Cuban waters; and remembering the wide distribution of the preceding species, we do not consider it impossible that with the Sagre should be also identified in species GÜNTHER'S *Spinax granulosus* from Chili.

The Sagre swims in shoals and, despite its insignificant size, pesters the fisherman after the same fashion, if not in the same degree, as the Picked Dog-fish. It often bites on the long-line, and is a disappointing substitute for the expected catch. Its diet is similar to that of the Picked Dog-fish, though it must, of course, confine itself more exclusively to small creatures. In a female 43 cm. long, from Bohuslän, the contents of the stomach comprised fish-scales (some Scopeloid species), a small cuttle-fish (? *Octopus*), almost digested, feet of crustaceans (some shrimp or *Pandalus*), several specimens of an indeterminable Annelid, fragments of worm-tubes, and a quantity of clayey sediment. The same female contained in the left ovary 8 eggs, in the right 5, about 14—17 mm. in diameter; but no eggs had passed into the oviducts. During April STORM found in Trondhjem Fjord a female with 14 young in the oviducts, and at the middle of July COLLETT obtained off Namdalen females with 7 or 8 fully developed fœtuses. In the Mediterranean, according to RISSO, the Sagre breeds all the year round, giving birth to 15—20 young about 1 dm. long.

The flesh of the Sagre is not used for food; but the liver yields a good oil.

Frequently the Sagre is infested with an ectoparasite, a Cirrhiped, *Anelasma (Alepas) squaticola*, LOVÉN, which forms at the dorsal fins and on the under surface of the head tumours, first described and figured by GUNNERUS.

FAM. SCYMNIDÆ.

Skin uniformly shagreened with tubercular or conical spinulæ. First dorsal fin situated half-way between the perpendiculars from the pectorals and ventrals or further forward. No externally protruding dorsal fin-spines. Teeth of the upper and lower jaws different from each other, but all smooth-margined and without lateral cusps.

The two genera that compose this family, *Scymnus* and *Acanthorhinus*, come nearest both in the dentition and the coloration to *Etmopterus*. HASSE has suggested[a] that the obscure pelagic forms *Isistius brasiliensis* and *Euprotomicrus Labordii* should also be ranged within this family, in which case the above character for the position of the first dorsal fin must be altered, this fin being removed rather far back in the two last-mentioned genera, more as in the family *Echinorhinidæ*. In either case we are apparently confronted here with one or more series of reduction-forms, which have originated from the Picked Dog-fish type, and whose genealogical relations to one another and to the primordial forms still require elucidation. The Scandinavian fauna possesses only one genus.

[a] *Nat. Syst. Elasmobr.*, Allgem. Th., p. 43.

GENUS ACANTHORHINUS.

Teeth of the upper jaw conical, carinated on the anterior surface, and set in several simultaneously functional transverse rows. Teeth of the lower jaw obliquely shaped incisors, set in several transverse rows, of which the foremost two or three are simultaneously erect and set close together. Length of the snout about the same from the eyes as from the mouth. Length of the caudal fin at the upper edge less than $^1/_5$ of the length of the body.

Of this genus two species have been described, one of which, however, *Acanthorhinus rostratus*, from the Mediterranean and the Atlantic outside, is extremely little known, and has been founded on characters that seem rather uncertain. The name of the genus was coined by BLAINVILLE, who in 1816 conferred it upon all the Sharks without anal fin[a], with especial reference, it is true, to the Picked Dog-fish, but also enumerating among the species our Greenland Shark. Subsequently the genus has received several names, which must be rejected, however, for different reasons. In 1817 CUVIER included the Greenland Shark in the subgenus *Scymnus* (*les Leiches*), from which it was afterwards removed on account of the dentition. LESUEUR (1818) gave the genus the name of *Somniosus*, a translation of *the Sleeper*, as the Greenland Shark is called by American fishermen. In 1841 MÜLLER and HENLE bestowed upon it the name of *Laemargus*, which KROYER had conferred shortly before (1837) on a genus of crustaceans. The oldest available name is BLAINVILLE'S, and as it cannot be applied to either of the two preceding genera, both of which have earlier names, its employment here is fully justifiable.

THE GREENLAND SHARK (SW. HAKÄRINGEN OR HASKARDINGEN).

ACANTHORHINUS CARCHARIAS

Plate LII, fig. 3.

Skin rather sparsely shagreened with thorn-like (conical) spines, in an unworn state pointed, with grooved base and arcuately recurred tip. Length of the snout about $^4/_5$ of the postorbital length of the head or more. Greatest depth of the body about 15—17 %, its least depth (just in front of the caudal fin) about $3^1/_2$—4 %, of its length. Coloration brown or black, shading on the sides into violet; iris blue, pupil green.

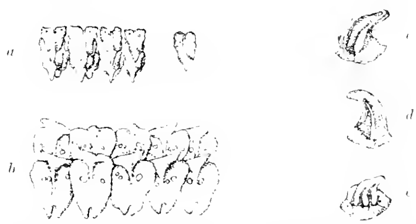


Fig. 342. Upper (*a*) and lower (*b*) jaw-teeth of a Greenland Shark (*Acanthorhinus carcharias*) $3^1/_2$ m. long, nat. size; *c*, *d*, and *e*, three dermal spines (scales) of different form from the same individual as *a* and *b*, magnified.

Syn. Hay, EGEDE, *Grønl. Perlustr.*, p. 49. *Canis marinus*, *Canis Carcharias*, CRANTZ, *Grønl. Hist.* (ed. suec.), lib. II, cap. 2. § 14. *Hav-Kerring*, STRÖM, *Söndm. Beskriv.*, p. 284. *Hakall*, OLAFS., *Reis. Isl.*, pp. 359, 597, 839.

[a] RAFINESQUE had indeed collected all these Sharks into one genus (*Dalatias*) previously (*Car. Alc. N. Gen. Spec.*, p. 10); but he characterized them by the absence of spiracles, and besides he was not acquainted with any species of the present genus.

Squalus Carcharias (*Haa-Skierding*), GUNN., Trondhj. Sels. Skr., vol. II (1763), p. 330, tabb. X et XI; LIN. (p. p.), *Syst. Nat.*, ed. XII, tom. 1, p. 400; FABR., *Fna Groenl.*, p. 127; MÜLL., *Zool. Dan. Prodr.*, p. 38; RINK, *Grønl.*, vol. I, 1, p. 135; vol. II, p. 212.

Squalus microcephalus, BL., SCHN., *Syst. Ichth.*, p. 135; KR. (*Scymnus*), *Danm. Fisk.*, vol. III, p. 914; MGRN, Öfvers. Vet. Akad. Förh. 1864, p. 536; 1867, p. 264; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 212; MALM, *Gbgs, Boh. Fna*, p. 626; WINTH. (*Læmargus*), Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 59; LTKN (*Somniosus*), Vid. Meddel. Naturh. For. Kbhvn 1879—80, p. 56; MELA (*Scymnus*), *Vert. Fenn.*, p. 366, tab. X; JORD., GILB. (*Somniosus*), Bull. U. S. Nat. Mus., No. 16, p. 15; STORM (*Scymnus*), N. Vid. Selsk. Skr. Trondhj. 1883, p. 44; COLL. (*Somniosus*), N. Mag. Naturv. Chrnia, Bd 29 (1884), p. 117; DAY (*Læmargus*), *Fish. Gt. Brit., Irel.*, vol. II, p. 320, tab. CLXII, fig. 1; PETERSEN (*Somniosus*), Vid. Meddel. Naturh. For. Kbhvn 1884—86, p. 160; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 679.

Acanthorhinus Norwegianus, BLNVLLE, Bull. Sc. Soc. Philom. 1816, p. 121 (+ *A. Microcephalus*, ibid.).

Somniosus brevipinna, LESUEUR, Journ. Acad. Nat. Soc. Phil., vol. I (1818), p. 222; STOR. (*Scymnus*), Mem. Amer. Acad. Arts. Sc., N. ser., vol. IX (Boston 1867), p. 235, tab. XXXVIII, fig. 2; MOR. (*Læmargus*), *Hist. Nat. Poiss. Fr.*, tom. I, p. 361.

Squalus borealis, SCORESBY, *Acc. Arct. Reg.*, vol. 1, p. 538, tab. XV, figg. 3—5; FLMNG (*Scymnus*), *Brit. Anim.*, p. 166; YARR. (*Greenland Shark*), *Brit. Fish.*, ed. 1, vol. II, p. 403; MÜLL., HLE (*Scymnus, Læmargus*), *Plagiost.*, p. 93; NILSS. (*Scymnus*), *Skand. Fna, Fisk.*, p. 724; COUCH, *Fish. Brit. Isl.*, vol. 1, p. 57, tab. XIII; DÜM., *Hist. Nat. Poiss.* (N. su. à BUFF.), tom. I, p. 455 (+ *Scymnus* [*Læmargus*] *brevipinna*, p. 456); GTHR (*Læmargus*), *Cat. Brit. Mus., Fish.*, vol. VIII, p. 426.

Squalus glacialis, FAB., *Fisch. Isl.*, p. 23; NILS., *Prodr. Ichthyol. Scand.*, p. 116.

Scymnus micropterus, VAL., Nouv. Ann. Mus. Hist. Nat., tom. I (1832), p. 454, tab. 20.

Squalus (*Scymnus*) *Gunneri*, RICHARDS., *Fna Bor. Amer.*, part. III, p. 313.

Obs. As we were compelled above to recognise the Linnæan specific name of *catulus* for the Black-mouthed Dog-fish, although it was originally intended for another species, here too we must acknowledge the specific name of *carcharias*, which was transferred by GUNNERUS in precisely the same manner to the Greenland Shark, all the more, since LINNÆUS himself included GUNNERUS's determination among the synonyms of his own *Squalus Carcharias*.

Next to the Basking Shark the Greenland Shark is the largest Scandinavian fish. Specimens so large as those known from hearsay by GUNNERUS — nearly 8 m. in length — must be reckoned as exceptions; and the statement may perhaps depend on a confusion with the Basking Shark. Both FABER and RINK give 18 feet (56 dm.) as the greatest length of the Greenland Shark, and according to the latter its average length on the coast of Greenland is only 25—28 dm. NILSSON assumed the maximum length might be fixed at 15 feet ($4\frac{1}{2}$ m.). In Trondhjem Fjord, according to STORM, the Greenland Shark hardly exceeds a length of 3 m.

The body is of a handsome and regular, compressed fusiform shape, sometimes, like that of the Sagre, somewhat approaching in front to the so-called hog-backed form. The head is strongly arched above, the snout convex both above and below, anteriorly depressed towards the edges, which meet in a tip parabolically rounded in the horizontal plane. The back is broad in front, in uninterrupted continuation of the arched head: but behind the perpendicular from the base of each pectoral fin it is compressed, and acquires in the median line a carina, anteriorly imperceptible, gradually ascending, and continued by the anterior margin of the first dorsal fin. The median line is also somewhat keeled between the two dorsal fins and in front of the caudal fin, the beginning of these fins being consequently difficult to fix externally. The peduncle of the tail, however, behind the second dorsal fin and the cloaca, often — as may occasionally be observed in the two preceding species — has a longitudinal impression both above and below, and on the lower part of each side we find, as in the Picked Dog-fish, a more or less distinct longitudinal carina. The greatest breadth of the body, just in front of the branchial apertures, is about $\frac{2}{3}$ of the greatest depth, at the beginning of the first dorsal fin, where the breadth is more variable, according to the distension of the abdominal cavity[a]. The peduncle of the tail also shows considerable variation of form, the breadth (thickness) of its shallowest part varying at least between 71[b] and 82 % of the depth thereof.

During the growth of the body from a length of 15 to one of 19 dm. the length of the head decreases from about $20\frac{1}{2}$ to $18\frac{1}{2}$ % of that of the body[c]. The eyes are round and rather small, measuring $\frac{1}{9}$—$\frac{1}{10}$ of the length of the head and about $\frac{1}{5}$—$\frac{1}{6}$ of the interorbital width. They are closely surrounded by the margins of the orbits, which are not very large. The

[a] According to VALENCIENNES the breadth at this point is $\frac{7}{12}$ of the depth.

[b] According to VALENCIENNES down to 50 %.

[c] In a stuffed specimen $3\frac{1}{2}$ m. long the length of the head is only $17\frac{1}{2}$ % of that of the body; but the measurement is, of course, uncertain.

nostrils are similar to those of the two preceding species, but are set at about the end of the first third of the snout, measured from its tip. The broad and but slightly curved mouth has free corners and deep grooves outside them. The teeth (fig. 342, *a* and *b*) are most like those of the Sagre. In the upper jaw they are set in 5—7 transverse rows. Lateral cusps are wanting or, if present, small and tuberous. The base of the tooth is higher than in the Sagre, more quadrangular, and on the broad anterior surface has a terete carina, continued to a greater or less distance on the cusp. In the lower jaw the first two rows of teeth are commonly erect, the compensatory teeth, on the other hand, the five or six posterior (inner) rows, directed downwards. Here too the lamellar base is higher, in proportion to the obliquely set, serrature-like cusp. In the lower margin it has a median sinus and on the anterior surface above the sinus a median carina, with one or more holes on each side. In comparison with those of the two preceding species the spiracles are small and set high. They have the appearance either of triangular or elongated, narrow openings, their length not exceeding the diameter of the iris. Their distance from the tip of the snout measures about $^{2}/_{3}$ (61—68 %) of the length of the head, and their distance from each other about half as much (about 30 % of the length of the head). The gill-openings are hardly middle-sized, the height of the first being about twice the diameter of the iris, but their height gradually increases from the first to the hindmost opening. They differ from those of the two preceding forms in that the last aperture lies a little in front of, not quite close to, the base of the pectoral fin.

All the fins are distinguished by their insignificant size. The two dorsals are obliquely quadrangular, longer than high, with the upper anterior angle roundly truncate and the upper posterior elongated to a point. The first dorsal begins at about the end of the fourth and ends at the termination of the fifth tenth of the body; the second begins just in front of the end of the seventh tenth and ends at the termination of the third quarter. The distance between the posterior extremities of their bases is consequently equal to that between the second dorsal and the upper tip of the caudal fin. This distance is also similar to that between the beginning of the pectoral insertion and the end of the base of the first dorsal. The caudal fin is comparatively broad, but short, its form being more nearly approximated than in any of the preceding Sharks to the Teleostean caudal fin. A peculiarity almost or entirely absent in the two preceding species is, however, that the hind margin is interrupted above by a shallow break, calling to mind the incision usually present in the other Sharks. The upper anterior margin of the fin measures about 18 %, its lower anterior margin about 12 %, of the length of the body. Among the paired fins the ventrals are not unlike the dorsal fins, but the pectorals are quadrangular in a different manner, as if the oval form were truncated and concavely emarginated at the broad end (the top). The relative position of the ventral fins to the second dorsal is about the same as in the Sagre; they begin at a distance from the tip of the snout measuring about $^{3}/_{5}$ (63 %) of the length of the body. The distance between the pectoral fins and the tip of the snout is rather more than $^{1}/_{4}$ (26—28 %), and the length of these fins at the anterior margin about 7—10 %, of the length of the body.

The shagreen and the coloration are noticed above. The small spiny scales are of the same type as in *Scymnus*, and resemble in miniature the spines of *Echinorhinus*, but are not so densely grooved. The white teeth of the mouth stand off sharply, as in the Sagre, against the dark ground of the body. Soon after the Greenland Shark is drawn out of the water, the loose epidermis peels off, and the body assumes a bluish gray tint. v. WRIGHT's figure (Pl. LII, fig. 3) represents the fish as it appears immediately after its capture.

The Greenland Shark is really an Arctic species, its affinity to *Acanthorhinus rostratus*, a form observed in the Mediterranean and on the coast of Portugal, being as yet unelucidated[a]. Fisheries for the Greenland Shark have long existed on the coasts of Greenland, Iceland, and Norway, and in recent times Spitzbergen has also become a fishing-station. On the North American coast the species goes south to Cape Cod. Isolated specimens have been met with in the North

[a] We need hardly remind the reader of the erroneous conceptions which stuffed specimens either of Sharks or Rays may give. With the other close resemblances to be observed between *Acanthorhinus carcharias* and *A. rostratus*, it would appear quite possible that the very strong prolongation of the occiput in the latter, according to CAPELLO's (Jorn. Sc. Math., Phys., Natur., Lisboa 1869, p. 146, tab. IX, figs. 2, 2 *a*, 3 *b*) and CANESTRINI's (Mem. R. Accad. Sc. Torino, ser. 2, tom. XXI, p. 364, tab. II, figs. 2—4) figures, may be due to stretching in the process of stuffing. The slenderness of the body and the great size of the eyes in *Acanthorhinus rostratus* may be characters of youth

Sea and the Channel (off the mouth of the Seine), as well as in the Cattegat, even off Mount Kullen, where Baron GYLLENSTJERNA secured a specimen during the spring of 1831, and on the north coast of Zealand, whence KRØYER and PETERSEN each adduce a specimen. On the coast of Bohuslän the Greenland Shark is not too scarce to have received a special name among the fishermen, being called *Hamär* (as in Norway) and, on Koster, *Blamauer* or *Blamaq-mär*. Strictly, however, it is a deep-sea fish, with its true habitat at a depth of some hundreds of fathoms, so that its appearance in the upper strata and in shallow water must be regarded as more or less fortuitous.

The Greenland Shark is sluggish and insensitive, but rapacious. Its acute hearing and keen smell have always been remarked by the fisherman. From the depths and from afar it is attracted by the odour of dead flesh, whether a whale is being cut up, a seal-hunt in progress, or a piece of carrion be cast out as a bait. From the carcase of the whale it tears pieces as big as a man's head, and cares little if the exasperated whaler stabs it with his long knife or pierces it with a lance. It is soon ready again to renew its voracious repast. To a moderate-sized Greenland Shark a seal is a comfortable mouthful. In the stomach of a Greenland Shark, according to GUNNERUS, the carcase of a reindeer has been found; and FABER relates that, when horses belonging to the Icelanders venture on too thin ice and are drowned, the Greenland Shark makes its way up the narrowest fjords — where it never puts in an appearance at other times — to feed on horse-flesh. But as a rule, no doubt, its prey consists of live animals; and in the stomach of a specimen 44 dm. long FABER found a whole seal (*Phoca vitulina*), 8 large Cod, a Ling $12\frac{1}{2}$ dm. long, the head of a large Halibut, and several pieces of whale-blubber. It has even been considered dangerous to man. FABRICIUS relates that it attacks the Greenlanders in their kayaks and bites both boat and kayaker in two. The Greenlanders, he states, therefore took care never to make a noise or talk aloud when passing over deep spots, for fear the Greenland Shark should hear them and come up. RINK, however, seems to give no credence to these accounts, and even says that the Greenlanders are only afraid of the very large Greenland Sharks, which by their movements and with their sharp skin might tear holes in the kayaks. FABER states that in Iceland no instance had been recorded of a Greenland Shark attacking human beings.

As has been indicated above, ichthyologists are still doubtful whether the Greenland Shark gives birth to living young or lays eggs. FABRICIUS states positively that it is viviparous, and FABER adds that the young are born in July and August. A female of *Acanthorhinus rostratus* dissected by CORNALIA[a] had 6 fœtuses in the oviducts, and another prepared by MM. GAL at Nice[b] contained 12 fœtuses. LÜTKEN, however, pointed out the singularity of the fact that in recent times, so far as he could ascertain, no fœtus had been found in any Greenland Shark, and also cited express statements from Iceland, where a general conviction obtains that the Greenland Shark is oviparous. In support of this opinion he adduces the circumstance that the eggs of the Greenland Shark, which have been found, inside the fish, of the size of goose-eggs, are so numerous that an adult female sometimes contains a barrel and a half or two barrels thereof; and such numerousness, he says, is surely not compatible with the development of the fœtuses within the oviducts, provided the development be simultaneous or nearly so. The last-mentioned assumption, however, has not been demonstrated; and so long as this is the case, we have good reason to follow LILLJEBORG and give the preference to the earlier belief that in this respect the Greenland Shark resembles its nearest relatives, and gives birth to living young[c].

[a] See LÜTKEN, l. c.

[b] See MOREAU, l. c.

[c] Long after the printing of the above in the Swedish edition of the present work, on Christmas Eve, 1894, the Royal Museum received a female Greenland Shark that had been taken some days before on the coast of Bohuslän. The length of the body to the tip of the upper caudal lobe was 172 cm., to that of the lower caudal lobe 158 cm. The length of the abdominal cavity was about 44 % of the former measurement. The two pointed lobes of the liver, which gradually narrowed behind, were longer than the said cavity, the length of the left lobe being about $1\frac{1}{3}$ times (136 % of) that of the right lobe $1\frac{1}{4}$ times (126 % of) the length of the abdominal cavity; and they were therefore bent behind, their posterior extremities being directed forwards. Both were of about the same breadth, which measured, where greatest (in front), about $\frac{1}{10}$ of the length of the abdominal cavity. The gall-bladder was rather large, twice as long as broad, and about equal in length to the base of the ventral fins or about $\frac{1}{8}$ as long as the abdominal cavity. On each side of the ventrally median peritoneal fold joining the gall-bladder to the diaphragm, opened the anterior end of the oviducts, which were of almost uniform thickness throughout

The fishery for the Greenland Shark is fairly lucrative in many localities. On the coast of Norway, and occasionally on that of Bohuslän, the Greenland Shark is sought after principally for the sake of its liver, from which oil is extracted; but in Iceland and Greenland the flesh is eaten both by man and dogs. A large fish contains, according to RINK, two barrels of liver, which, when melted down, yields oil to the amount of about 53 %. The flesh is also oily, but the oil exudes in process of drying, or may be removed by pressing while the fish is fresh. The Icelanders, like the Norwegians in GUNNERUS's time, cut the flesh up into *rar* and *räkling*[a]. The Greenlanders prefer to eat it rotten. When fresh, it tastes like Halibut, according to RINK, and has an agreeable, white appearance, but is somewhat coarse and tough.

In Norway the Greenland Shark is caught on large hooks, turning freely on a swivel, and with a snood of slender iron-chain, which the fish cannot bite asunder. The line is a centimetre thick or a little thinner, and is wound up on a small windlass, made fast to the bulwark of the vessel. With this tackle the bankers lie at anchor in the open sea between Norway and Bear Island or Spitzbergen, in 100—200 fathoms of water. The method practised is the same on the coasts of Iceland and South Greenland; but in North Greenland, according to RINK, the Greenland Shark is taken with far less trouble and much greater success through holes in the fast ice. The strong-smelling bait is dangled only a few metres below the surface, or it even happens that the Shark may be enticed right up to the hole, where it is captured with a gaff. The sluggishness of the Greenland Shark is such that it sometimes allows itself to be taken on an ordinary Cod-line.

Among the parasites of the Greenland Shark is often observed a crustacean, *Lernæopoda elongata*, which attaches itself to the cornea of the eye, and which was first figured by SCORESBY and, after him, by COUCH in his figure of the Greenland Shark.

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their length, and which crooked backwards along the posterior surface of the diaphragm, each to its respective side, below and along the spinal column. The two ribbon-shaped ovaries were symmetrically suspended on each side in the anterior part of the abdominal cavity and were of about the same size, 30 cm. ($^2/_3$ of the length of the said cavity) long and $2^1/_4$ cm. broad. The eggs were innumerable, and hardly distinguishable to the naked eye. At no point was there any indication of an earlier development in one part of the egg-mass than in another. This specimen too seemed accordingly to bear out LÜTKEN's opinion as to the reproductive operations of the Greenland Shark; but the question cannot be fully solved until older and ripe females have been examined.

[a] See above, p. 415.

PISCES CYCLOSTOMI.

Skeleton cartilaginous only at the head and tail, elsewhere fibrous. Notochord unaltered throughout life: no complete spinal column. No true maxillary or mandibular parts. No true gill-arches, the branchial lamellæ being serially arranged on the inside of sacs each with a separate aperture or all having a common aperture on each side of the body. One nasal aperture only, in a developed state dorsal. No paired fins. No shoulder-girdle, no pelvis.

Hitherto all the fishes under our consideration have been of indisputable piscine nature. We now approach the primordial limits of the vertebrate type, where the differences between the various classes find more or less imperfect expression in the structure of the several forms. Our knowledge of the geological evolution of the vertebrates is indeed deficient as yet in many respects, and fails us when we have to determine the origin of the classes. Besides, many remains cannot be expected to be preserved of animal forms which for the most part were indubitably without firm skeleton. But morphology and ontology (the development of the individual) point so clearly to intermediate forms which probably had representatives once in the living world, that the imagination has full right to picture an extensive area of the system, principally tenanted by extinct animals in which the characters of the different classes were combined or not yet differentiated. The Cyclostomous order survives during the modern age in such a position. The points of resemblance between these fishes and the rest are indeed so many that none can well deny the piscine nature of a Myxine or a Lamprey; but several portions of their structure lend themselves best to explanation by a comparison with the organs of batrachian larvæ.

A very salient proof of the low rank occupied by the Cyclostomes as vertebrates lies in the metamorphosis pointed out by A. MÜLLER[a] in the transition from *Pride* (*Ammocœtes*) to *Lampern* (*Petromyzon*). The transformation is here as great in certain respects as that undergone by many invertebrates, and is also accomplished, at least in part, by histolysis (dissolution) of the organs to be transformed.

The order contains two families, one of which, that of the Myxine, never acquires any true (discoid) suctorial mouth, the name of *Cyclostomi* (*with round mouth*)[b] — which we retain in accordance with the rules of zoological nomenclature — being hence less appropriate than the later *Marsipobranchii* (*with saccate gills*)[c].

Fam. PETROMYZONIDÆ.

Seven gill-openings on each side of the forepart of the body (the throat). The nasal duct terminates cæcally and in a developed state has its inner (posterior) end situated between the anterior part of the notochord and the œsophagus, under the former and above the latter.

On account of the above-mentioned intermediate position occupied by the family of the Lampreys, as well as by the following family, with relation to the other classes of vertebrates, its study has possessed

[a] Müllers Archiv 1856, p. 323.

[b] C. DUMÉRIL, *Zoologie Analytique*, Paris 1806, p. 100.

[c] BONAPARTE, *Selachiorum tabula analytica*, N. Ann. Sc. Nat., Bologna, Ann. I, tom. II (1838), p. 214, and *Systema Ichthyologiæ*, ibid., Ann. II, tom. IV (1840), p. 277.

great morphological significance. In the structure of the skeleton of the Lampreys the difference between the internal (vertebral) and the external (extravertebral) parts is far more prominent than in the fishes we have hitherto considered, the latter parts being here endowed with a more preponderating importance. The purely vertebral parts appear in the Lampreys merely as the framework of the cranium and its nearest appendages and as very imperfectly developed neural arches (fig. 343, *arc*) on the sides of the myelon and the unaltered notochord (*etch*). In the vertical fins too cartilaginous rods are developed which are applied to the neural arches in such a manner that it has been proposed to interpret them as representing spinous processes both superior (neural) and inferior (haemal). The skull itself is an almost straight continuation of the fibrous medullispinal sheath, which has been dilated, and which grows, on each side of the brain, to form a more or less complete roof for the cerebral cavity (*tegmen cranii*, *t*). Laterally and downwards the floor expands in three places on each side into flat processes. The foremost pair of these processes projects from the ethmoidal part, the posterior two pairs issue from the sphenoidal part. The former is evidently homologous with a palatine arch (*pal*), the latter answer to the upper parts in the suspensory apparatus of the mandibular and hyoid arches. But no mandibular arch proper is developed in these fishes. The two posterior processes on each side are confluent at the base; but the anterior of them (*ptg*) grows outwards and forwards, in a loop below the eye, until it coalesces with the top of the foremost (palatine) process (*pal*). In this manner a flat ring is formed, surrounding an aperture (*fenestra suborbitalis* or *fissura orbitalis inferior*, *fo*), and composing the bottom of the

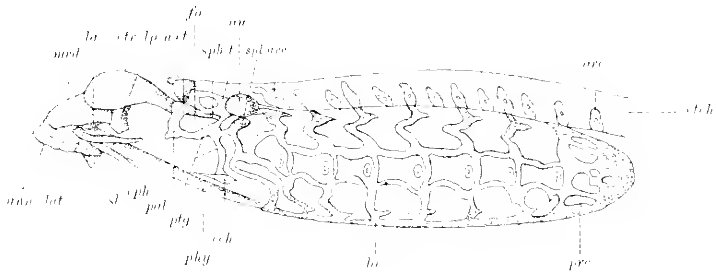

Fig. 343. The cartilaginous skeleton of the anterior part of a Lampern (*Petromyzon fluviatilis*), $^3/_2$ nat. size.
ann, annular cartilage of the oral disk; *arc*, rudimentary neural arches; *au*, cartilaginous capsule of the auditory apparatus; *br*, branchial basket; *ceh*, ceratohyal cartilage; *etr*, posterior cartilage of the roof of the mouth (*cornua trabecularum*); *eph*, epihyal cartilage; *et*, ethmoidal part of the cranial floor; *etch*, outer sheath of the chorda dorsalis; *fo* suborbital fenestra; *la*, anterior lateral cartilage of the roof of the mouth; *lat*, lateral labial cartilage; *lp*, posterior lateral cartilage of the roof of the mouth; *med*, median cartilage of the roof of the mouth; *n*, olfactory capsule, with the tubular orifice of the nasal duct; *pal*, palatine part of the roof of the mouth; *phy*, posterior hyoid cartilage; *pre*, pericardial cartilage; *ptg*, pterygoid part of the roof of the mouth; *sl*, sublingual cartilage; *sph*, sphenoidal part of the cranial floor; *spl*, sympleetic (? hyomandibular) cartilage; *t*, lower part of the cranial roof (*tegmen cranii*).

is invested in the developed Lamprey with a more or less complete cartilaginous capsule (*t*) originating from the skeletogenous layer round the anterior end of the notochord. The part first formed, the cranial floor, answering to a sphenoidal region (*sph*) applies itself to and coalesces with the already present auditory capsules (*au*). In a forward direction are developed the so-called cranial trabeculae, around the cerebral appendage (hypophysis, posterior nasal duct) and the under-brain (infundibulum); and after their union in front into an ethmoidal part (*et*) they advance to the so-called *cornua trabecularum* (*etr*), which coalesce into a disk in front of the nasal capsule (*n*). Upwards the cranial floor cranial orbit. To the top of the hindmost process is attached the hyoid arch proper. The upper part of the latter is an unbroken downward continuation of the said process, and represents an epihyal bone (*eph*); the lower (ventral) part, which is suspended at right angles to the lower tip of the upper part, answers to a ceratohyal bone (*ceh*). A certain similarity to this structure of the cranial roof of the palate and pharynx we have indeed seen in the Chimaeras (fig. 291, p. 1065), where a coalescence, suggestive of a development presumably very primitive, has taken place between the pterygo-palato-quadrate parts and the cranium. But the closest resemblance to this structure in the Lampreys meets us in batrachian larvae (fig. 341), a reminder that in their origins these two types were structurally not far removed from each other. The tongue of the Lampreys contains a long rod-like supporting apparatus, capable of protrusion and retraction, and suspended under the ceratohyal. This apparatus consists of two cartilages, an anterior, semipateriform, excised in front, situated in the mouth, and a posterior (*phy*), much longer, the posterior extremity of which projects into the branchial basket. It is interpreted as homologous with a basihyal, and the anterior cartilage bears the lingual teeth (fig. 345), at the very tip a curved, transversal dental plate (*aln*), with firm, rounded and obtuse teeth, and further back two plates (*pln*), lying more loosely in the gums, meeting anteriorly in an ellipse, and furnished with small but acute, retral teeth.

The whole oral apparatus of the Lampreys, which is abundantly supplied with cartilages, paired and unpaired, pateriform or lamellar and rod-like — one of

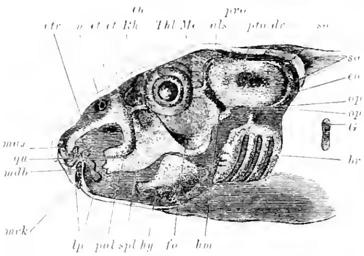

Fig. 344. Cartilaginous parts etc. in the head of a tadpole about 1 in. long, at the time when the hind legs begin to appear. About 9 times nat. size. After PARKER.

ctr, *n*. and *et*. as in preceding figure: *Rh*, *Thl*. and *Me*, the three anterior divisions of the brain; *Oc*. eye; *als* (alisphenoid), *pro*, (prootic), *pto* (pterotic), *so* (supraoccipital), *eo* (exoccipital), and *op* (episthotic), all answering to *t* in preceding figure; *dr*. section of the skin; *G*. gill-opening; *br*. as in preceding figure; *hm* and *spl*. answering to *spl* in preceding figure; *fo*. as in preceding figure; *hy*. answering to *phy* in preceding figure; *lp*, lips (dermal flaps); *mck*. Meckelian cartilage; *mdb*. mandible; *qu*. quadrate bone; *mx*, upper jaw.

them annular — belongs to the extravertebral structures. Below the *cornua trabecularum* (fig. 343, *ctr*) is medially situated an invertedly pateriform cartilage (the median cartilage of the roof of the mouth, *med*, MÜLLER's "vordere Deckplatte des Mundes"), which has behind it on each side a flatly convex cartilage of a rounded quadrangular form (the posterior lateral cartilage of the roof of the mouth, *lp*, MÜLLER's "hintere Seitenleiste") and at about the middle of its side-margin a narrower, more terete plate (the anterior lateral cartilage of the roof of the mouth, *la*, MÜLLER's "vordere Seitenleiste"). Under and before the said median plate lies the annular cartilage (*ann*, MÜLLER's "knorpeliger Lippenring"), the bearer of the largest teeth, which has behind it a median plate (the sublingual cartilage, *sl*, MÜLLER's so-called "Zungenbein"), situated under the tip of the hyoid bone, in front expanded and convex, behind acutely elongated. On each side of this sublingual plate lies behind the annular cartilage a rod-like cartilage (the lateral labial cartilage, *lat*, MÜLLER's "*stielförmiger Anhang des Lippenringes*"); and three small cartilages, the bearers of the lateral teeth of the mouth, lie loosely in the skin on each side of the annular cartilage.

The branchial basket (*br*) too is entirely extravertebral, a network of thin flat cartilaginous rods, supporting the outer walls of the gill-sacs. Anteriorly this network is suspended from the epihyal cartilage; posteriorly the cartilaginous mass developes into a saccate case for the heart, a pericardial cartilage (*prc*).

The nervous system of the Lampreys has thrown light, especially in two points, on the morphology of

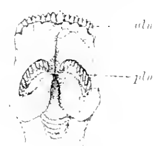

Fig. 345. Tip of the tongue and its dental plates in a Lampern (*Petromyzon fluviatilis*). × about 5.

aln. anterior dental plate of the tongue; *pln*. posterior dental plate of the tongue.

the higher vertebrates. These points have reference to the interpretation of two organs still involved in great obscurity, the cerebral appendage and the pineal gland.

At the bottom of the human cranial cavity, as well as on the under surface of the brain in all other true vertebrates, lies a glandiform organ whose function is still doubtful. It is known anatomically as the *hypophysis cerebri*. In man it is about as large as a pea, oblong in form and transversally set, lodged in the depression on the upper surface of the sphenoid bone (the so-called *sella turcica*) and attached to the brain by a funnel-shaped prolongation thereof in a downward direction from the bottom of the third cerebral ventricle. It consists of two parts, an anterior, the development of which we shall now describe, and a posterior, whose development originates from the brain. Great importance was formerly attributed to it both by physiologists and psychologists. By GALEN, in the second century

A. D., and after his time far into the middle ages, even if the conception was modified in several manners, the cerebral hypophysis was explained as an extremely important organ for the purification of the fluids contained in the brain. It was also called the gland for the secretion of the nasal mucus (*glandula pituitaria*), an error which was not refuted until the seventeenth century. Another opinion was advanced, which even at the beginning of the present century was maintained by so eminent an anatomist as MECKEL, namely that it secreted some kind of important fluid, which was supplied to foetal life than afterwards and is comparatively larger in young persons than in old, as is the case with several other organs whose significance appears to be more historical than physiologically clear.

Better than its function, however, we know the origin of the hypophysis[a]. In man it arises as an involution of the embryonic ectoderm in the region which afterwards becomes the roof of the mouth cavity. This involution rises, towards the anterior end of the notochord. It makes its appearance before the mouth cavity proper is formed, and long before the mouth has

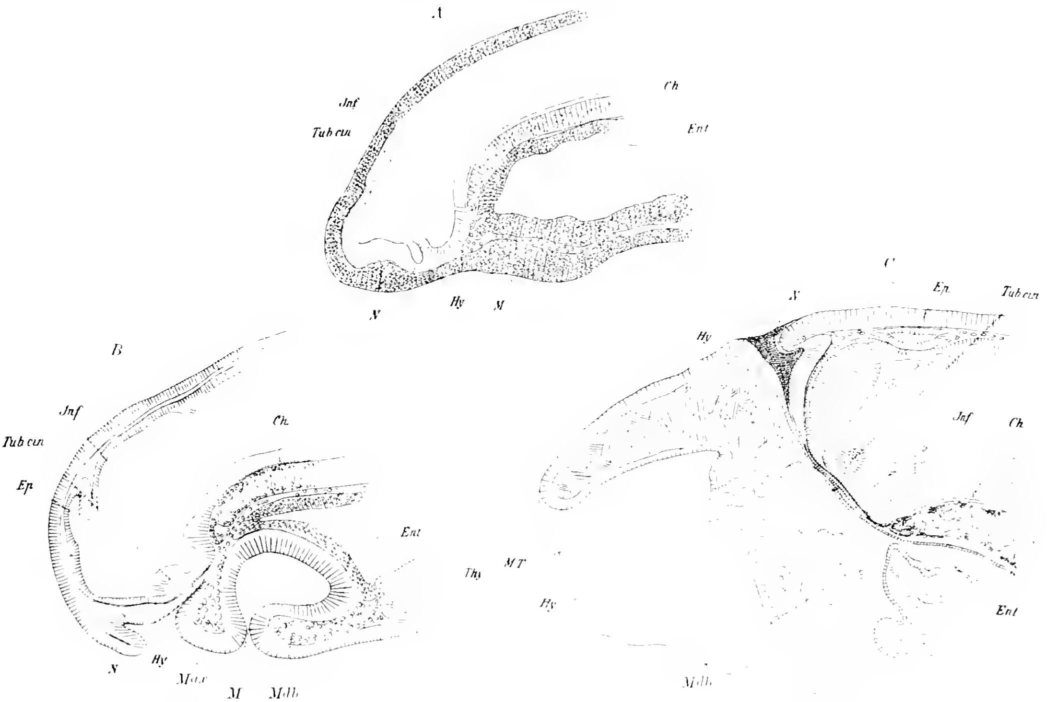

Fig. 346. Longitudinal section of the forepart of larvae of *Petromyzon Planeri*, after A. DOHRN. *A* three days, *B* six days, *C* seventeen days after exclusion.

Ch, chorda dorsalis; *Ent*, entoderm; *Ep*, epiphysis; *Hy*, hypophysis; *Inf*, infundibulum; *M*, stomodeum, future mouth cavity; *Max*, upper jaw; *Mdb*, lower jaw; *MT*, mouth tentacle; *N*, nasal sinus, future nasal cavity; *Thy*, thyroid gland; *Tub. cin*, tuber cinereum.

the third ventricle of the brain. In modern days physiology does not seem to devote very much attention to its interpretation: it is most generally referred to the so-called blood-vascular glands, which it resembles in the greater part of its structure. Remarkable is the circumstance that it has a more robust growth during broken a passage through the pharynx to join the intestinal canal. In the form of a tube it grows up towards the rudiment of the brain; and when the floor of the skull is developed the lower part of this tube closes, in the region where the presphenoid bone subsequently coalesces with the postsphenoid: the commu-

[a] The first investigator hereof was RATHKE, *Ueber die Entstehung der Glandula pituitaria*, Müllers Archiv 1838, p. 482.

nication with the mouth cavity is interrupted, and the hypophysis lies enclosed in the cranial cavity. Such is the development in all the higher vertebrates. In the lower, on the other hand, as for instance in the frogs, the cerebral hypophysis appears still earlier, before the mouth cavity is developed enough to contain the origin of this appendage within its region. In *Pelobates fuscus* GOETTE[a] has shown that the origin thereof is visible even before the future mouth cavity is indicated in any way. There, accordingly, the cerebral hypophysis is at least as primordial an organ as the mouth. In the Lampreys DOHRN[b] and, after him, KUPFFER[c] saw a stage of development (fig. 346, *A* and *B*) in which the nasal cavity (*N*), the hypophysis (*Hy*), and the mouth cavity (*M*) had begun to appear on the under surface of the rudimentary head in the form of three uniserially (in a sagittal row) arranged impressions of the ectoderm. But here the homologue of the hypophysis becomes much more than, and something quite different from, a mere appendage of the brain. Such an appendage is indeed present in the Lampreys; the said rudiment here too grows in a tubular form upwards and backwards towards the tip of the notochord, but it also moves upwards round the snout, continually growing, and becomes the so-called nostril of the Lampreys, which throughout their life opens on the dorsal side of the head and thence extends in a tubular form backwards and downwards over the pharynx. During its growth and migration as described above the nostril draws within its limits the true olfactory apparatus (fig. 343, *n*), a capsule imperfectly divided internally into two chambers, and developed from the nasal cavity (fig. 346, *B*; *N*) that once lay before the rudiment of the hypophysis. In this manner the Cyclostomes attain a unique position among the vertebrates. They possess, it is true, a well-developed olfactory apparatus, but only *one* nasal capsule and *one* nostril. HECKEL therefore called them *Monorhini*.

The hypophysis is accordingly a very primitive organ — at least as ancient as the mouth — but in the highest animals has lost its most essential significance[d]. Similar is the history of the pineal gland.

In 1881 LUYS published a psychology[e] as the result of his works on the brain and its functions, giving us in a very popular way means to understand the relation between the different parts of the brain. By numerous and successful sections he traced the course of the nerve fibrils to the brain and within this to the connexion between its countless ganglion cells. Contemporaneously with these and other anatomical works FERRIER in England, FRITSCH and HITZIG and, after them, MUNK in Germany, had published their famous attempts to discover in the superficial layers of the brain the so-called psychomotor centres and to define their limits. These and other later researches in many points have modified the views advanced by LUYS, especially as to the arrangement of the sensorial tracts, but for our present purpose we may leave those discrepancies out of sight. The brain of the higher vertebrates, with its rich psychical life, is, however, of so complex a nature that the mysteries of that life would probably have never been solved by the methods of natural history, had not more simple material been placed at the investigator's disposal. The study of the lowest fishes in particular has led to the one comprehensive conclusion after the other. Thus we shall, no doubt, be able at length to trace the origin of different psychical faculties in connexion with the different development of some part or other of the brain. Already in 1840 JOHANNES MÜLLER foreshadowed this, when in his work on the nervous system of the Myxines he chose the cerebral structure of these fishes and of

[a] *Entwickelungsgeschichte der Unke*, p. 288, taf. II, figs. 34—38.

[b] Mittheil. Zool. Stat. Neapel, Bd. IV, p. 172, taf. 18.

[c] Arch. f. Mikr. Anat., Bd. 35 (1890), p. 537, taf. XXXI, fig. 62.

[d] In the Quart. Journ. Micr. Sc., N. ser., vol. XXIII (1883), pp. 349, cett., HUBRECHT has tried to show that both the hypophysis and the notochord are inheritances from the worm-like predecessors of the vertebrates. The hypophysis, he contends, represents the proboscis of the flat-worms and the notochord their proboscidian sheath. At the limit between the proboscis and the sheath — where the latter suffers invagination to receive the former when retracted — lies the principal mass of the Platyelminth nervous system; and at the corresponding point in the skull of the lower vertebrates, at the limit between the epichordal and prechordal parts of the brain, there too do the notochord and hypophysis meet each other.

Neither the hypophysis nor the notochord would thus be peculiar to the vertebrates; they would have their prototypes in the lowest worms. The hypophysis lies under our brain in the most protected spot throughout our body, as even GALEN remarked, as if it were a most important and delicate organ; but it lies there, according to HUBRECHT, merely as a relic, a vestige of an organ which serves the lowest worms for purposes of touch, offence, and defence. In us adults the notochord has entirely disappeared; but during our fœtal life and that of the other higher animals, as well as in the adult state of lower vertebrates, this string is the axis round which the vertebræ are developed and their bodies chondrified or ossified; — and this string, says HUBRECHT, was once a sac within which the homologue of the hypophysis might find concealment.

[e] *The Brain and its Functions*, Intern. Scient. Series, vol. XXXVII, Lond. 1881.

the Lampreys as the basis of his explanation of the corresponding structures in the higher vertebrates; —and even he could declare that "the structure of the brain in the Lamprey and Pride is a perfect parallel to the earliest stages in the development of the brain of the higher vertebrates."

From the results of the history of evolution BEARD[1] drew a picture of the worm-like ancestors of the vertebrates, ancestors which have all disappeared from the earth, so far as we know, without leaving a trace of their existence. Their body, he says, was anteriorly furnished with several, at least eleven pairs of gill-clefts, and above, i. e. at the dorsal termination of each gill-cleft, lay a sense organ in the skin, probably to warn the animal of the approach of any dangerous object towards the gill-bearing parts of the body. The nearest guide, sense organs of the same kind have originated the development of all the other higher senses. Even in the mammals FRORIEP[2] has traced the same course of development for three of the cranial nerves (*facialis*, *glossopharyngeus*, and *vagus*) as BEARD found to obtain in Rays and other fishes for all these nerves, including those of smell, hearing, and taste. In order to obtain their basal ganglion these nerves grow from the sides of the rudimentary spinal canal downwards and outwards to the inner surface of the embryonic skin and meet a thickening thereof at a spot answering to a primordial sense organ of a gill-cleft. The ganglion is formed by the growth and multiplication of the epidermal cells at this point; but the rudiment of the primordial sense organ disappears after having thus done its duty

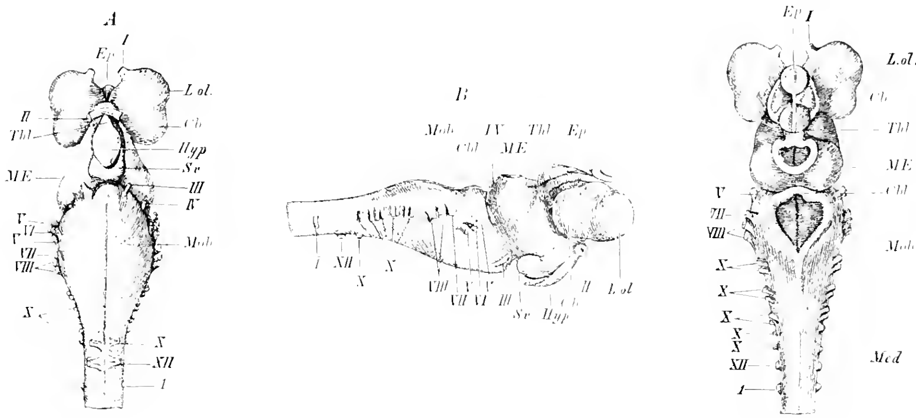

Fig. 347. Three sketches of the brain and medulla oblongata in a Pride (*Petromyzon* in the *Ammocates* stage), magnified. After WIEDERSHEIM. *A*, from below; *B*, from the right; *C*, from above.

I—X, cranial nerves in order from in front; *1*, first pair of spinal nerves; *Cb*, cerebrum; *Cbl*, cerebellum; *Ep*, epiphysis; *Hyp*, hypophysis; *L. ol.*, lobi olfactorii; *ME*, mesencephalon; *Med*, medulla; *Mob*, medulla oblongata; *S. v.*, saccus vasculosus; *Thl*, thalamencephalon.

parallel to the sense organs of the gill-clefts in their original form is thus afforded by the lateral-line system of fishes and batrachians, with their marvellous development to the possession of a sense which we as yet scarcely understand, a specification of the sense of pressure, enabling these lower vertebrates to appreciate certain undulations of the water, and thus to detect at a distance the presence of objects or the approach of changes which under the same circumstances could hardly be perceived by the senses of the higher vertebrates. But if the history of evolution be a faithful in the history of evolution, without ever having felt a sensation. Even the formation of the eye may be referred, considering the manner of origin shown by the ciliary ganglion and the lens, to the same scheme. Originally a number of these sense organs would thus seem to have been present in the skin of the vertebrates; but according to this assumption most of them have become useless since the development of the senses in their present form. The course of this process is known at least in the case of one such organ, the pineal gland, whose fate has been traced with fair precision.

[1] *Syst. branch. Sense Org.*, Quart. Journ. Micr. Sc., Nov. 1885, and *Develop. Peripher. Nerv. Syst.*, same periodical for Oct., 1888.
[2] *Ueber Anlagen von Sinnesorganen am Facialis, Glossopharyngeus und Vagus* etc., Arch. f. Anat. u. Physiol. 1885. Anat. Abtheil.

When AHLBORN resumed the study of the brain of the Lampreys in 1883[a], its structure appeared in a new light, different from that shed upon it in JOH. MÜLLER's day. In the brain of the lower vertebrates (fig. 347) a distinction is now drawn in the first place between a posterior and an anterior part. The posterior, epichordal part — so called because it extends as far forward as the subjacent *chorda dorsalis* — contains the *medulla oblongata* (prolongated spinal cord or afterbrain, *Mob*) and the small homologue of our *little brain* (hindbrain or cerebellum, *Cbl*), but in the Lampreys is almost as large as the whole anterior portion, the so-called prechordal part. All the cranial nerves, except those of sight and smell, have their roots in this posterior part of the brain. In the prechordal brain the homologue of the *brain proper* (forebrain or cerebrum, *Cb*) of the higher animals is merely a small, hollow prominence on each of the two olfactory lobes (*L. ol.*). The two parts of the brain which are incomparably most developed in man — the cerebrum and cerebellum — are thus the smallest in the Lamprey; and but little, though somewhat, greater is the development of the cerebrum in true fishes (Teleosts) and batrachians. Merely for anatomical reasons it has been possible to prognosticate that in these animals the cerebrum is simply a gathering-place and a control-station for the sensations coming from the organs of smell. In 1868 GOLTZ successfully extirpated the cerebrum of frogs, which still lived for some time "with their intelligence preserved," as he expressed it; and in 1886 the same experiment was performed on fishes by STEINER at Heidelberg and VULPIAN in Paris. A Carp which lived six months after the removal of its cerebrum (forebrain), the other parts of the brain, even the olfactory lobes, being left intact, showed no other irregularity of behaviour, according to VULPIAN, after the wound had healed, than that it was apparently destitute of the sense of smell. Yet in the higher vertebrates that part of the brain of which it was deprived, is the foundation for the subsequent development of the material substratum in everything that bears the name of consciousness. Thus in the fish it is only those ganglion cells with which the conscious apprehension of the impulses of smell is bound up that lie there. Another part of the prechordal brain appears in fishes to occupy exactly the same relations to the stimuli of sight. This is the postero-superior part, the so-called midbrain (*ME*), which on the dorsal side is closely applied to or even confluent with their *little brain*. The first control-stations for the sensations of sight within the region of the brain, however, lie in the antero-inferior part of the median portion of the prechordal brain, the so-called 'tweenbrain (fig. 347, *Thl*). Originally, as here in the Lampreys, the 'tweenbrain and midbrain enclose that cavity of the brain known as the third ventricle, and this they also do in the embryos of the highest vertebrates; but in the adult brain of the latter they have sunk down to the bottom of the ventricle; and before this has happened, great revolutions have taken place in the surroundings of that ventricle. The midbrain has dwindled into the

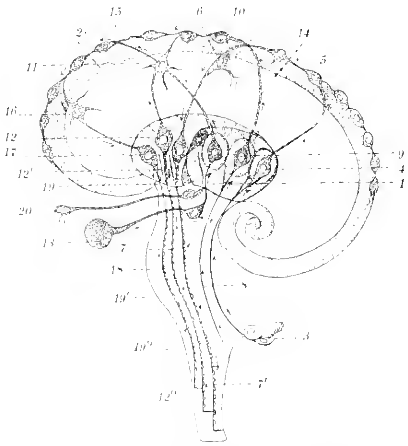

Fig. 348. Diagram of a longitudinal section through the human cerebrum and medulla oblongata, to illustrate the higher functions of the brain, according to the assumptions advanced by LUYS.

1, *thalami optici*; *2*, *corpora striata*; *3*, course of the propagation of acoustic impressions (labyrinth of the internal ear). These impressions arrive in the corresponding centre (*4*), are radiated towards the sensorium (*5*), and reflected at *6*, to the large cells of the corpus striatum, and thence at *7* and *7'*, towards the motor regions of the spinal axis. *8*, Course of sensitive impressions. These are concentrated (at *9*) in the corresponding centre, radiated thence into the plexuses of the sensorium (*10*), reflected to the large cortical cells (*11*), and thence propagated to the large cells of the corpus striatum, and finally to the different segments of the spinal axis. *13*. Course of optic impressions. These are concentrated (at *14*) in their corresponding centre, then radiated towards the sensorium (at *15*). They are reflected towards the large cells of the corpus striatum and afterwards propagated to the different segments of the spinal axis; *18*, *19'*, *19''*, the antero-lateral fibres from their point of origin in the corpus striatum, are invested by the elements of cerebellar innervation which begin to appear in the peduncles (*19*), to become considerably thicker at *19'*, on a level with the region called the *pons*, and to diminish insensibly on a level with the medullary regions, *19''*. — *20*, peripheral expansion of the olfactory nerves.

[a] *Unters. üb. das Gehirn der Petromyzonten*, Zeitschr. f. Wiss. Zool., Bd. 39.

corpora quadrigemina, and thus become a part of the enrolling stations for the nervous action which proceeds, according to LUYS, between the surface-layers of the cerebral hemispheres and the central gray matter of the spinal column, i. e. between the psycho-intellectual and the vegetative life. The 'tweenbrain, on the other hand, has developed into the optic thalami, which now, however, have a far greater importance than that of mere collectors of the visual sensations, for hither, according to LUYS (fig. 348), stream all the sensations not yet idealised, but destined to the consciousness. Here LUYS distinguished between four centres, well-defined gangliar masses in each optic thalamus (*1*), the foremost of which receives and transmits the impulses of smell (*20*), the second those of sight (*13—14*), the third those of touch (*8—9*), the fourth those of hearing (*3—4*). Before and outside the optic thalami lies the primitive floor of the cerebrum was a time when it was supposed that the soul had a fixed and special station in some part of the brain, and DESCARTES assumed that the pineal gland was the seat of the soul: — it had such a remarkably central situation, and it was solitary, unpaired. Had the soul dwelt in a paired organ, said DESCARTES, we should always have two ideas about the same thing, and there would be a continual conflict to determine which side should have the mastery. The researches of modern times have certainly divested the pineal body of most of its reputation from this point of view; but its historical importance claims all the greater recognition.

Before the transformation of the 'tweenbrain into optic thalami, even before the appearance of the rudiment of the true optic thalami, this part of the brain grows laterally outwards in a vesicular form and supplies the rudiments of the eyes and optic nerves, and in a downward direction it forms an expansion known

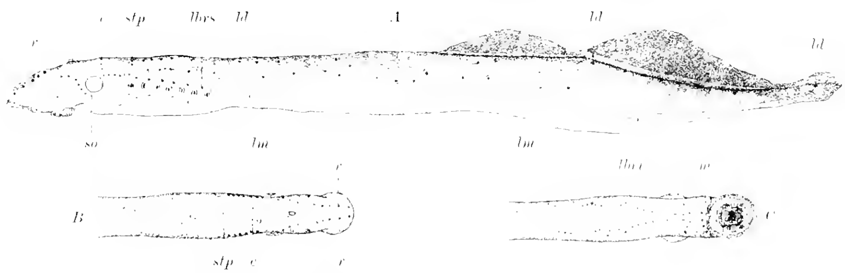

Fig. 349. Ripe female of the Lampern (*Petromyzon fluviatilis*, forma *branchialis*), nat. size. *A*, from the left; *B*, forepart, from above; *C*, the same, from below.

c, anterior connecting branch between the fronterostral canals; *stp*, posterior connecting branch; *r*, rostral branch; *so*, suborbital branch; *m*, mandibular branch; *lm*, mediolateral line; *ld*, dorsolateral line; *lbrs*, superior branchiolateral line; *lbri*, inferior branchiolateral line.

(forebrain), the so-called *corpora striata* (*2*), to which the manifestations of consciousness that have been derived from the said sources and developed in the surface-layers of the cerebral hemispheres are conducted (*14—15—16—17*; *9—10—11—12* and *4—5—6*) for their first realisation, with that contribution to the power and distinctness of the currents which is supplied by the little brain, whose upper peduncles, according to LUYS, by means of their yellow fibrils join the ganglion cells in the yellow nucleus of each *corpus striatum*. Between the optic thalami and the *corpora quadrigemina* lies a small swelling, the pineal gland (*Ep* in fig. 347), the history of whose transformations is among the most remarkable. In man the nervous matter of the pineal body probably plays the same part as that of the *corpora quadrigemina*, but is of less importance. Yet there as the underbrain (*Inf.* in fig. 346); but in the roof of the 'tweenbrain there appear two thickenings of the cerebral wall (behind *Ep* in fig. 347), situated side by side and usually of unequal size. These collections of nervous matter become the rudiments of the true optic thalami. Over the 'tweenbrain the cerebral wall has grown out into a vesicular swelling (*Ep* in figs. 346, 347), which is at first flattened, but rises, becomes tubiform, and grows forward over the brain. This is the first appearance of the pineal gland in the lower vertebrates, and in them it attains a considerable development. In the Lampreys it is even externally visible through the skin as a light, round spot behind the tubular aperture of the nostril (fig. 349, B).

The pineal gland belongs, as mentioned above, to that division of the brain with which the origin of the

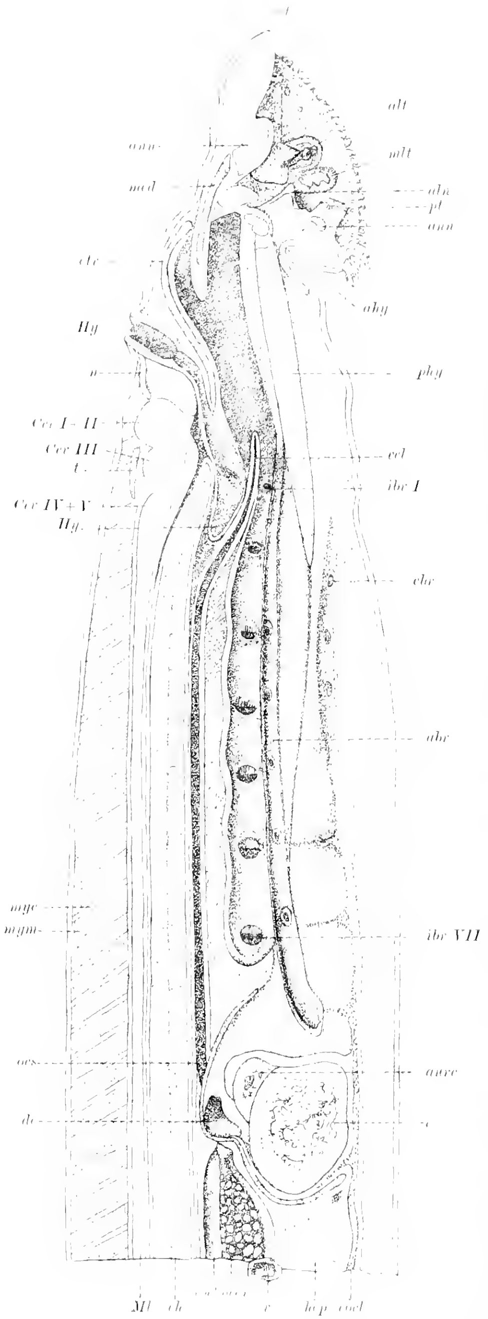

Fig. 350. Section of the forepart of a Lampern (*Petromyzon*); about twice the nat. size; partly after PARKER, partly after VOGT and YUNG. *abr*, branchial artery; *ahy*, anterior hyoid cartilage; *aln*, anterior linguodental plate; *alt*, anterior lateral dental plate; *ann*, annular cartilage of the mouth (severed in two places); *at*, anterior dental plate; *aur*, auricle of the heart; *c*, ventricle; *Cer I + II*, prosencephalon and thalamencephalon; *Cer III*, mesencephalon; *Cer IV + V*, cerebellum and medulla oblongata; *ch*, chorda dorsalis; *coel*, abdominal cavity (cœlom); *ctr*, cornua trabecularum; *dc*, ductus Cuvieri; *ebr*, outer gill-openings; *hep*, liver; *Hy*, nostril; *ibr I—VII*, first-seventh inner gill-openings; *med*, median upper cartilage of the mouth; *Ml*, myelon; *mlt*, left mediolateral dental plate; *myc*, myocomma; *mym*, myomere; *n*, olfactory capsule (the severed cartilaginous wall); *oes*, oesophagus; *ovar*, anterior extremity of ovary; *phy*, posterior hyoid cartilage; *pt*, posterior dental plate of the mouth; *t*, tegmen cranii; *v*, anterior part of intestine; *vel*, velum.

paired eyes is connected, and its manner of origin is the same, the difference is strictly but local. In its highest development too, it becomes an eye with optic nerve, an eye in the middle of the skull, asymmetrical, for its nerve root would appear to originate from the left optic thalamus, though before this becomes a true optic thalamus, and while it still lies, as in the Lampreys, in the roof of the brain and bears the name of *ganglion habenulæ* (*intermedium*) *sinistrum*. This pineal eye, whose functional time proper fell under the period known by geologists as the Mesozoic, bore within itself, however, the seeds of its destruction in the vertebrates, for it was constructed on the ocular type of the invertebrates: — its lens was an ependymal instead of an epithelial (epiblastic) growth, and its retinal cells had the base directed peripherally instead of centripetally into the eyeball. And after the advent of the Tertiary period this Polyphemous type disappeared from among the vertebrates. In many, however, as in the Lampreys, it endures in a more or less vestigial condition. To all appearances the pineal eye was more ancient than the paired eyes, perhaps originally the only true eye in the worm-like ancestors of the vertebrates, hardly elevated as yet above the level of the invertebrates; and all the sensations destined for our consciousness still follow in the optic thalami (if we may believe LUYS, fig. 348) a path laid down through the realm where the pineal eye once held sway.

The mental faculties of the higher vertebrates had a long history before they became what they are. The pineal eye and the sensory organs of the primitive gill-clefts are examples of structures at different grades of abortion. The first has almost ceased to functionate at all, and terminates its existence as a functional organ in the class of reptiles; the latter do not extend so high in the animal series, and they nowhere retain their original, preponderating significance; but they have a descendant, the system of the lateral line, which still serves one of the most important senses possessed by fishes and batrachians.

The lateral-line system of the Lampreys retains perhaps a relic, at least a reminder, of the primitive condition assumed by Beard, a pore of the system being present above each gill-opening (fig. 349, *lbrs*). In its extension over the body this system is otherwise not unlike that of the Teleosts. Behind the eyes run two transverse series of pores (*c* and *slp*); and the lateral line proper is double (*lm* and *ld*). The frontorostral branches and their subdivisions are most distinct below and before (*so*) the eyes and in two parallel longitudinal rows (*r*) on the upper surface of the snout. Round the lower jaw runs a mandibular branch (*m*), which sends out backwards on each side a sub-branchial series (*lbri*) below the gill-openings. In most cases, however, all these pores, except the rostral, are very difficult of detection.

Another primitive condition is manifested, according to Langerhans, in the skin of the Lampreys, its outer epidermal layer (cuticular cells) being frequently furnished, though irregularly and in patches, with cilia — calling to mind a very common appearance in the skin of the invertebrates. But in the Lampreys, according to Langerhans, these cilia are dead, motionless (sensory hairs). Neither the Lampreys nor the following fishes show any sign of squamous growths in the skin.

The intestinal canal of the Lampreys is simple and straight, the divisions being scarcely distinguishable from without. Only at the extreme front and back is it attached by a mesentery to the dorsal wall of the abdominal cavity; throughout the rest of its course it lies free in the cavity. The anterior part, answering to an œsophagus and a stomach, is wider but has thinner walls than the duodenum, which is lined with longitudinal folds, one of them deeper than the rest and bending at the middle of the duodenum into three or more spiral coils. Behind the duodenum and separated therefrom by an annular valve, lies a short but somewhat dilated rectum. The liver lies as usual in the extreme front of the abdominal cavity, and is rather small, but firm and without lobes. There is no gall-bladder. The air-bladder is also wanting. The kidneys are paired and ribbon-like, with the sharp inferior margin hanging free in the posterior part of the abdominal cavity, but extending forward beyond the middle of its length. Their efferent ducts have a common opening at the top of a papilla projecting behind the cloacal aperture and longer and more pointed in the males than in the females. This common outlet, however, has on each side (to the right and left) an opening (a slit) from the abdominal cavity, and by this route the sexual products, both ova and sperma, after being shed into the said cavity, are expelled through the papillar orifice. Both the ovaries and the testes are unpaired, suspended between the kidneys, without special deferent canals. When ripe, they fill the abdominal cavity throughout its length, surrounding the shrunken intestine.

Especially interesting is the foremost part of the intestinal canal, the œsophagus, as it appears during the metamorphosis of the Lampreys. In their larvae, the Prides (*Ammocœtes*), the branchial cavity (fig. 351, *br I—VII*) communicates directly on the one hand (anteriorly) with the pharynx and mouth, on the other (behind) with the œsophagus (*oes*) and the intestine, so that all food must pass through the branchial cavity in company with the water used for respiration. During

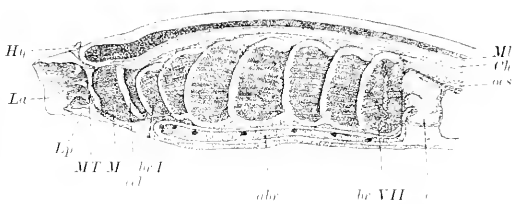

Fig. 351. Section through the forepart of a Pride (*Ammocœtes*), about 3 times the nat. size.

abr, branchial artery, with seven openings, for the arterial branches supplied one to each gill-opening; *br I—VII*, first-seventh branchial sacs; *C*, heart; *Ch*, notochord; *Hy*, nostril; *La*, anterior lip; *Lp*, posterior lip; *M*, posterior (inner) mouth cavity; *Ml*, myelon; *MT*, mouth tentacles; *oes*, œsophagus (anterior part of intestine).

the metamorphosis, however, the posterior passage is closed, and a new œsophagus (fig. 350, *oes*) is formed above the branchial cavity, in the form of a string first solid and afterwards hollow. The food receives a special passage. The water used for respiration passes neither through the mouth nor the nose, but must be received and expelled through the branchial apertures. At the same time the rostral region is developed, from the *cornua trabecularum* (see above) to the jaws and dentition inclusive.

The family of the Lampreys hardly contains a score of species, though more have been described. These are distributed among four or five genera, only one of which belongs to the Scandinavian fauna.

Genus PETROMYZON.

The diphycercal caudal fin continuous above with the posterior part of the dorsal. Anterior dental plate of the mouth furnished only at each end with an elevated tubercle or pointed tooth.

As we have mentioned above, in the Lampreys we cannot speak of real jaws or jaw-teeth; but within the suctorial disk of adult Lampreys are set several horny, pointed teeth or terete protuberances, characteristic of different genera and species, and to these teeth it has been hitherto customary to give such names as if they were set in real jaws. The oral aperture is first surrounded, as we have seen, by an annular cartilage (fig. 343, *ann*). This bears both on its anterior (upper) and its posterior (lower) margin an horizontal dental plate furnished with more or less pointed teeth (fig. 352), which may be called respectively anterior teeth (*at*) and posterior teeth (*pt*). On each side of the annular cartilage there lie in the sucking-disk, next the mouth, three small loose cartilages, each set with 1—3 horny teeth (protuberances), which we entitle the lateral teeth of the mouth (*alt*, *mlt*, and *plt*). Outside these the sucking-disk has within its fimbriated margin a number of scattered teeth, arranged in rings or in curved rows, suctorial teeth, as GÜNTHER calls them (*ist* and *est*). Within the mouth itself, between the anterior and posterior dental plates, appear the lingual teeth, an anterior (*aln*) and two posterior (*pln*) curved dental plates, parallel to the posterior dental plate of the mouth. It must be observed, however, that when the tongue is protruded to its utmost extent its posterior teeth project beyond the anterior ones, and probably serve as the most powerful rasping organ of the Lampreys. The dental character assigned above to the genus *Petromyzon* is intended to express the fact that the anterior dental plate of the mouth is neither bipartite, as in the Pacific genus *Mordacia*, with a group of three teeth on each part, nor tridentate, as in the genus *Ichthyomyzon* from the west coast of North America[a]. The other character given above differentiates all these genera from *Geotria*, a Pacific genus, with the caudal fin separated from the posterior dorsal. A deep-sea genus, *Bathymyzon*, "with the suproral and infroral plates or laminæ destitute of odontoid tubercles," was distinguished by GILL[b] among the fishes taken by the American fishing-schooner *Albatross* at a depth of 520 fathoms within the area of the Gulf Stream in lat. 49° N. He remarks, however, that the only species known (*Bathymyzon Bairdii*) comes very near to *Petromyzon marinus*.

The species of the genus *Petromyzon* that belong to the Scandinavian fauna are the same as are found in other parts of Europe; but considering the variability of form which here asserts itself, we distinguish only the following:

A: Anterior dental plate of the mouth so short that its two teeth stand close together — Subgenus Petromyzon .... *Petromyzon marinus.*

B: Teeth on the crescent-like anterior dental plate distant from each other — Subg. Ammocœtes .... *Petromyzon fluviatilis.*

- *a. var. major:* the two dorsal fins more or less distinctly divided from each other — *Petromyzon fluviatilis.*
- *b. var. minor:* the two dorsal fins more or less distinctly confluent — *Petromyzon branchialis.*

[a] According to JORDAN and FORDICE a median tooth sometimes occurs on the anterior dental disk in *Petromyzon fluviatilis branchialis*, so that the genus *Ichthyomyzon* can hardly be retained.

[b] Proc. U. S. Nat. Mus. 1883, p. 254.

THE SEA LAMPREY (SW. HAFSNEJONÖGAT).

PETROMYZON MARINUS.

Plate LIII, fig. 1.

Anterior linguodental plate medially recurved and hollowed from in front. Teeth on the anterior dental plate of the mouth contiguous at the base. Length of the suctorial disk when closed (in adult fishes) more than half that of the head to the first gill-opening.

Syn. Mustela, AUSON., *Mos.*, vers. 107. *Lamproye de mer*, BELON, *Nat., Div. Poiss.*, p. 66. *Lampetra*[a], RONDEL., *De Pisc.*, p. 398. *Lampreta* I. *Lampreda*[b], GESN., *De Aquatil.*, p. 592; Paralip., p. 22. *Petromyzon*[c] maculosus, ordinibus dentium circiter viginti. ART., *Ichthyol., Gen. Pisc.*, p. 64; *Syn. Pisc.*, p. 90. STRÖM, *Sondm. Beskr.*, pt. I, p. 297 (*Negenogen*). *Sea-Lamprey*, PENN., *Brit. Zool.* (ed. 1776), vol. III, p. 67, tab. VIII, No. 27.

Petromyzon marinus, LIN., *Syst. Nat.*, ed. X, tom. I, p. 230; *Fna Suec.*, ed. II, p. 106; GUNN., Trondhj. Selsk. Skr., vol. IV (1768), p. 22, not.; BL., *Fische Deutschl.*, pt. III, p. 38, tab. LXXVII; RETZ., *Fna Suec. Lin.*, p. 302; BORN, Zeitschr. Organ. Phys. (HEUSINGER), Bd. I (1827), p. 170; NILSS., *Prodr. Ichthyol. Scand.*, p. 121; YARR., *Brit. Fish.*, ed. 1, vol. II, p. 448; SEL. LONGCH., *Fne Belge*, p. 226; KR., *Danm. Fisk.*, vol. III, p. 1025; NILSS., *Skand. Fna, Fisk.*, p. 743; HCKL. KN., *Susswasserf. Östr. Mon.*, p. 374; SIEB., *Susswasserf. Mitteleur.*, p. 368; MALM (*Lampetra*), Gbgs Vet., Vitt. Samh. Handl., Ny tidsf., H. VIII (1863), p. 87; MGRN (*Lampreta*), *Finl. Fiskfna* (disp. Helsingf. 1863), p. 75; COUCH (*Petromyzon*), *Fish. Brit. Isl.*, vol. IV, p. 385, tab. CCXLVII, fig. 1; BLANCHARD, *Poiss. d. eaux douces d. l. Fr.*, p. 512; CANESTR., Arch. Zool., Anat., Fisiol. (Modena), vol. IV, p. 184; GTHR, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 501; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillægsh., p. 218; 1879, No. 1, p. 106; N. Mag. Naturv. Chrnia, Bd. 29 (1884), p. 122; MALM, *Gbgs, Boh. Fna*, p. 630; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 61; FEDDERS., ibid., p. 94; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 602; BNCKE, *Fisch., Fischer., Fischz. O., W. Preuss.*, p. 194; MELA, *Vert. Fenn.*, p. 369, tab. X; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 356, tab. CLXXVIII; FREMY, Compt. Rend. Acad. Par. 1883, No. 11 (Mars 2), p. 721; MOB., HCKE, *Fisch. Osts.*, p. 159; JORD., FORD., Ann. New York Acad. Sc., vol. III, p. 283; LILLJ., *Sv., Norg. Fna, Fisk.*, vol. III, p. 719.

Petromyzon Lampetra, PALL., *Zoogr. Ross. Asiat.*, vol. III, p. 66.

Petromyzon Americanus, LESUEUR, Trans. Amer. Phil. Soc. 1818, p. 373 (+ *Petr. nigricans*, p. 385); DEK., *New York Fna*, pt. IV, Fish., pp. 379 et 381, tab. 66, fig. 216; tab. 79, fig. 247; STOR., Mem. Amer. Acad. Arts, Sc., N. ser., vol. IX, pp. 251 et 253, tab. 38, fig. 4; tab. 39, fig. 6.

Ammocœtes bicolor, LESUEUR, l. c., p. 386; DEK., l. c., p. 383, tab. 79, fig. 248; — formam larvalem hujus speciei censuerunt JORDAN et FORDICE, l. c.

Petromyzon appendix, DEK., l. c., p. 381, tab. 64, fig. 211.

Ammocœtes unicolor, DEK., l. c., p. 383, tab. 79, fig. 250; — form. larval. sec. JORD., FORD.

Petromyzon maculosus, GRONOV., *Cat. Fish.*, ed. GRAY, p. 2.

The Sea Lamprey attains a length of about 1 m. and a weight of about $1\frac{1}{2}$ kilo. Still larger specimens, weighing at least $2\frac{1}{4}$ kilo., are indeed adduced[d], but are certainly rare. According to LINNÆUS' WAHLBOM caught at Calmar a Lamprey of an arm's thickness. In spite of its dimensions this species undergoes its metamorphosis from the larval stage at a length of only about $\frac{3}{4}$—$1\frac{1}{2}$ dm.[f]

The body is Eel-like, anteriorly terete or showing some lateral compression, which increases more and more behind. The greatest depth, about half-way between the last gill-opening and the beginning of the first dorsal fin, is about 7 or 8 % of the length of the body. Behind the body gradually tapers; but even at the space between the two dorsal fins the depth is about 5 or 6 % of the length. In front the depth is more constant forward to the head, the form of which is determined by the singular snout. When the fish is not attached to any object, the snout is not unlike an inverted spoon; but the under surface, the sucking-disk, can alter its position, when the fish attaches itself, till the snout terminates in a more or less vertical, broadly

[a] "A lambendis petris".

[b] Ex *lampen*, German. = dependere.

[c] "A πέτρος lapis et μύζω s. μυζάω sugo, quia sugendo lapidibus adhæret in fluviis". *Philos. Ichth.*, p. 73.

[d] PENNANT, *Brit. Zool.*, vol. III (ed. 1776), p. 68; DAY, l. c., p. 359.

[e] *Fna Suec.*, l. c.

[f] DEKAY states the length of *Petromyzon appendix* at 101—152 mm. STORER adduces a length of 76—178 mm. for *Petr. nigricans*. In Scandinavia SCHAGERSTRÖM (according to LILLJEBORG), MALM, and COLLETT have found fully developed Sea Lampreys about $14\frac{1}{2}$ cm. long. The larvæ (*Ammocœtes unicolor*) attain, according to DEKAY, a length of at least about 1 dm.

elliptical disk. In its first-mentioned condition, when the disk can almost be folded together from the sides, its length is about equal to the depth of the body, somewhat greater or less, and as a rule more than $4/5$ of the length of the snout (to the anterior margin of the eyes), which varies between 10[a] and 8 % (exceptionally approaching 7 %) of the length of the body or between $2/3$[b] and $3/4$ of that of the head to the first gill-opening.

In the mere size of this suctorial disk, even relatively greater than in the following forms, we have a very good character for the Sea Lamprey; but the most characteristic peculiarities are shown by the dentition of the mouth and tongue. The suctorial disk is edged with a double or multifarious series of densely set fringes (dermal papillæ), and within these appear numerous rows of teeth (12 or 11 on each side of the median line), directed in a more or less sharp crook towards the mouth; but exactly in the preoral median line the row is straight, and the rows on the posterior part of the suctorial disk are only slightly curved, each row being directed inwards with fair regularity towards one of the teeth (cusps) of the posterior dental plate of the mouth. The teeth in these rows (the suctorial teeth, fig. 352, *est* and *ist*) are unicuspidate, conical, gradually increasing in size inwards, separated by grooves in the gums, which are thus divided into lozenges, one to each tooth. Four rows meet the sides of the mouth, and the two innermost (largest) teeth in these rows (the lateral teeth, *alt*, *mlt*, and *plt*) are so closely set that they are joined at the base into bicuspid teeth, each on its own root (lateral dental plate). The bicuspid anterior dental plate of the mouth (*at*), situated between but a little behind the anterior lateral plates,

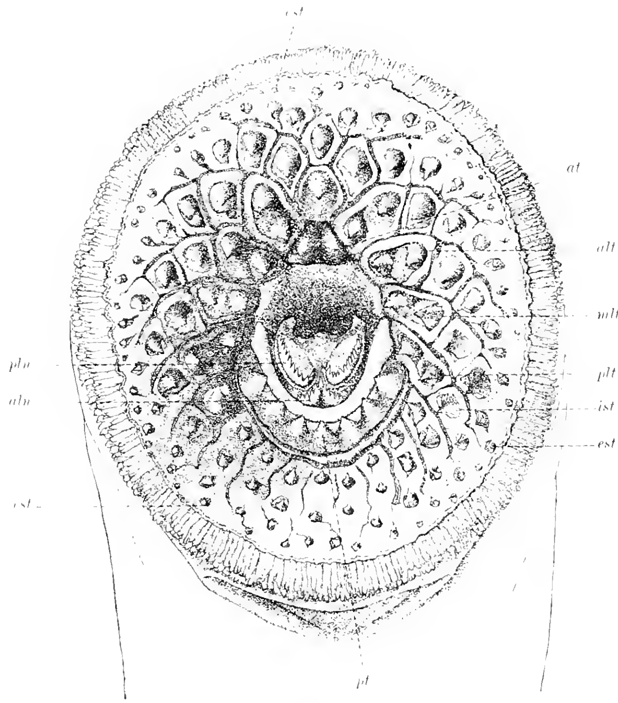

Fig. 352. Oral disk of a Lamprey (*Petromyzon marinus*) $8\frac{1}{2}$ cm. long, × 2.
alu, anterior linguodental plate; *alt*, anterior lateral dental plate; *at*, anterior dental plate; *est*, outer suctorial teeth; *ist*, inner suctorial teeth; *mlt*, mediolateral dental plate; *plu*, posterior linguodental plate; *plt*, posterior lateral dental plate; *pt*, posterior dental plate.

[a] Sometimes 11 in the variety occurring in Cayuga Lake (at Ithaca, N. Y.); see MEEK in JORDAN and FORDICE, l. c.
[b] In exceptional cases only 63 %; see MEEK, l. c.

is of about the same size as these and of the same form. The crescent-shaped posterior dental plate of the mouth (*pl*), on the other hand, is considerably larger. In young specimens it is comparatively higher than in old, but also has comparatively smaller and usually more numerous (in many cases 8[a]) and more pointed teeth. In old specimens the latter (usually 7) are more conical, of about the same size and form as the large lateral teeth. All these teeth probably serve merely as an adhesive organ that holds the Lamprey fast to the skin of its prey, which is forced to drag it along. Within the mouth is the rasping lingual apparatus that opens the skin of the victim and saws into its flesh. The anterior linguodental plate (lingual plate, *alu*) is indeed simple and curved semilunarly like the posterior dental plate of the mouth; but at the middle it is deeply recurved, thus acquiring the form of a S. Of the two loops thus produced the left bears 7 or 6, the right 6 or 5 sharp points (tooth-cusps), exclusive of the hindmost median tooth of the plate. Here too it seems to be the rule that young Lampreys have more numerous and more pointed teeth than old[b]. Behind (within) this plate lie the posterior linguodental plates (supralingual plates, *plu*) beside one another, each resembling in form a reversed ruminant hoof, with the crook directed forwards and parallel to one of the loops of the anterior linguodental plate. The left supralingual plate is usually furnished with 13 pointed teeth, the right with 12, these being largest in front, on the crook, gradually smaller behind.

The eyes are round. Their size varies considerably with age; but as they are covered by the more or less transparent skin, the measurements taken depend greatly on the transparency of the skin and the method of measuring. In Sea Lampreys 4—8 $^1/_4$ dm. long KROYER found the diameter of the eyes to be $^4/_5$ % of the length of the body or about 7 % of the length of the head to the first gill-opening. Our measurements of the outer diameter of the iris in so large specimens fix the latter percentage at about 10 or 9[c]. The opening of the nasal duct (the nostril), more or less distinctly elevated into a tube, is about $^1/_3$ as large as the eyes, and is situated just in front of the interorbital space, at a distance from the tip of the snout measuring about $^2/_3$ (63—70 %) of the said length of the head. Behind the nasal duct lies the light, elliptical, but indistinctly bounded epiphyseal spot.

The gill-openings are comparatively small (see our figure in Pl. LIII), but when distended they attain a height not much less than the diameter of the eyes. They are each covered from in front, partly by the anterior margin itself, which forms a vertical dermal flap, partly by two other, somewhat pateriform, rounded dermal lobes, one of which rises from the inner part of the lower wall of the gill-opening, the other hanging down in a similar manner from above. The hind margin of each gill-opening is furnished with small fringes and papillae. The total extent occupied by the seven gill-openings in a row one after another measures about 9 or 10 % of the length of the body, and in young Sea Lampreys (2—3 dm. long) is in many cases equal to the length of the snout to the nostril or about $^2/_3$ of the length of the head to the first gill-opening[d], in the old greater, about $^4/_5$ (77—84 %) of the said length of the head, which in the young is up to 15 %, in the old only about 11 %, of the length of the body.

The first dorsal fin is an elongated, low triangle, with the greatest depth ($^1/_5$—$^1/_4$ of the length) situated in the anterior part, but with the anterior end indistinctly delimited from the dorsal edge of the body, which margin in ripe individuals (oftenest in males, but sometimes too in females) may rise into a hard carina both before the first dorsal fin and between it and the second dorsal. This renders it also difficult to determine with certainty the distance between the first dorsal and the tip of the snout[e], but the rule appears to be that the fin commences close behind or even at the middle of the body, comparatively further

[a] According to MEEK (l. c.) exceptionally 9.

[b] Blunter and sharper teeth thus occur in this species as in the following one. In estimating the importance of this difference, which is by no means exclusively dependent on age, it should be remembered that we have here to deal not with real teeth, but only with points of horny sheaths, which are changed time after time. In ordinary cases the horny sheath is so loosely attached to the plate that it can be removed altogether, new, unworn, and therefore (if they be fully developed) more pointed teeth being thus exposed to view.

[c] LILLJEBORG gives 9 or 8 % ($^1/_{11}$—$^1/_{12}$). According to MEEK (l. c.) this percentage is about 16—13 in Sea Lampreys 2 $^1/_2$—3 $^1/_2$ dm. long from Cayuga Lake.

[d] According to MEEK (l. c.) sometimes only 55 % of the last-mentioned length.

[e] According to MEEK this distance varies with great irregularity between 55 $^1/_2$ and 49 % of the length of the body.

back in the young[a]. The length of the fin is about $9\frac{1}{2}$—12 % of that of the body. The second dorsal is considerably higher (sometimes twice as high or a little more), but essentially of the same form, its length varying between about 18 and 26 % of that of the body, with the highest percentage in old specimens. Behind it meets the caudal fin, or overlaps the upper anterior margin thereof, but is always sharply defined, as well as the first dorsal, at its posterior termination. In front it is separated from the first dorsal by an interval which in adult specimens (over $2\frac{1}{2}$ dm. long) varies with age from about 6 to 4 % of the length of the body, and which, according to WILDER's measurements of the North American fresh-water form, is less in the males than in the females. The diphycercal (almost symmetrical) caudal fin is uniformly widened behind (tongue-shaped), with short, triangular but rounded tip. The entire length of the caudal fin occupies in adult Lampreys about $9\frac{1}{2}$—$8\frac{1}{3}$ % of the length of the body.

The anal aperture lies below the anterior portion of the second dorsal fin, at a distance from the tip of the snout measuring 75[b]—72 % of the length of the body, further back in the young than in the old. The urogenital papilla is comparatively small. As mentioned above, all the Cyclostomes are without anal fin; but between the vent and the caudal fin a dermal carina frequently occurs, similar to that of the dorsal margin.

The coloration varies with age, locality, and the time of year. Our figure represents a nearly ripe female in a fresh condition, as received by the Royal Museum from Ringkjobing (Jutland) at the end of May through Mr. O. FREDERICKSEN. Here only the white and blue colours prevailed, the former being pure on the belly, the latter pale but unmixed on the head, and composing the pale ground-colour of the sides and back, which were mottled with a darker blue, shading into black. The fins were pale, mottled with blue, with a dash of gray. The pupil was black, the iris of a faint silvery lustre but not much paler than the prevailing colour. The gill-openings and mouth were tinged with red. DONOVAN[c] figures and describes the species as more variegated, with a ground-colour of lustrous green, mingled with blue, yellow, and red, with a handsome marbling of black. He also adduces blue and olive varieties, as well as reddish ones mottled with chestnut-brown instead of black. According to KROYER the under surface of the head is yellow, the fins being reddish, of a dark orange, the dorsal fins besides mottled with black. According to both MALM and COLLETT the marbling is absent in young specimens; and according to LESUEUR and DEKAY this also applies to the larvae.

The larval stage, so far as is known, has not yet been observed in Europe; but in North America an *Ammocoetes bicolor* was described by LESUEUR (1818) and another form, *Amm. unicolor*, by DEKAY (1842), both of which have been referred by JORDAN and FORDICE to *Petromyzon marinus* as its larvae. The former of these, according to DEKAY, has not been rediscovered since LESUEUR's time, but had been named from its coloration, reddish on the back and sides, white on the belly, with a sharp, undulating limit between these two colours. The latter (*unicolor*) is in all respects still more like an earthworm, but has developed distinct eyes. Its coloration is described by DEKAY as a nearly uniform dark or dusky brown, occasionally verging to bluish, somewhat lighter beneath; the anterior part of the head darkest. The form of the body cylindrical for two thirds of its length from the head, becoming slightly compressed just anterior to the vent, very much compressed and acuminated at the tail. Greatest depth of the body $7\frac{1}{2}$ % of its length. Surface smooth, with between 80 and 90 transverse folds (myocommata), giving the body an annulated appearance. The fins appear to be nothing more than mere membranous prolongations of the skin, without the slightest vestige of rays. The dorsal commences at the beginning of the 3rd fifth of the length of the body (from the snout), in a scarcely perceptible furrow, and advances low and subequally until about the middle of its length, when it begins to rise, and then rapidly diminishes at the tip of the tail, where it unites with the caudal and anal, which latter is obsoletely triangular, and becomes insensibly effaced at a point corresponding to the beginning of the last fourth of the length of the body. The vent is a large longitudinal aperture between the 2nd

[a] Our measurements of Sea Lampreys $2\frac{1}{2}$—$8\frac{1}{2}$ dm. long show that the distance from the tip of the snout to the beginning of the first dorsal fin diminishes with increasing age from 53 to 48 % of the length of the body. KROYER's measurements of specimens 4—$8\frac{1}{3}$ dm. long indicate that these percentages decrease from $51\frac{1}{2}$ to 50.

[b] According to MEEK (l. c.) exceptionally 77 or even 80.

[c] *Brit. Fish.*, pl. LXXXI.

and 3rd third of the length of the body. Mouth quadrilateral. Opening to the throat very large, but accurately closed by six irregular and ragged subcartilaginous processes, which meet in the centre. Anterior lip transverse, convex on its outline, and emarginate at each end, where it unites with the lateral lips: these latter are wide and convex on their slender margins, uniting posteriorly below the edge of the lower lip, leaving them free above. Length of the snout to the eyes 5 %, and the diameter of the eyes $1^{1}/_{4}$ %, of the length of the body. Eyes distinct, lateral, covered with the common teguments, and placed in a depression over the margin of the lower lip. Nasal orifice large, and surrounded by a raised margin; contracted, linear in front, circular behind; its distance from the tip of the snout $3^{3}/_{4}$ % of the length of the body. The branchial furrow occupies $^{1}/_{8}$ of the length of the body, is directed obliquely downwards, and extends to a point above the lower angle of the lateral lips; the apertures are exceedingly small, and appear to be capable of being closed by their membranous edges. Such was DEKAY's description of this larva. It is said to be common in the muddy bottom of most streams in the north and west of New York State. JORDAN and GILBERT explained it as a larva of DEKAY's *Petromyzon appendix:* and when JORDAN and FORDICE combined this nominal species with *Petromyzon marinus*, the larva, of course, had to be referred to the latter species. If the explanation is correct, the Sea Lamprey thus undergoes a metamorphosis similar to that of the following species, though not in every detail. The mouth apparatus and the snout are entirely re-formed (see above). The eyes advance further forward from the gill-openings. The nostril loses its anterior narrow part. The anal aperture is removed further back. The dorsal fin-growth is divided, and its beginning moved more to the front. A special caudal fin is developed; but the rudimentary anal fin disappears. *Ammocœtes bicolor*, which has also been referred to the present species, was said to resemble the developed Sea Lamprey more nearly in the dorsal fins and the position of the anus, though the eyes were still indistinct.

The Sea Lamprey, as we have seen, has an extensive geographical range, embracing all the seas of Europe. According to PALLAS the same species inhabits the Caspian Sea and ascends the Volga; but KESSLER ranged this form as a new species, *Petromyzon Wagneri*. It would also appear uncertain whether we can still rely on PALLAS's statement that our Sea Lamprey also occurs in the Sea of Okhotsk. From "West Africa", however, according to GÜNTHER, the British Museum has received the true *Petromyzon marinus;* and this Lamprey has perhaps a more congenial habitat in the west of the Atlantic and the east of North America than in Europe. There it has even been landlocked in several lakes, and lives in these without ever finding its way to the sea. In this species we accordingly find the same state of things as among the Salmons, and the form landlocked in Cayuga Lake (Ithaca, N. Y.) was regarded by WILDER as a distinct species, *Petromyzon dorsatus*, its dorsal carina being particularly well developed.

In Scandinavia the Sea Lamprey is found everywhere from the extreme north, though of unfrequent occurrence. From the Vestmannaeyiar, on the south coast of Iceland, it was remarked by KRØYER, from the Faroe Islands by the elder REINHARDT. In Greenland it is unknown. In Norway, as well as in Bohuslän and on the other coasts of Sweden, probably too in Denmark, many years may elapse without the catch of a single specimen being notified to the museums, and as a rule only solitary individuals are taken. In the Baltic, where it is so well known on the coast of Blekinge, according to NILSSON, that it has a special name (*Sillapipare*) among the fishermen, the species penetrates so far that, according to MALMGREN, "a fairly large and handsome specimen has been taken in the seine in Gammelstadsvik" (Southern Finland).

All that is known of the life led by the Sea Lamprey in salt water is that it swims like the Eel, bending the whole body in serpentine movements. Frequently it is taken from shore in the Herring-seine; and this would in all probability not happen so often, unless the Lamprey were moving about among the Herrings. Most of its time, however, it no doubt passes attached to stones or floating objects, such as driftwood or boats, and to the fishes which it selects as its victims. GUNNERUS (l. c.) states that Sea Lampreys fix themselves in great numbers to the body of the Basking Shark and do not leave it until it is dead"[a]. The Sea Lamprey also attacks finer fish, such as Mackerel, Codfish, etc. GESNER relates[b], on the authority of a Strasburg fisherman, that the Sea Lamprey attaches itself to Salmon ascending from salt water, and is thus conveyed far up the rivers.

[a] The same statement, given on the authority of Governor CHRISTIE of Bergen, appears in KRØYER, l. c., p. 1038.

[b] *De Aquatilibus*, p. 596.

But the Sea Lamprey also roves into fresh water on its own account, when it makes its way, early in the year or at latest in early summer (Feb.—June), to the spawning, which is performed during summer. On these excursions, however, the Sea Lamprey proves to be no very powerful swimmer, capable of stemming the current with ease: "but, when the stream is so strong that the Lamprey has difficulty in surmounting it, the fish plunges quickly forwards and hastily attaches itself to some fixed object, then awaiting an opportunity for a new plunge" (YARRELL and KRØYER). Consequently it does not penetrate far up the stream in rapid rivers; but in the Gotha Elf it goes at least to Lilla Edet (LLOYD[a] and MALM[b]); in the Kjeflinge River (Scania) it ascends at least a couple of leagues from the sea (NILSSON); and in the River Helge it was taken by SCHAGERSTRÖM at Kristianstad (LILLJEBORG). In Germany it is found still farther inland, in the Rhine to Basel, in the Elbe up to Bohemia (BENECKE). In the Loire it has been met with above Orleans, in the Rhone and Isère beyond the frontier of Savoy (BLANCHARD).

The spawning of the Sea Lamprey was observed by PANIZZA[c] at Pavia on the River Po; and BARTLETT wrote to STORER (l. c.) of its breeding operations in Massachusetts. "They ascend the rivers a little earlier than the shad, and move mostly in the night. It is not known by the fishermen when they return, as they are never seen. There is a notion that they all die. They are often seen in the summer in pairs at work together, constructing a little mound of stones. They build this about three feet in diameter at the base, and about two feet high, of stones from the size of an ounce bullet to that of the fish. They often aid each other in carrying the same stone. This is pretty evidently a *labor of love*, as they copulate once in five minutes, or so, during the whole time. The young go down the river when the water begins to freeze. They are from six to eight inches long". But to take the above words of BARTLETT to imply that the metamorphosis from the *Ammocœtes* stage takes place within the first year, would, no doubt, be too hasty. Strange to say, no observations are recorded in Europe either of the development of the Sea Lamprey in its earliest stages.

The Sea Lamprey is a palatable dish, if skilfully prepared, when caught in spring and before it is ripe for spawning. In former times it was offered as a Christmas gift by the city of Gloucester to the sovereign of the realm. It may be stewed like Burbot, or marinaded for preserving. DAY gives the advice, however, to remove the notochord before boiling, as being too indigestible. Many consider the whole fish uneatable. In many places it is related that the Sea Lamprey is far rarer now than it was formerly. The once famous fishery of the Severn has decayed so greatly that, according to DAY, the usual price of a Sea Lamprey there is now half-a-crown. In France the Sea Lamprey was protected, together with the Salmon and Shad, in the piscatorial laws of ancient times, by fishing prohibitions under certain circumstances, and the trade was strictly regulated. At the present day, says BLANCHARD, it is, if not exactly rare, so uncommon that no great attention is paid to it. In Scandinavia this fishery has never possessed any importance.

All the Lampreys are tenacious of life, and this adapts them eminently for use as bait. The Sea Lamprey, however, can seldom serve the Scandinavian fisherman for this purpose.

THE LAMPERN OR RIVER LAMPREY (SW. NÄTTINGEN).

PETROMYZON FLUVIATILIS.

Plate LIII, figs. 2—4.

Anterior linguodental plate evenly and slightly curved, with the convexity in front. Anterior dental plate of the mouth semilunarly curved and so long (in the transverse direction of the body) that the elevated, dentiform ends are distinctly separated from one another[d]. *Length of the oral disk in adult specimens less than half that of the head to the first gill-opening.*

Syn. *Lamproye d'eau douce* + *Lamproyon*, BELON, *Nat., Divers. Poiss.*, p. 67. *Lampetra parva et fluviatilis*, RONDEL., *Pisc. fluv.*, p. 202. *Mustela* + *Alterum genus Lampredæ*, GESN., *De Aquat.*, pp. 595 et 597. *Lampetra fluviatilis*, WILLUGHB.,

[a] *Scandinav. Advent.*, vol. I, p. 147.

[b] MALM also cites a newspaper paragraph which seems to indicate that the Sea Lamprey sometimes passes the locks at Trollhättan into Lake Wener.

[c] Mem. Istit. Lomb. Sc., Art., Milano, vol. II (1845), p. 25.

[d] = Genus *Lampetra*, GRAY, *List Spec. Fish., Brit. Mus.*, part. I, *Chondropt.*, p. 140.

Hist. Pisc., p. 104, tab. G. 2, fig. 1 (+ *Lamp. cæca*, p. 106, tab. G. 3, fig. 2 + *Lamp. cæca Bältneri*, p. 107, tab. G. 3, fig. 1). *Petromyzon* unico ordine denticulorum minimorum in limbo oris, præter inferiores majores + *Petrom.* corpore annuloso, appendicibus utrinque duabus in margine oris, ART., *Ichthyol.*, *Gen. Pisc.*, p. 64; *Syn. Pisc.*, pp. 89 et 90; *Spec. Pisc.*, p. 99. *Petromyzon* pinna dorsali secunda angulata (Suecis Neinöga, Westrobothniensibus Natting) + *Petr.* pinna dorsali secunda lineari, labio oris superiore pone lobato, LIN., *Fau. Suec.*, ed. I, p. 102. *Lesser Lamprey*, PENN., *Brit. Zool.* (ed. 1776), vol. III, p. 70, tab. VIII, No. 28 + *Pride*, p. 71, tab. VIII, No. 29.

A: forma *major*, pinnis dorsalibus minoribus, remotis.

Petromyzon fluviatilis, LIN., *Syst. Nat.*, ed. X, tom. I, p. 230; BL., *Fisch. Deutschl.*, part. III, p. 41, tab. LXXVIII, fig. 1; RETZ., *Fau. Suec. Lin.*, p. 303; SWALL., *Svensk Zoologi*, II, 6, No. 33; PALL., *Zoogr. Ross. Asiat.*, tom. III, p. 66; CUV., *Regn. Anim.*, ed. I, tom. II, p. 118; NILSS., *Prodr. Ichthyol. Scand.*, p. 122; EKSTR., Vet. Akad. Handl. 1834, p. 70; YARR., *Brit. Fish.*, ed. 1, vol. II, p. 454; KR., *Danm. Fisk.*, vol. III, p. 1042; NILSS., *Skand. Fau.*, *Fisk.*, p. 745; HECK. KN., *Susswasserf. Östr. Mon.*, p. 377; SIEB., *Susswasserf. Mitteleur.*, p. 372; MALM, Gbgs Vet., Vitt. Samh. Handl., Ny Tidsf., VIII, p. 88; MGRN, *Finl. Fiskfau.* (disp. Helsingf. 1863), p. 72; v. BEMM. in HERKLOTS, *Bouwst. Fau. Nederl.*, part. III, p. 392; BLANCH., *Poiss. d. eaux douces Fr.*, p. 515; CANESTR., Arch. Zool., Anat., Fisiol., vol. IV, p. 185; *Fau. Ital.*, *Pesc.*, p. 31; GTHR., *Cat. Brit. Mus.*, *Fish.*, vol. VIII, p. 502; COLL., Forh. Vid. Selsk. Chrnia 1874, Tillæggsh., p. 219; 1879, No. 1, p. 107; N. Mag. Naturv. Chrnia, Bd 29 (1884), p. 122; LIKN, *Arct. Man.* (RUPERT JONES, 1875), p. 122; MALM, *Gbgs, Boh. Fau.*, p. 632; FEDDERS., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 94; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 604; BNCKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 196; MELA, *Vert. Fenn.*, p. 370, tab. X; DAY, *Fish. Gt. Brit.*, *Irel.*, vol. II, p. 359, tab. CLXXIX, fig. 1; MOR., HCKT., *Fisch. Osts.*, p. 161; FATIO, *Fau. Vert. Suisse*, vol. V, part. II, p. 512; LILLJ., *Sv.*, *Norg. Fau.*, *Fisk.*, vol. III, p. 693; LÖNNB., Bih. Vet. Akad. Handl., Bd 18, Afd. IV, No. 2.

Petromyzon argenteus, BL., *Ausl. Fisch.*, part. IX, p. 74, tab. CCCCXV, fig. 2; BL., SCHN., *Syst. Ichthyol.*, p. 532, tab. 102, fig. 1; COUCH, *Fish. Brit. Isl.*, vol. IV, p. 400.

Petromyzon pricka (ex DAUBENTON, Encycl. Méth.), LACÉP., *Hist. Nat. Poiss.*, tom. I, p. 18.

Petromyzon Omalii, V. BEN., Bull. Acad. Sc. Belg., ser. 2, tom. II (1857), p. 549 cum tab. ad p. 554; tom. XX (1865), p. 46; MALM, ll. cc.

? *Petromyzon plumbeus*, AYRES, Proc. Calif. Acad. Nat. Sc. 1855, p. 27. *Petr. ayresii*, GTHR., l. c., p. 505. *Ammocœtes cibarius*, JORD., GILB., Ann. N. Y. Acad. Sc., vol. III (1885), p. 292.

B: forma *minor*, pinnis dorsalibus altioribus, approximatis.

Petromyzon Planeri, BL., *Fisch. Deutschl.*, part. III, p. 47, tab. LXXVIII, fig. 3 (dub.); LACÉP., l. c., p. 30 (+ *Petr. sanguisuga*, tom. II, p. 101, tab. I, fig. 3 + *Petr. septœil* + *Petr. niger*, tom. IV, p. 667, tab. 15). OSB., Vet. Akad. Handl. 1804, p. 181; SWARTZ, l. c.; CUV., l. c., p. 119; NILSS., *Prodr.*, l. c.; YARR., l. c., p. 457; KR., l. c., p. 1052; NILSS., *Fau.*, l. c., p. 747; KESSL., Bull. Soc. Natur. Moscou, 1856, p. 390; A. MÜLL., Müll. Archiv 1856, p. 325; HECK. KN., l. c., p. 380; SIEB., l. c., p. 375; MALM, Gbgs Handl., l. c., p. 92; MGRN, l. c., p. 73; BLANCH., l. c., p. 517; CANESTR., Arch., l. c., p. 186; *Fau.*, l. c.; LANGERH., Ber. Verh. Naturf. Ges. Freib. i. B., Bd VI (1873), H. 3; FEDDERS., l. c., p. 95; MOR., l. c., p. 606; BNCKE, l. c., p. 197; FATIO, l. c., p. 499; LILLJ., l. c., p. 708.

Petromyzon plumbeus (= *P. septœil*, LACÉP.) + *Petromyzon bicolor* (= *P. niger*, LACÉP.), SHAW, *Gen. Zool.*, vol. V, p. 263.

Petromyzon branchialis (+ larva), GTHR., l. c., p. 504; COLL., Forh. l. c., 1874, Tillæggsh., p. 220; ibid., 1879, p. 107; MALM, *Fau.*, p. 636; MELA, l. c., p. 371, tab. X; DAY, l. c., p. 362, tab. CLXXIX, figs. 2 (larva) et 3; JORD., GILB. (*Ammocœtes*), l. c., p. 293.

C: forma larvalis.

Petromyzon branchialis, LIN., *Syst.*, l. c.; BL., *Fisch. Deutschl.*, l. c., p. 45, tab. LXXVIII, fig. 2; SWARTZ, l. c.; DUM. (*Ammocœtus*), *Dissert. Poiss. Cyclost.* 1808; CUV. (*Ammocœtes*), l. c., p. 120; NILSS. (*Petromyzon*, subg. *Ammocœtes*), *Prodr.*, p. 123; YARR. (*Ammocœtes*), l. c., p. 459; KR., l. c., p. 1060; NILSS., *Fau.*, l. c., p. 748; HECK. KN., l. c., p. 382; CEDERSTR., Öfvers. Vet. Akad. Förh. 1861, p. 91.

Petromyzon ruber, LACÉP., l. c., tom. II, p. 100, tab. I, fig. 2.

Petromyzon lumbricalis, PALL., l. c., p. 69.

Adn. *Ammocœtes aureus* (BEAN, Proc. U. S. Nat. Mus. 1881, p. 159; BR.-GOODE, *Fish.*, *Fish. Industr. U. S.*, Sect. I, tab. 251), ex Alaska, *Petrom. fluviatilis* simillimus videtur. Caput (fide descriptionis) perparvum, $^{97}/_{1000}$ longitudinis corporis l. $^{187}/_{1000}$ distantiæ inter apicem rostri et originem pinnæ dorsalis primæ, quod nunquam in nostra specie vidi. Figuræ tamen citatæ has rationes non confirmant.

The Lampern attains in Scandinavia a length of at least $4^{1}/_{2}$ dm. In Germany and France it is said sometimes to measure 5 dm. In this respect, however, there is great difference between the Lamperns of different tracts within the same country, this species too, in its full development, being an anadromous fish, and requiring the bounteous resources and saltness of the sea, or at least of brackish water, to attain its most typical size and form. How variable the anadromous fishes are in this respect, we have seen most distinctly in the Salmons; but the Sea Lamprey here affords a comparison at closer quarters. Where the Lampern lives in brooks and other small collections of fresh water, it usually appears as a smaller form, about 2 dm. long. The same differences may be observed in the size of the larvæ. Sometimes the metamorphosis from *Ammocœtes* to *Petromyzon* takes place at a length of 1 dm., sometimes larvæ are met with at least $1^{1}/_{2}$

dm. long. What are the causes that retard the metamorphosis or accelerate the growth of the larvae, we do not know; and sometimes we find in the same waters Prides which are larger than the Lamperns[b].

The size, the teeth, the closer proximity of the fins, and the usually immaculate colour distinguish the Lampern from the preceding species; "but in all other relations of form, both external and internal", wrote LACEPÈDE, "the two Lamprey species are so like one another that they seem to be two copies of the same model". The Eel-like body is here too more or less terete in front, laterally compressed behind, with the same variability as in the Sea Lamprey, though somewhat greater[c].

The length of the head to the first gill-opening varies in the true Lamperns between about 14 and a little over 10 %[d] of the length of the body, the percentage being least in the oldest specimens; but here too it is as a rule greater than the length of the series of gill-openings[e]. In the Prides, on the other hand, the length of the head is only about $6^1/_2$—$7^1/_2$ % of that of the body and always less than that of the branchial region, which occupies about 12—$12^1/_2$ % of the last-mentioned length. The length of the snout to the anterior margin of the eyes is in the Lamperns about $^2/_3$ (60—68[f] %), in the Prides only $^1/_2$, of the length of the head. These differences are external expressions of the alterations involved by the metamorphosis; but herewith too is connected the great difference in the structure and form of the mouth and oral disk. The Prides (Pl. LIII, figs. 3 and 4) are toothless and never attach themselves by suction. They lead a more worm-like life, buried in sand or mud. Their mouth is edged in front and on the sides with a horseshoe-shaped or semiquadratic anterior lip (fig. 351, *La*), the lateral parts of which are rounded and pendent, passing evenly or with a shallow sinus into the corners of the anterior side, but sharply terminated behind, where they enclose between them the shallower, transversal posterior lip (*Lp*). The outer mouth cavity is forniciform, with a patch of small papillae, set in rows, at the middle of the roof, and is bounded behind by a coroniform series of concentrically directed processes with verrucose ramifications (papillae, *MT*). Behind this corona lies an anterior pharyngeal cavity (inner buccal cavity *M*), of somewhat smaller capacity than the other and bounded behind by an annular, contractile valve (velum, *vel*), whose lateral parts are tumid; and behind this again lies the still smaller true pharynx, the entrance to the tubiform branchial cavity, through which the food too must pass. In the anterior pharyngeal cavity the lingual apparatus is developed. The corona of papillae disappears. The lips are thickened, but coalesce into a ring, which becomes the suctorial disk of the Lampern (Pl. LIII, fig. 2). The most important differences between the suctorial disks of this species and the preceding one have been already noticed. Here the disk is both smaller—the dimensions of the snout being thus also reduced — and more feebly armed. The edge is fringed with papillae here too, but sometimes only in a single row. Just within the margin we see a ring of small horny teeth (*est*), like the other teeth pointed or blunt, white or yellow[g]. Within the anterior part of this ring and parallel to it, we find in ordinary cases a curved row of similar, simple teeth (*ist*), and the rule is that the remaining surface of the suctorial disk, outside the composite teeth of the mouth, is smooth or very finely verruculose. This is one of the most patent characters of the species, in contradistinction to the lozenged comparting of the suctorial disk in the Sea Lamprey, where the gums round the bases of the several suctorial teeth are bounded by grooves intersecting in a diamond pattern (see fig. 352). Frequently, however, we find here too, in the Lampern, scattered suctorial teeth on the anterior part of the disk, and in a pair (♂ and ♀) of Lamperns from Archangel (fig. 353), which are otherwise quite typical specimens—only that the middle pair of the lateral teeth of the mouth, a peculiarity which is

[a] 2 dm., according to BENECKE.

[b] At Helgevärma Mill, near Wexiö, Baron G. C. CEDERSTRÖM caught, in May, 1857 and 1860, Prides 145 mm. long and Lamperns (forma *Planeri*) 120 mm. in length.

[c] The greatest depth of the body varies in the Lamperns from about $7^1/_2$ to nearly 9 % of the length thereof. In the small Prides, which as a rule, however, have a more tumid branchial region, the depth behind this is sometimes only $6^1/_3$ % of the length of the body.

[d] 10·3 is the least percentage we have found for this relation.

[e] An exception is adduced by KRÖYER in the largest Lampern measured by him. The variations may be due, however, to the different degree of contraction in the snout and dorsal muscles at death or in alcohol.

[f] In the preceding species 68—75 %.

[g] The dental differences in these respects are so variable that we have not been able to reduce them to any rule; but it would appear that specimens from the sea or with only intumescent genital organs and not yet shrunken intestinal canal most often have the most pointed and whitest teeth.

not uncommon, are bicuspid instead of tricuspid — there not only appear anterior suctorial teeth (*ist*, above in the figure), in almost the same arrangement as those of the Sea Lamprey and with lozenged frames, but the male also possesses, on the posterior part of the disk, a curved though irregular row of teeth (*ist*, below in the figure). The specific character in the anterior dental plate of the mouth (*at*) we have pointed out above. The posterior dental plate (*pt*) is of the same form as in the preceding species; but its two outermost cusps are larger than the others and oftenest bifid (bicuspid). The number of cusps between them is as a rule five, exceptionally (fig. 353) four, so that the total number of cusps varies between 7 and 9. The lateral dental plates of the mouth (*alt*, *mlt*, and *plt*) are similar to those of the preceding species, but lie farther apart, and the middle pair on each side (*mlt*) are, as we have mentioned, usually tricuspid. The anterior linguodental plate (*aln*) is crescent-shaped, with the median cusp on the uniformly curved margin largest, and with 5 or 6 small cusps on the lateral parts. The posterior linguodental plates lie, when at rest, deep in a groove between the tumid lateral halves of the tongue[a], and are only slightly curved but otherwise of the same form as in the preceding species. Their 10 or 12 retral teeth are very small.

The orifice of the nasal duct undergoes almost the same alterations as in the preceding species. In the Pride it is pear-shaped, anteriorly pointed, with the dermal margin more elevated and expanded behind. In the Lampern it is more uniformly round, with the margin more or less elevated. In consequence of the somewhat shorter snout, the distance between this orifice and the tip of the former is also less than in the Sea Lamprey. In the Pride this distance is rather less than $^2/_5$ (about $37^1/_2$ %), in the Lampern rather less than $^3/_5$ (about 53—59 %[b]), of the length of the head to the first gill-opening. The series of gill-openings is somewhat longer than in the preceding species, varying, however, between about $9^1/_2$ and $11^1/_2$ % of the length of the body; and the several gill-openings may be closed from the anterior margin by a continuous, even flap of skin. In the Lampern too their posterior margin is verruculose.

In the form and position of the fins we can indeed distinguish between two varieties of Lampern, but only with far from reliable characters; and the variability in these relations is such that we cannot even state a perfectly trustworthy distinction between the Lampern and the Sea Lamprey. The rule, however, is that the limit between the caudal fin and the second dorsal is less distinct in the Lampern; and as the two dorsal fins are sometimes contiguous, and a fin-like, though rayless,

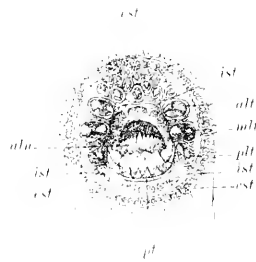

Fig. 353. Oral disk of a male Lampern (*Petromyzon fluviatilis*, var.), $31^1/_2$ cm. long from Archangel. × 2. Signification of the letters explained in the preceding figure.

dermal ridge is usually perceptible between the caudal fin and the anus, the Lampern may be regarded as a lower form, with more distinct vestiges of the larval condition. As regards the difference between the two assumed varieties of Lampern, it has been asserted, first and foremost, that the exclusively fresh-water form *Petromyzon branchialis* or *Planeri* in general has higher and closely contiguous dorsal fins. According to KROYER the following relations hold good:

	Petromyzon Planeri.	*Petromyzon fluviatilis*
Length of the body expressed in millimetres	144—261	333—392
Greatest height of the first dorsal fin in % of the total length of the head and branchial region	11.1—14.8	7.6—8.2
„ „ „ „ „ „ „ „ „ „ „ distance between the first dorsal and the tip of the snout	5.1—6.6	3.2—3.3
„ „ „ „ second „ „ „ „ „ „ „ total length of the head and branchial region	20—32.4	17.6—18.2
„ „ „ „ „ „ „ „ „ „ „ distance between the first dorsal and the tip of the snout	9.2—11.6	6.9—7.7

[a] Our figure (Pl. LIII, fig. 2) of the oral disk, as it appeared through the glass wall of an aquarium, where the Lampern had attached itself, shows in the middle these lateral halves, separated by a V-shaped groove under the anterior dental plate of the mouth. Under them the anterior linguodental plate, which is also white, may be seen; but the dental cusps are too minute to be visible in the figure.

[b] In the preceding species about 63—68 %.

However patent these differences may appear, intermediate forms give rise to very great uncertainty. As examples we will here adduce the corresponding measurements in four Lamperns of the form usually called *Petromyzon Planeri*, two males and two females 278—309 mm. long, taken together in Lake Ifö (Scania):

	Minimum.	Maximum.
Greatest height of the first dorsal fin in % of the total length of the head and branchial region	9.1	14.2
„ „ „ „ „ „ „ „ „ „ „ distance between the first dorsal and the tip of the snout	1.3	6.5
„ „ „ „ second „ „ „ „ „ „ total length of the head and branchial region	16.8	21.7
„ „ „ „ „ „ „ „ „ „ „ distance between the first dorsal and the tip of the snout	7.8	9.9

and in four females of the form *Petromyzon fluviatilis*, 255—288 mm. long, taken together at Lulea:

	Minimum.	Maximum.
Greatest height of the first dorsal fin in % of the total length of the head and branchial region	7.4	9.9
„ „ „ „ „ „ „ „ „ „ „ distance between the first dorsal and the tip of the snout	2.8	3.7
„ „ „ „ second „ „ „ „ „ „ total length of the head and branchial region	14.4	18.7
„ „ „ „ „ „ „ „ „ „ „ distance between the first dorsal and the tip of the snout	5.6	7.7

As may be easily seen, these percentages partly overlap one another, partly approach one another in very close proximity.

Equally variable is the character drawn from the relative position of the two dorsal fins. The length of the space between them varies in *Petromyzon fluviatilis*, according to LÖNNBERG's measurements of 142 specimens 245—375 mm. long, between 1·8 and 7·8 % of the length of the body; and on examining the results of these measurements we find that in the 12 smallest (245—255 mm. long) the average percentage was 4·5, in the next 65 specimens (260—295 mm. long) 4·3, in the next 52 (300—335 mm. long) 4·1, and in the 13 largest specimens (340—375 mm. long) 4·7. During the period of growth examined by LÖNNBERG it thus appeared that at first *Petromyzon fluviatilis* approached nearer and nearer to the character of *Petr. Planeri*, but eventually receded all the more abruptly therefrom. Often, however, we find a dermal flap extending forward from the beginning of the second dorsal fin in the median dorsal line towards the first dorsal, so that the limit of the former fin is difficult to fix. And SCHNEIDER[a], WAYGEL[b], and BENECKE[c] have totally rejected the specific distinction between the two forms. The relation between them, as LÖNNBERG has remarked, is very like that between the large Trout (*grälax*) and the Salmon (*blanklax*); and in the preceding pages we have made the same observation in many other parts of the history of the Scandinavian fishes. Fresh-water life has had greater influence on *Petromyzon fluviatilis* than on *Petr. marinus;* and two varieties have thus arisen, which in their typical forms are indeed easy of distinction, with the guidance of the above-mentioned characters, but are linked together by intermediate forms. "Among 7 specimens of *Petromyzon Planeri* from the same locality (Bieberbach, near Giessen) 3 had the two dorsal fins separated by an interval, while in 4 the fins were contiguous" (SCHNEIDER).

The first dorsal fin begins in the Pride and usually too in *Petromyzon Planeri* somewhat in front of, in the typical *Petromyzon fluviatilis* somewhat behind, the middle of the body. The second dorsal begins in the former two in front of[d], in the last-mentioned form behind, the beginning of the posterior third of the body. The caudal fin is of the same symmetrical form as in the preceding species. The boundary between it and the second dorsal, marked by the more distinct rays of the latter fin, is more prominent in *Petromyzon fluvia-*

[a] *Beitr. Vergl. Anat., Entwickl. Wirbelth.*, p. 35, § 1.

[b] Verh. K. K. Zool.-Bot. Ges. Wien, XXXIII (1884), p. 311.

[c] *Handb. Fischz., Fischer.* (MAX V. D. BORNE), p. 193.

[d] Exceptions not seldom occur in old specimens of *Petromyzon Planeri*.

tilis than in *Petr. Planeri.* Its length varies here too between about 10 and 8 % of that of the body. The anal aperture also occupies the same position as in the Sea Lamprey but the urogenital papilla is generally more developed, especially in *Petromyzon Planeri*, and longest and most pointed (projecting far back), as usual, in the males. Besides this sexual character may be observed during the breeding season, especially in the females, an hydropical tumidity of the skin (fig. 349), in particular round the anus and along the anal fin-ridge, which is sometimes considerably elevated at this season, as well as along the base and in front of the second dorsal fin.

The coloration differs from that of the preceding species in its monotony, being without sharply defined spots, and as a rule on the back steel-blue or darker, on the belly white, with a silvery lustre on the sides of the body. Yet it varies with the age of the fish, the season of the year, and the locality. In fresh water and with age the back becomes greener, and the belly assumes a muddier tone. The fins are either transparent, grayish white, or, in old specimens, brownish. The Prides are entirely destitute of silvery lustre and sometimes greenish yellow, sometimes bluish green. Our figures of Prides, as well as of the Lampern, are painted from living specimens taken by Professor RETZIUS at Elfkarleby early in October.

The Lampern is dispersed throughout Europe, Northern Asia, and Japan, as well as the northern regions of North America together with Greenland. THEEL and TRYBOM brought home Prides of this species from the Yenisei; GÜNTHER referred the *Petromyzon japonicus* described by MARTENS[a] to the same species as our Lampern; *Petromyzon plumbeus* (*cibarius*) and *Petr. aureus* from the west coast of North America have apparently no greater claim, judging by the descriptions, to a specific rank; and from Southern Greenland, according to LÜTKEN, the Museum of Copenhagen has received two specimens of *Petromyzon fluviatilis.* Throughout Sweden this species occurs in both varieties, but seems to be less common in the west than in the east, besides which it has long been known that the more typical form is commonest and largest in the Baltic and the rivers of Northern Sweden. In Norway the last-mentioned form, according to COLLETT, is very rare and has been met with only in Christiania Fjord, but *Petromyzon Planeri* is said to be common enough south of the Dovrefjeld, where it attains, according to RASCH, a length of at least 3 dm. North of the Dovrefjeld the species has not been found; but MELA adduces it from Varanger Fjord, and it has long been known from the White Sea and the rivers of Northern Russia. In Denmark it has been met with both on the islands and in Jutland. In the Sound it is no rarity. On Bornholm, according to FEDDERSEN, only the smaller form has been found. In Russia, Germany, the Netherlands, Southern Europe[b], and the British Islands it is as common as in Scandinavia, in some places perhaps commoner. According to FATIO it is unable to pass the great falls of the Rhine and Rhone, being wanting both in Lake Constance and the Lake of Geneva. In Scandinavia, on the other hand, each of the forms occurs both in Lake Wener, above Trollhättan, and in Lake Wetter. Nearest the sources of the brooks and in small collections of water the smaller form has its home; the larger keeps to the lower courses of the rivers and, in the lakes, to the outlets of the brooks. How high the Lampern ascends in the mountain regions of Scandinavia, is scarcely known as yet. OLSSON[c] says that both Lamperns and Prides are common in the southern part of Ströms Vattudal (Jemtland), though they do not ascend the streams flowing thither. According to TRYBOM[d] Prides 11—13 cm. long have been found at Asele (Angerman Elf, 64° 10' N. lat.; 300 m. above the sea-level), on flax placed in the river to steep; and similar specimens are sometimes taken, it is stated, in Lake Storlögde (Lögde Elf). LILLJEBORG found *Petromyzon Planeri* at Karesuando (Muonio Elf, 68° 25' N. lat.; 320 m. above the sea-level). FATIO sets the limit to the ascent of the Lampern in Switzerland at about 600 to 700 m. above the level of the sea.

Tenacious of life and greedy of prey, the Lampern has the same habits as the preceding species. Its manner of life in the sea is hardly known, for it is met with too seldom in salt water. Baltic specimens have been found to have the intestinal canal (stomach and spiral intestine) filled to distension with a pulpy mass, in which we could distinguish in one specimen morsels

[a] Wiegm. Arch. XXXIV, p. 3.

[b] Not adduced from Greece, however, by APOSTOLIDES.

[c] Öfvers. Vet. Akad. Förh. 1876, No. 3, p. 140.

[d] Nord. Aarsskr. Fisk. 1883, p. 307.

of bone and fin-rays, probably remains of some Goby. From the island-belt of Lulea WIDEGREN writes[a] that during summer Lamperns follow the shoals of Baltic Herrings and fasten themselves to the fish, gradually devouring them. COLLETT received from Christiania Fjord a Lampern that had attached itself to a bit of Herring with which a long-line had been baited. From Lough Neagh a Lampern was sent to HYNDMAN[b] that had fastened itself to a large Trout. Otherwise the Lampern lives on minute creatures, such as worms, crustaceans, and the larvae of insects. The Prides, which are toothless and without closed sucking-disk, must naturally confine themselves to the smallest prey and the decomposing matter they may find in the mud or sand. The Lamperns that have ascended the rivers to spawn, with their greatly shrunken intestinal canal, cease to take any nourishment.

The Lampern displays activity as it wriggles along in the streams like an Eel or a snake, now and then taking a rest by attaching itself. At such times the branchial region may be observed continually expanding and contracting, opening and shutting the gill-openings at a breath, about 200 times a minute when the fish is most lively. Or it creeps up on jetties, dams, or projecting stones, with head and branchial region above the water, the air expressed from its gills causing a faint bubbling sound. So tenacious is the bite of the Lampern on these occasions that even if the body be cut off the head sometimes retains its position. The Lampern and its larva can live for hours or days out of the water, and may thus be kept for transmission or consumption as required; but in thunder-storms it often happens that most of the captives die.

In autumn, from September till November, the Lampern ascends the rivers from the sea. It is then taken in great quantities, especially near the mouths of the Norrland rivers. At this season the generative organs are of fairly advanced development, with eggs measuring $^2/_3$ mm. or less; but not until the spring or early in the summer, when the ova have attained a diameter of 1 mm., does the spawning take place, after the same fashion as we have seen above in the case of the Sea Lamprey. The Lamperns that constantly inhabit fresh water do not repair to the spawning-places until shortly before the commencement of the operation, in Scandinavia usually during April or May. The ova of the small Lamperns are then about equal in size to those of their larger fellows. Hence the number of the eggs is highly variable, from a thousand or so in small individuals to several tens of thousands in large fish.

AURELL[c] observed the behaviour of small Lamperns at their spawning-places in the brooks of Lake Wetter. "They occurred in very shallow water and where there was a brisk current, sometimes 2 to 10 or 20 in company. When alone, they were timid and usually shot off with almost lightning speed down the current if disturbed. But this was not often the case, for they sought one another with passionate eagerness. The males were more slender and cylindrical than the females, which, seen from the sides, were broader. When the males were touched, the milt spirted out through the genital papilla to a distance of a yard or two, and on being touched the female emitted her roe. Their colour showed great variability, and some, both male and female, were mottled." Else, according to A. MÜLLER[d], the male attaches himself to the neck of the female and coils his body round her in a half spiral. The spawning-place is chosen preferably on a pebbly bottom, where the fish hollow out a cavity by wriggling the body, or construct, as we have mentioned of the Sea Lamprey, a shelter for the eggs. After the lapse of about three weeks the larvae are excluded.

The development, first to Pride and then to Lampern, was known even to the Strasburg fisherman BALDNER, who in the 17th century wrote a *Fischbuch*[e] of the Middle Rhine; but his remarks were forgotten until attention was drawn to them by SIEBOLD, after A. MÜLLER had succeeded (1856) in watching the spawning of *Petromyzon Planeri* in the Panke, a brook that falls into the Spree at Berlin, and in seeing Prides develop from the deposited eggs. According to MÜLLER the Pride lives three or four years before its transformation into a Lampern. It buries itself meanwhile in mud or sand, or dwells in brooks or by the banks of rivers among fallen and decayed leaves. At times the fish raises the forepart of the body and swings it to and fro in the water, or wriggles itself entirely free but hastens again into concealment. It is so gregarious that in many

[a] Landtbr. Akad. Handl. 18:de delen (1858), p. 200.
[b] THOMPS., *Nat. Hist. Irel.*, vol. IV, p. 265.
[c] LILLJ., l. c., p. 717.
[d] Cf. too BENECKE, *Fisch.*, *Fischer.*, *Fischz. O.*, *W. Preuss.*, p. 38.
[e] This manuscript, which was rediscovered by SIEBOLD in the Museum of Strasburg, is also quoted in several passages by WILLUGHBY.

places it may be dug up in numbers, after the stream has been dammed above the spot. Its Swedish name of *linal* (Flax Eel) is derived from its habit of creeping among flax laid in the water to rot. In August the metamorphosis begins, and by the New Year or soon afterwards it is completed. The organs of generation become distinct even earlier than this.

After depositing its eggs the Lampern dies, according to MÜLLER; and TRYBOM[1] has remarked, as evidence of this, that all the eggs in its ovaries are of the same size, so that no undeveloped ova, to be matured for another year's spawning, can be detected. *Petromyzon Planeri*, according to their assumption, only lives a few months in its adult state. Of *Petromyzon fluviatilis*, on the other hand, BENECKE assumes that the larvæ migrate to the sea while undergoing metamorphosis; and their life in salt water is unknown. But the fact is that sexually mature individuals of both varieties are found differing so widely in size that it is almost inconceivable that they can be of the same age. It would thus appear that some attain maturity the very first year after the metamorphosis, others not until several years have elapsed. For the present, as FATIO has also observed, we must consequently regard it as an open question, whether most of the spent Lamperns may not survive, but conceal themselves somewhere beyond our ken, and possibly reappear at the spawning of the following year.

The Lampern is a useful fish. For a good digestion it is excellent eating. Smoked and broiled it is a delicious whet before dinner; but for this purpose it is fit only during the cold season; in summer it is lean and dry. It is always a very valuable bait. It is taken in *kassar* (closely woven baskets, preferably of osier) and *nättingstockar* (small square boxes made of thin boards perforated with small holes), which are placed between the stones where the current is of a suitable strength. The fishery succeeds best on dark nights, for the Lampern, like the Eel, is most active between sunset and dawn.

The Lampern has several Swedish names. *Nejonöga* is originally a German word (*Neunauge*). In Halland it is known as *stensugare* (Stone-sucker). In Blekinge it is said to share with the preceding species the name of *sillapipare*. The smaller variety is called by SWARTZ *igel-neinöjon* (Leech-Lamprey).

FAM. MYXINIDÆ.

(Described by GUSTAF RETZIUS.)

Outer branchial apertures either single or several (6—7[2]) on each side of the forepart of the body (the throat). Nasal duct open behind, penetrating the palate.

This remarkable family in its essential characters comes near to the preceding one, and has therefore been coupled therewith to form the Cyclostomous order; but in other respects it exhibits such important differences from the *Petromyzonidæ* that at present, the links which would seem to have once connected them having apparently disappeared, the investigation of their mutual relationship and collocation in the phylogenetic system is no easy task.

Perhaps they are both more or less retrogressive forms; this is probable at least with respect to the Myxinoids. In several respects, however, the latter display obviously lower characters than the family of the Lampreys.

The time may possibly come where the ontogenetic evolution of the Myxinoids may in some degree supply an answer to these questions, so important to a conception of the origin from which the vertebrates have sprung; but as long as the said evolution of the Myxinoids, in spite of the pains devoted to its study, remains all but unknown, the proper course is to refrain from drawing any conclusions that are not borne out to the full by ascertained facts.

The Myxinoid family is represented in the modern fauna by only two genera, *Bdellostoma* and *Myxine*. The former, of which three species, inhabitants of the southern seas, have been distinguished, is characterized principally by the presence on each side of the body of six or more outer branchial apertures, each composing the opening duct of a gill-sac. In the genus *Myxine*, on the other hand, each side of the body is furnished with only one branchial aperture, the common orifice of the six gill-sacs.

[1] Förh. Allm. Sv. Fisk. Konf. Göteborg 1891, p. 88.

[2] According to GIRARD sometimes 14.

Of the latter genus too three species have been distinguished, respectively from the North Atlantic, the Pacific Ocean (Sea of Japan), and the extreme south of South America.

As the Scandinavian fauna, however, contains only one representative of the Myxinoid family, namely *Myxine glutinosa*, our principal attention shall be confined below to this species, which has besides in recent times been the most frequent subject of investigation, and whose structure is therefore best known.

Genus MYXINE.

On each side of the forepart of the body (the throat) a single branchial aperture, at which the ducts given out by the six gill-sacs of each half of the body, after uniting into a common duct, find an outlet.

In *Myxine*, as in *Petromyzon*, the cylindrical notochord, continuous, unsegmented, persists throughout life, anteriorly terminating in a conical tip at the basis cranii, under the brain, posteriorly extending close to the tip of the tail and terminating there after gradual contraction but somewhat obtusely, before the posterior extremity of the spinal cord (fig. 354, *e*). This notochord, composed of large cells filled with a clear fluid and cemented together by their investing membranes, is enveloped in two closely fitting sheaths, which have been somewhat differently interpreted by morphologists. These are surrounded by fibrous connective tissue, which does not differentiate, however, into any true vertebral skeleton. Only at the head and tail are cartilages developed, but in *Myxine* they never assume any vertebrally segmented character. Thus in the tail (fig. 354, *a*) we find a median cartilaginous plate with a dorsal and a ventral lamella, which are confluent behind and form round both sides of the termination of the spinal cord a more or less narrow, short canal.

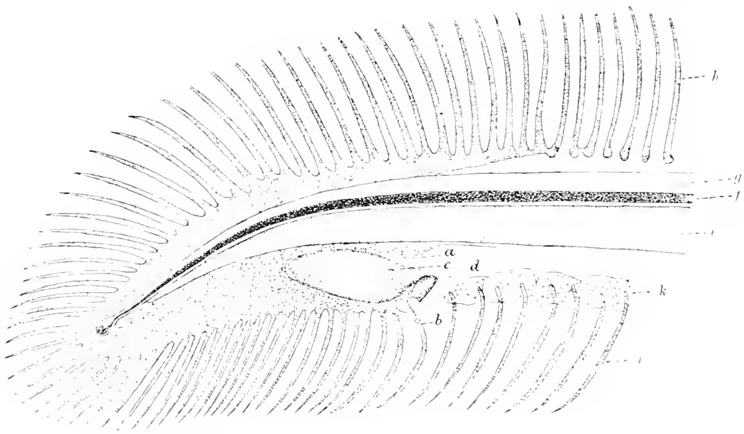

Fig. 354. Caudal cartilage of *Myxine glutinosa*, seen from the right. × 7.

a, ventral plate of the caudal cartilage; *b*, ventral cartilaginous rods (fin-rays) issuing therefrom; *c*, right sac of the caudal heart; *d*, button-shaped process of the ventral plate; *e*, notochord; *f*, spinal cord; *g*, medullispinal canal; *h*, free dorsal and *i*, free ventral cartilaginous rods of the caudal fin; *k*, dermal muciferous glands.

The outer edges of this cartilaginous plate send out upwards, backwards, and downwards a great number of slender cartilaginous rods (*b*), pointed at the tip, which compose the supporting rays of the caudal fin, and not without reason have been compared — or at least regarded as analogous — to the spinous processes of higher vertebrates. Even in front of the said cartilaginous plate there appears in the caudal fin, above and below, a series of similar rods, the proximal ends of which terminate in a button-like form within the septum of connective tissue and are unjoined by cartilaginous tissue (fig. 354, *h*, *i*). In *Myxine* there is not a sign, as in *Petromyzon*, of lateral cartilaginous arches, to represent vertebral apophyses.

In the *head* of *Myxine* the cartilaginous skeleton is comparatively far more developed and complex. Here we meet with two kinds of cartilaginous tissue, one rather hard, of a yellowish colour, the other soft, colourless. This cartilage forms the floor of the cranium, as well as a number of processes and arches originating therefrom and composing a singular framework or "basket-work" within the head. No segmentation into vertebral parts can be observed, as we have already stated; but by means of a comparison with *Petromyzon* and its larval form and, above all, with the phenomena during the development of amphibian larvæ, it has been attempted, not without success, to interpret in detail the cartilaginous framework of the skull in *Myxine*. Following PARKER's explanation we here give a brief description (fig. 355).

The anterior conical termination of the notochord is surrounded by a sheath of hard cartilage (the *parachordal cartilage* or *investing mass*, fig. 355, *b*), which in the median line exhibits a dorsal fissure and on the sides passes into the rounded kidney-shaped *auditory capsules* (*c*), also formed of hard cartilage, which have their longitudinal axes directed from within and behind outwards and forwards, and present on their inner superior side the foramina for the branches of the auditory nerve. In front the parachordal cartilage passes into two slender cartilaginous rods, the so-called *cranial trabeculæ* (*d*), which enclose an elongate oval hole (the *basicranial fontanelle*, *e*) composing the floor of the cerebral cavity and in great part filled by fibrous connective tissue, but containing behind and in the middle a spoon-shaped cartilage (the *posterior intertrabecula*, *f*). Anteriorly the trabeculæ pass on each side into the *palatine cartilages* (*g*), which, together with the *ethmoid cartilage* (*h*) joining them to each other in front, form the anterior limit of the fontanelle. From the anterior ends of the palatine cartilages projects on each side a cartilaginous rod (*cornu præpalatinum*, *i*), curved outwards and forwards and pointed at the tip. True cornua trabecularum are wanting. In the median line lies a long cartilaginous rod (the *anterior intertrabecula*, *k*) originating from the dorsal side of the anterior termination of the fontanelle and from the ethmoid region. This rod supports the long tube, formed of transversal cartilaginous rings, that composes the *nasal duct* (*l*) and leads behind partly to the olfactory organ, partly to the palate, into the cavity of which it has a free opening. On each side of the fore end of the anterior intertrabecula and the anterior opening of the nasal duct are two pairs of short, somewhat curved, anteriorly pointed rods of cartilage (*m*), which are the supports of four — two on each side of the nasal aperture — tentacles or papillæ ("barbels"). On the outer side each of the two trabeculæ is bounded by an elongate oval hole (*fenestra suborbitalis*, *n*) and on the outside of the latter is another cartilage (*pterygoideum*, *o*), which here forms the outer edge of the cartilaginous framework of the skull and behind borders on another, larger hole (*fenestra lateralis anterior*, *p*), also of an elongate oval shape. On the inner side of this fenestra

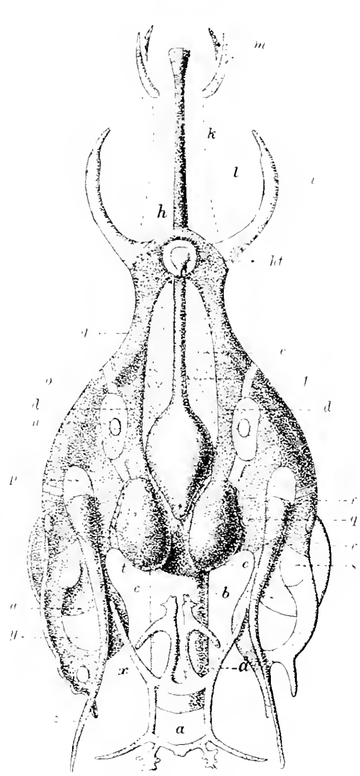

Fig. 355. Skull of *Myxine glutinosa*, seen from below, × 5. After PARKER.

a, notochord; *b*, parachordal cartilage; *c*, auditory capsules; *d*, trabeculæ; *e*, basicranial fontanelle; *f*, posterior intertrabecula; *g*, palatine cartilage; *h*, ethmoid cartilage; *ht*, ethmoidal tooth; *i*, cornua præpalatina; *k*, anterior intertrabecula; *l*, nasal duct (in outline); *m*, cartilaginous rods of the four circumnasal tentacles; *n*, suborbital fenestra; *o*, pterygoideum; *p*, anterior lateral fenestra; *q*, mandibulo-hyoid fenestra; *r*, quadratum; *s*, symplectic region; *t*, interhyoideum; *u*, epihyoideum; *v*, ceratohyoideum, *x*, first epibranchial; *y*, posterior lateral fenestra; *z*, first pharyngobranchial; *α*, second pharyngobranchial.

the pterygoid cartilage passes into a narrow cartilage which has been named the *mandibulohyoid*, and on the inner side of the last-mentioned cartilage, close to and below the outside of the auditory capsule, lies a small, narrow, oval hole (*fenestra mandibulo-hyoidea*, *q*). The small part (PARKER's "*pedicle*") in front of this hole answers to the upper end of the suspensorium; and the part (*hyomandibulare*) that bounds the hole behind

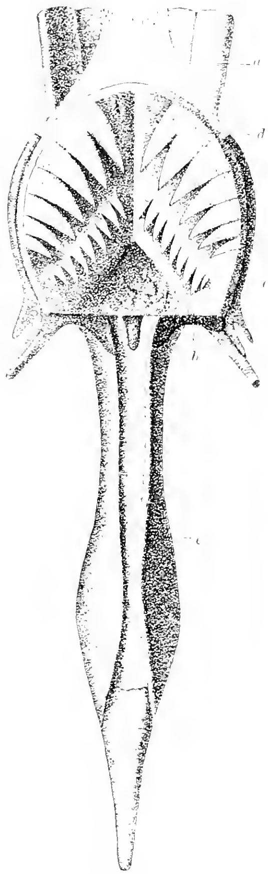

Fig. 356. Cartilaginous framework of the tongue in *Myxine glutinosa*, with the teeth in position, seen from above, × 5. After PARKER.

a, *b*, basihyal cartilages; *c*, supralingual cartilage; *d*, supralingual teeth; *e*, basibranchial cartilage.

to the head of the hyoid arch. On the outside of the anterior lateral fenestra there lie, behind the pterygoideum a broad plate of hard cartilage, answering to the quadrate region (*quadratum*, *r*), and behind this again a soft cartilage (*regio symplectica*, *s*), which forms the posterior limit of the anterior lateral fenestra and passes inwards, behind the hard mandibulo-hyoideum, into another soft cartilage (*interhyoideum*, *t*) and its continuation (*epihyoideum*, *u*). These last-mentioned cartilages emit in an outward direction two soft cartilaginous arches, the anterior (whose upper part is named the *ceratohyoideum* (*v*), the extero-inferior part the *hypohyoideum*) bending outwards and downwards and attaching itself to a hard cartilage (*basihyoideum*), the posterior (*epibranchiale primum*, *x*) curving downwards and forwards and attaching itself annularly to the symplectic region, together with which it surrounds a large hole (*fenestra lateralis posterior*, *y*). On the inside of, but not directly continuous with, the interhyoideum, epihyoideum, and symplectic region, lies a cartilage which answers to the first pharyngobranchial bone (*z*), and which with its hard, clavate, anterior end, close to the inner margin of the quadratum, occupies the posterior part of the anterior lateral cavity and with its soft, tapering, posterior end reaches a little way behind the epibranchial cartilage. The second branchial arch (*pharyngo-branchiale secundum*, *a*) is represented only by its pharyngeal, upper part, which is here composed of a few medially connected, singularly formed, branched rods of soft cartilage, embedded in that fold of the palatine mucous membrane which lies behind the pharyngeal aperture of the nasal duct.

The lingual apparatus of *Myxine* displays an especially powerful development and is furnished with large cartilages both hard and soft (fig. 356). Thus there are four hard *basihyal cartilages* (*a*, *b*) and on their upper surface a part consisting of several cartilages (the *supralingual cartilages*, *c*), which bear the powerfully developed *supralingual teeth* (*d*). Backwards from the basihyal cartilage runs a dorsally grooved rod of fibrocartilage (the *basibranchial cartilage*, *e*), which extends back to the region of the gill-sacs.

The *muscular system* of *Myxine* exhibits about the same developmental type as that of *Petromyzon* and even, in the main, as that of the other piscine orders, i. e. on each side a "*great lateral muscle*" divided into very numerous parts (*myomeres*) by septa of connective tissue (*myocommata*), and thus showing a segmental arrangement, though the axial skeleton is not segmented, and two ventral muscles. There being no extremities, or lateral fins, the muscles belonging to them are also wanting; but the head, on the other hand, contains rather numerous singular muscles, which partly enter into the composition of the tongue, partly are intended for the locomotion in different directions of the said organ, the mouth and nasal duct, and the palate and branchial apparatus. These muscles consist of striated fibre.

As for the *blood-vascular system*, the heart (fig. 358) is composed, as in other fishes, of an atrium, a ventricle, and a *truncus arteriosus*. Of the two Cuvierian ducts only the left attains full development, and of the two cardinal veins the right is feebly developed and joins the left. The blood coming from the hind part of the body accordingly flows into the left Cuvierian duct; the hepatic veins are discharged by two trunks directly into the *sinus venosus*. The portal vein, which also receives the numerous veins coming from the generative organs (mesovarium or mesorchium), dilates into a wide sac, the "portal heart" discovered by A. RETZIUS, before distributing itself to the two lobes of the liver.

The *lymphatic and serous system* is strongly developed in *Myxine*. Under the greater portion of the cutis there lies, throughout the dorsal region, from the snout to the tip of the tail, on both sides a large (subcutaneous) lymph-space, which dorsally extends quite to the median line, where a thin lamina of connective tissue, provided with nerves and bloodvessels, divides the two lateral spaces, except in the cephalic region, where they are in open communication with each other. Ventrally the space extends close to the row of muciferous glands that runs on each side of the body. But on the ventral side[a] there is no similar, large and continuous lymph-space, only a fairly abundant and dense subcutaneous connective tissue. In the head, however, especially around the tongue and pharynx, there lie more profound lymph-spaces, which, according to KLINCKOWSTRÖM[a], are in open communication with the large subcutaneous space; even the gill-sacs are furnished, according to the same author, with lymph-spaces. Between these parts of the lymphatic system and the portal heart, according to him, there apparently exists a communication. He also describes a direct communication between the vessels metamerically radiating in the tail from the lateral (and "ventral") lymph-spaces and a vessel running at the margin of the caudal cartilage and "opening into the paired caudal heart discovered by RETZIUS". This last-mentioned organ (fig. 354, *c*), which has a certain resemblance to the pulsating organ long since observed in the Eel, appears on each side of the ventral lamella of the caudal cartilage, is furnished with special muscles, and exhibits quick, rhythmical contractions; it is sanguiniferous and discharges its contents directly into the vena caudalis[b]. Of interest is the circumstance made known by KLINCKOWSTRÖM that the subcutaneous lymph-spaces as a rule carry a red fluid with a strong admixture of blood; the explanation of this may well be supplied in part by the above-mentioned communications between the blood-vascular system and the lymphatic system, but the circumstances require further elucidation, for the bursting of bloodvessels in consequence of the usually rapid transference of the animal from a great depth may contribute to the said appearance.

The skin, which owing to the large lymph-spaces on the greater part of the body is free and moveable, consists of a rather thick, fibrous cutis and a superincumbent epidermis, which is composed of several layers of polygonal nucleated cells, towards the surface of the body as a rule somewhat shallower, more flattened. No scale-growths can be traced in the skin. Of *glandular growths* in the same only the muciferous glands so characteristic of the Myxinoids are known. These are set in a single row on each side of the belly, to a number of more than a hundred; the foremost (fig. 363, *g*) are situated behind the head (2·5—3 cm. from the tip of the snout); the hindmost extend, in opposition to what is sometimes stated, a good way beyond the cloaca, back to the anterior end of the ventral lamella of the caudal cartilage (fig. 354, *k*), though with a break behind the cloaca (fig. 363, *h*). In form they are oval, and consist of sacs about as large as hempseed, lying under the skin and opening on its surface each at a small fine pore-like aperture, which apertures lie in a line at a distance of 2 or 3 mm. from one another. These glands copiously secrete an extremely tough, whitish gray mucus, which proves on microscopical examination to consist of fine, strong threads, which have lain rolled up in the secretory cells of the glands and been formed of the protoplasm within those cells.

True *fins* there are none, but in the median line the skin forms folds, partly in the caudal region, where the fold contains the rays of the caudal cartilage and thus to a certain degree represents a *caudal fin*, and partly on the belly, from the cloaca forward to a point

[a] AXEL KLINCKOWSTRÖM, Biol. Föreningens Förh., Bd IV, Nos. 1—2, 1891.

[b] G. RETZIUS, Ein s. g. Caudalherz bei Myxine glutinosa, Biolog. Untersuchungen, N. F. I, 1890.

about 1 cm. behind the branchial apertures, where there appears a fold triangular in section, thus with broad base and as a rule with the free flap measuring only about 2—3 mm. in height, which fold may be regarded as representing a *ventral fin*.

No external limit is visible between the body and the head. The tip of the snout terminates dorsally in a median triangular dermal flap; underneath this is the slit-like oval nostril (fig. 363, *l*), flanked on both sides by two (thus altogether four) conical, pointed tentacles (papillae) about 3 mm. long and directed forwards and somewhat upwards. These contain in their axial part the above-mentioned small cartilaginous rods (fig. 355, *m*) and are covered with soft skin. Under the tip of the snout the anterior surface of the head slopes backwards and downwards, and 7—8 mm. behind the tip of the snout opens the oral aperture (fig. 363, *m*), its appearance varying with its functional position. In its superior margin may usually be seen, when it is retracted, two large and two small folds of skin and in its inferior margin several small folds of a somewhat variable nature. Suctorial mouth or sucking-disk, like those of *Petromyzon*, there is none; nor are there any true lips. On the other hand, both sides of the oral aperture are furnished in *Myxine* with two, thus altogether four tentacles (papillae) of a similar kind to those situated round the nostril. Of these tentacles the inner pair (situated nearer the month) are small and broad; the other pair, set outside and somewhat above the former, are longer, narrower, and more pointed. The irregularly slit-like ("stelliform") mouth, open only when the animal is eating, leads into a long buccal cavity, dilating behind, in the roof of which, about 1 cm. behind the tip of the snout, is a somewhat crooked horny tooth with retral tip. This tooth, surrounded by folds of mucous membrane, is attached to the ethmoid cartilage and is therefore called the *ethmoidal tooth* (fig. 355, *ht*). A few millimetres further back (13—14 mm. behind the tip of the snout), viz. when the tongue is in its normal position of rest, lie the *supralingual teeth* (fig. 356, *d*), attached to the upper surface of the tongue (to the supralingual cartilage) and arranged in anteriorly convex, approximately concentric curves; these are also horny, and their tips are directed backwards and inwards. When the tongue is protruded, this dental apparatus is visible at the oral aperture. Above and behind the same opens the above-mentioned tubiform nasal duct (fig. 357, *c*) through a canal (*d*) sloping downwards and backwards in the palate, and further back appears a fold of mucous membrane at the transition to the pharyngeal tube, which (*e*) runs straight back above the long tongue-apparatus to pass behind the branchial apparatus, in the form of an also comparatively narrow and long "œsophagus", into the *intestinal canal*. This (fig. 363, *e*, *f*) has the form of a straight, thick-walled, broad and capacious tube, furnished internally with shallow, longitudinal, zigzag folds, but without "spiral coils", and runs to a point distant about 3—4 cm. from the tip of the tail, where, after bending downwards (ventrally), it opens into the *cloaca*, situated in the median line and nearly 1 cm. long, which terminates in a sagittal slit, the *outer cloacal aperture* (*i*), flanked by two dermal flaps or lips.

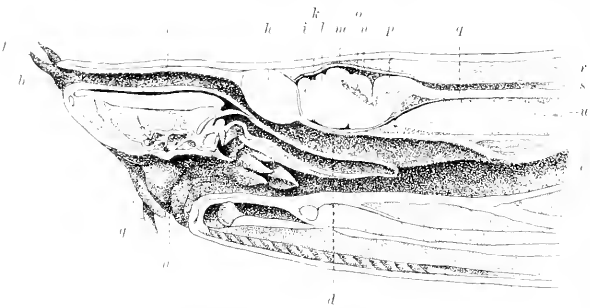

Fig. 357. Sagittal section of the cephalic end of *Myxine glutinosa*. ×4. *a*, mouth aperture; *b*, nostril; *c*, nasal duct; *d*, connecting canal between the nasal duct and the pharynx; *e*, pharynx; *f*, nasal tentacles; *g*, oral tentacles; *h*, olfactory organ; *i*, olfactory lobe; *k*, forebrain; *l*, ganglion habenulae; *m*, midbrain; *n*, hindbrain (little brain); *o*, central ventricle; *p*, afterbrain (medulla oblongata); *q*, myelon; *r*, dorsal muscular layer; *s*, medullispinal canal; *u*, notochord.

The *gall-bladder duct* enters the foremost part of the intestine. The gall-bladder lies between the two widely separated lobes of the *liver* (fig. 363, *d*) and receives a duct from each of them. Of *pancreas* and *spleen* not a trace has yet been found. The *kidney* of *Myxine* exhibits, as Johannes Müller, in his famous work on the Myxinoids, first showed, a very remarkable, extremely low development ("pronephron"); on each side of the notochord runs a duct opening into the cloaca and receiving during its course in the abdominal cavity a number of lateral branches, whose capsule-like dilated ends each contain a plexus of vessels, a *glomerulus* composing a branch of the aorta.

In consequence of the powerful development of the tongue the *branchial apparatus* (fig. 358) is removed far back. It is not furnished with any branchial basket proper, but only with the above-mentioned cartilaginous rods, situated in its foremost part. The six gill-sacs (*br*) on each side communicate inwards by means of a short transverse duct with the œsophagus; outwards each of them emits a longer duct (*br'*), curving downwards and outwards. These latter ducts coalesce on each side into a single canal, thus finding an orifice on the two outer sides of the body at an opening situated far back, the two *outer branchial apertures* (fig. 358, *s*; fig. 363, *k*).

Nervous system. The brain of *Myxine* exhibits a rudimentary structure with decidedly retrogressive characters (figs. 357 and 359). As mentioned above, the investing cerebral capsule consists of cartilage under-

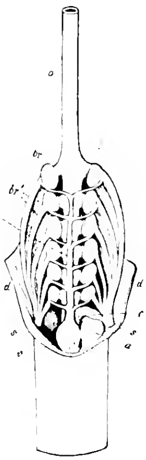

Fig. 358. Branchial apparatus, heart, branchial artery, and œsophagus of *Myxine glutinosa*, after JOHANNES MÜLLER. Nat. size.

o, œsophagus; *i*, inner branchial ducts; *br*, gill-sacs; *br'*, outer branchial ducts, which coalesce and have a common opening at *s*, the outer branchial aperture; *a*, atrium of the heart; *v*, its ventricle; *ab*, branchial artery, which sends a division to each sac; *d*, flaps of skin, folded back.

neath alone; its sides and roof are of a fibrous texture. The brain is first enveloped in a thin, blood-vascular, connective tissue, a kind of *pia mater*, which descends into and fills the cerebral sulci. Seen from above (fig. 359) the naked brain is triangular, with the base of the triangle directed forwards. By a dorsal longitudinal sulcus in the median line a bisection into two lateral halves is indicated. In each lateral half five divisions, bounded by transverse sulci, may be traced, namely, beginning from in front, the *olfactory brain*, *forebrain*, *midbrain*, *hindbrain*, and *afterbrain*. Of the *forebrain* there appears dorsally, in the angle between the forebrain and midbrain, a small, rounded or oval protuberance, the *ganglion habenulæ*, usually consisting of a right and a left lobe; but of the epiphysis itself not a trace can else be detected; on the ventral side is a small infundibulum with a lamellar appendage, the *hypophysis*. The afterbrain (medulla oblongata) is strongly developed; its anteriorly dilated central canal advances through the midbrain to a cæcal termination, somewhat before the posterior half thereof. The third ventricle is obliterated, with the exception of two small vestiges. Of lateral ventricles there is no trace. No ependymal pallium, like that of the Teleosts and *Petro-*

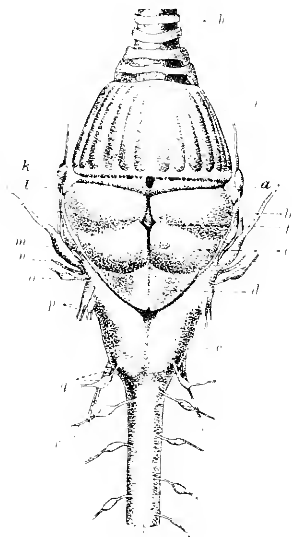

Fig. 359. Brain of *Myxine glutinosa*, seen from above. × 7

a, olfactory lobe; *b*, forebrain; *c*, midbrain; *d*, hindbrain; *e*, afterbrain; *f*, ganglion habenulæ; *g*, spinal cord; *h*, nasal duct with cartilaginous rings; *i*, olfactory organ with cartilaginous basket; *k*, eye; *l*, optic nerve; *m*, trigeminus; *n*, facialis (?); *o*, trigeminus (?); *p*, acoustic nerve; *q*, vagus; *r*, sensory roots of spinal nerves.

myzon larvæ, is to be found. It is hence impossible for the present to determine with certainty in the adult state whether the forebrain of *Myxine* merely corresponds to the corpora striata, or whether the cerebral pallium also enters into its structure.

The nerves issuing from the brain on each side are: *olfactorius*, *opticus*, *trigeminus*, *facialis*, *acusticus*, and *vagus*; of the others no trace can be seen.

The *spinal cord* consists of a flattened band, of uniform breadth and somewhat triangular in section, which in a fairly spacious medullispinal canal, lying on the notochord, follows the latter to its posterior termination, and there extends in a contracted ependymal filum terminale somewhat behind the same (fig. 354, *f*). By means of improved colouring methods the form, distribution, and processes of the ependymal as well as the neurogliar and ganglion cells has been elucidated on a fairly extensive scale in the spinal cord and partly too in the brain.

The nerves originating in pairs, but not quite symmetrically, from the spinal cord (spinal nerves) each have a ventral (motory) and a dorsal (sensory) root, and the latter is furnished with a ganglion. As in *Petromyzon*, all the nerve-fibres are "pale", being without myeline sheath. The motory nerve-fibres end their terminal ramifications on the muscular fibres in free

Fig. 360. Auditory organ of the right side of *Myxine glutinosa*, seen from above and within, × 18.

a, internal division with *e*, the *macula acustica*; *b*, external division with an ampulla at each end (*c*, *d*) and a *crista acustica* (*f*, *g*) in each ampulla; *i*, *i*, branches of the acoustic nerve; *h*, endolymphatic duct.

"end-trees" within more or less marked end-hillocks (end-plates). The sensory fibres terminate within the different organs also in free intercellular ramifications. Such is the case too with the nerves in the epithelium of the skin and mucous membranes. No special sensory organs (end-cells, end-buds, sensory corpuscles, etc.) have been demonstrated. Even in the tentacles surrounding the oral and nasal apertures only free terminal ramifications of the sensory nerves in the epidermis have been traced, but here there is a slight sign of end-buds, round whose cells the nerve-ends ramify. No lateral line with appertaining end-buds appears either on the head or the body. In the subcutaneous nerve-plexus, on the other hand, especially in the head, numerous ganglion cells have been found embedded. Possibly they belong to the *sympathetic nervous system*, whereof else no trace has hitherto been discovered. These ganglion cells further remind us by their position in some degree of the cells in the rostral region of the Lancelet, close to the foremost nerve-pair.

Of the *organs of sense* proper the *olfactory organ* is obviously the most powerfully developed. It forms (fig. 359, *i*) a conical organ situated close before the brain in a cartilaginous basket and consisting of nearly vertical and dense folds of mucous membrane, their surface covered with olfactory epithelium, i. e. olfactory cells with supporting cells arranged between them. The filamentous, central processes of the olfactory cells enter the olfactory bulb, and terminate there in numerous ramifications and with free ends in the olfactory glomeruli, in which other nerve-fibres, from the ganglion cells (mitral cells) of the bulb, running towards the periphery, also terminate in free ramifications. The olfactory organ of *Myxine* thus exhibits in the main the same structure as this organ retains throughout the whole of the vertebrates, even including man. Here there is no trace of "olfactory end-buds", as Blaue has endeavoured to demonstrate in the Teleosts. Neither in the latter nor the Cyclostomes, nor indeed in any of the vertebrates, do such "end-buds" exist as Blaue meant; and his theory of the genetic connexion between the olfactory organ and the sense-organs of the skin, especially the lateral line, is therefore without ground in the structure of the said organs.

Special *organs of taste* have not yet been demonstrated in *Myxine*, whereas *Petromyzon* and its larva display within the mouth cavity bulbous or gemmiform organs that may with reason be regarded as representing the gustatory organs of the higher vertebrates[a].

The *organ of sight* in *Myxine*[b] is very rudimentary. It is composed of the two very small, oblong eyes discovered by Johannes Müller, which, covered by the skin and a layer of muscles, lie on each side of the fore end of the brain (olfactory brain) and close to the posterior outer angle of the cartilaginous basket investing the olfactory organ (fig. 359, *k*). The two optic

[a] Cf. G. Retzius, *Biol. Unters.*, N. Folge, Bd. V, p. 69, taf. XXVII.
[b] Cf. „ „ , l. c., p. 64, taf. XXVI.

nerves (l), which, after crossing, emerge from the ventral side of the midbrain and afterwards turn first outwards and then forwards, penetrate the hind extremity of either eye, and their fibres may be traced some way in within its central parts. The eyes, surrounded by a capsule of connective tissue, do not show the regular structure common in the vertebrates; cornea, iris, and lens are entirely wanting, and of vitreous body there is only a rudiment; the retina does not present the normal arrangement, it fills nearly the whole orbit, its stratification is very irregular and difficult of elucidation, instead of rods and cones there is only an epithelial layer of obscure nature. By means of the modern colouring methods the presence of numerous cells of neuroglia-like appearance may be demonstrated, but also of some other cells that may possibly be of a true nervous description. Hence it appears that the eye of *Myxine* is not only undeveloped, but has probably also undergone retrogressive development. That no true sight exists, is evident from the structure of the eye and its concealment below the surface of the body. Yet physiological experiments might well be made to investigate whether, in spite of this, the fish may not be capable of appreciating with these rudimentary eyes certain intense lights.

The *auditory organ* of *Myxine* (fig. 360) is structurally the simplest known within the vertebrate kingdom, if we except *Branchiostoma*, in which no trace of such an organ has been discovered. It consists of a paired, annular, membranous organ, which lies enclosed in the above-described cartilaginous capsule situated on each side of the anterior end of the notochord at the bottom of the cranium (fig. 355, c). In the annular tube may be distinguished an inner division (fig. 360, a), furnished with a long nerve-ending, a macula acustica (e), and an outer division (b), furnished at each end with an ampullaceous dilatation (c, d) and a nerve-ending, thus with two cristae acusticae (f, g). This outer division may reasonably be interpreted as representing two semicircular canals, each with an ampulla. The inner division gives out a caecally terminating endolymphatic duct (h).

It is else not easy to institute any close comparison between the so little differentiated parts of the auditory organ in *Myxine* and those of the corresponding organ in other fishes and the higher vertebrates. Unfortunately this applies also to the same organ in *Petromyzon*, where it has many peculiarities and forms no true link between that of *Myxine* and of the other vertebrates. In *Petromyzon* (fig. 361) may be distinguished a large common chamber (the vestibule), a saccate appendage, and two semicircular canals each with an ampulla and appertaining crista acustica. In the vestibule is a large nerve-ending (macula acustica) perhaps composed of several, and a smaller one appears in the saccate appendage.

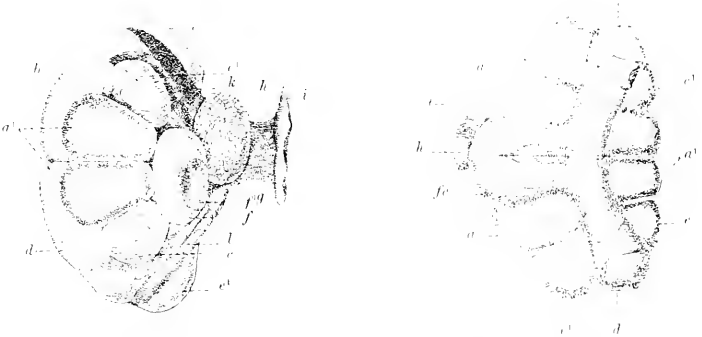

Fig. 361. Auditory organ (right) of a Lampern (*Petromyzon fluviatilis*), × 18.

A, seen from below; *B*, seen from above and without; a, a^1, vestibule; b, anterior semicircular canal; c, c^1, anterior ampulla; d, posterior semicircular canal; e, e^1, posterior ampulla; f, saccate appendage; f^1, its nerve-ending; fc, commissure; g, ganglion of the acoustic nerve; h, acoustic nerve; i, cerebral part from which the acoustic nerve originates; k, anterior branch of the acoustic nerve; l, posterior branch of the acoustic nerve.

It is first in the osseous and cartilaginous fishes (fig. 362, *A*, *B*, *C*, *D*) that the membranous auditory organ is developed to that fundamental type which it afterwards retains throughout its evolution within the vertebrate kingdom, even in the human race. It parts into two divisions, a *superior* and an *inferior*. The superior consists of a fairly wide, horizontally and sagittally directed tube, *utriculus* (*u*), which dilates anteriorly into a vesicular bulb, *recessus utriculi* (*rec*), in whose anterior and outer sides open two vesicular tubes, the *anterior* (*aa*) and the *external* (*ae*) *ampullæ*, continued each by a narrower, tubiform duct, the *anterior* (*ca*) and the *external* (*ce*) *semicircular canals*, which bend round and at their other end again open into the utriculus, the former at the upper end of an upward invagination thereof, *sinus utriculi superior* (ss), the latter into the lower part of it. At the posterior termination of the utriculus, *sinus utriculi posterior* (*sp*), opens a third vesicular tube, the *posterior ampulla* (*ap*), which

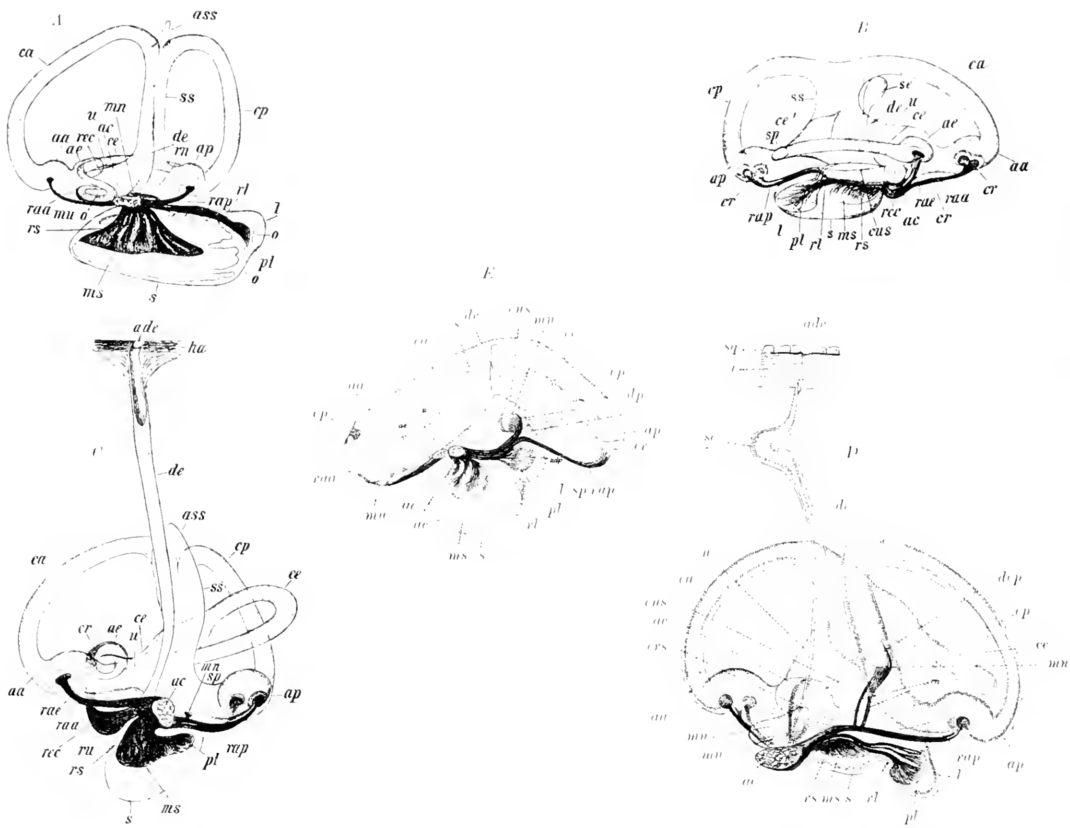

Fig. 362. Auditory organ of the right side: *A*, in a *Perch* (*Perca fluviatilis*; × 3, seen from within); *B*, in a *Sturgeon* (*Acipenser sturio*; $\times 3\frac{1}{2}$, seen from without); *C*, in a *Chimæra* (*Chimæra monstrosa*; $\times 3\frac{1}{4}$, seen from within); *D*, in a *Rough Hound* (*Scyllorhinus canicula*; $\times 3\frac{1}{3}$), and *E*, in a *Mud-eel* (*Siren lacertina*; $\times 11\frac{1}{4}$), both the last seen from within.

aa, ampulla anterior
ae, ,, externa
ap, ,, posterior
ac, nervus acusticus
ade, apertura externa ductus endolymphatici
adp, ,, ductus perilymphatici
ass, apex sinus superioris
c, cutis
ca, canalis anterior
ce, ,, externus
cp, ,, posterior
cr, crista acustica ampullarum
crs, canalis recessu-saccularis
cus, canalis utriculo-saccularis
de, ductus endolymphaticus
dcp, ductus canalis posterioris
dp, ,, perilymphaticus
l, lagena cochleæ
mn, macula acustica neglecta
ms, ,, ,, sacculi
mu, ,, ,, recessus utriculi
o, otolites (in the recessus utriculi, sacculus and lagena)
pl, papilla acustica lagenæ
raa, ramulus ampullæ anterioris
rae, ,, ,, externæ
rap, ramulus ampullæ posterioris
rl, ,, lagenæ
rn, ,, neglectus
rs, ,, sacculi
ru, ,, recessus utriculi
rec, recessus utriculi
s, sacculus
se, saccus endolymphaticus
sp, sinus utriculi posterior
ss, ,, ,, superior
sq, squamæ cutis
u, utriculus.

passes behind into a third *semicircular canal*, *canalis posterior* (*cp*), that bends upwards and afterwards forwards and inwards, opening into the upper end of the superior sinus (*ss*).

The superior division of the organ usually communicates by means of a small opening or a short tube, *canalis utriculo-saccularis* (*cus*), in the bottom of the utriculus, with the inferior division. The latter consists of a saccate part, *sacculus* (*s*), which in most fishes possesses behind a pouch-like appendage, *lagena cochleæ* (*l*), the first rudiment of the cochlea so richly developed in the higher animals and, above all, in man, together with its highest development (the organ of Corti). From the inner superior side of the sacculus there issues besides a narrow canal, *ductus endolymphaticus*, which as a rule lays itself on the membranes of the brain and terminates cæcally, but sometimes, as in the Elasmobranchs, ascends to the upper surface of the head, where it has a free orifice.

Of *nerve-endings* the superior division contains at least 4, namely a large one in the bottom of the recessus utriculi (*macula ac. recessus utriculi*, *mu*) and one in each of the three ampullæ (*cristæ ac. ampullæ anterioris*, *externæ*, and *posterioris*, *cr*), besides which there appears in most fishes at the bottom of the utriculus itself, in the neighbourhood of the opening into the sacculus, a small nerve-ending (*macula ac. neglecta*, *mn*). In the inferior division may be found, within the sacculus, a large ending (*macula ac. sacculi*, *ms*) and in most cases another, posterior one (*papilla ac. lagenæ*, *pl*), which is situated on the wall of the pouch-like cochlear appendage, as soon as this is developed. Thus in some fishes the number of nerve-endings is only 6, in others 7. These endings are everywhere of the same structure, the epithelium which lines them consisting of numerous cells (auditory or hair cells) furnished with hair-like processes (auditory hairs) projecting freely into the endolymphatic fluid, and of supporting cells set between the former and isolating them.

The *acoustic nerve* divides into several branches, which supply all these nerve-endings each with a bundle of nerve-fibres. These fibres, each of which issues from a bipolar ganglion cell embedded in the acoustic nerve and its branches, penetrate the epithelium of the nerve-endings and ramify around the auditory cells, over which they spin free terminal ramifications, without being directly continuous therewith.

Here we give some figures (fig. 362) to illustrate the various development of the auditory organ in cartilaginous and osseous fishes, namely *Chimæra*, *Acipenser*, and *Perca*, adding a figure of *Scylliorhinus* to show further how the organ has developed a special type in the Sharks and Rays. The auditory organ of the Lung-fishes and amphibians is most closely linked, among the forms adduced here, to the Ganoid type, as shown by fig. 362, *E*, which represents the appearance of this organ in *Siren lacertina*. The present, however, is no suitable opportunity for a closer consideration of these questions.

From the above it appears that, as we have already pointed out, the auditory organ of *Myxine* may justly be regarded as the lowest known form of the development of this organ among the vertebrates, but that, the intermediate links being absent, we can only imperfectly sketch its phylogenesis. In *Myxine* a division into a superior and an inferior part has presumably not yet taken place, and the inner part of the annular tube probably represents both utriculus and sacculus, which is also indicated by the emission from this part of the endolymphatic duct. The outer part of the annular tube probably answers to the anterior (or the outer) and the posterior semicircular canals with their respective ampullæ. Possibly in the future, when the development of *Myxine* has been brought to light, some knowledge may be gained both of this question and so many others, touching the systematic position of this remarkable creature and its relation to the rest of the vertebrates.

In the anatomical structure of *Myxine* we have still to consider the *organs of generation* and in connexion therewith the present knowledge of the impregnation and development.

The structure of the *ovary* and eggs has long been known. In the abdominal cavity of most specimens is found along the right side of the intestine a somewhat lobate, longitudinal mesentery, within which are enclosed, as it were suspended, rather numerous ova of varying dimensions. In small individuals these ova are generally of insignificant size and rounded form, some hardly visible to the naked eye, other somewhat larger, up to the size of a pin's head. In more full-grown individuals many similar eggs are also found, but there besides appear, as a rule, a number (10—15 or more) of larger ova, which are always oblong, fusiform, measuring in some cases only 3—10 mm., in others 11—12 mm. These eggs are enveloped in a firm membrane and yellowish in colour; the greater part of their contents consists of yolk. In its hindmost part the said ovarian mesentery (*mesovarium*) presents a totally different appearance; no eggs are visible here, and the mesentery assumes a still more lobate, tuberculate or granular form. On microscopical examination no eggs are found here, but only vesicles or capsules, containing a great number of large cells, many of which are in process of division. I. T. CUNNINGHAM[a] was the first to express the opinion, based on his investigations, that this hindmost part of the mesentery is a mesorchium and contains the male organ. Nay, he even considered that he had here found spermatozoa at different stages of development. FRIDTJOF NANSEN[b] followed up these researches and adopted the theory of hermaphroditism, adding that he had observed that, in young individuals which had not yet attained a length of 320—330 mm., the male organ was, as a rule, the more developed and contained almost ripe spermatozoa, whereas the female organ was more or less undeveloped. Larger (older) individuals he found, on the other hand, to contain more developed female organs and also large eggs, while the male organ was more rudimentary. Hence he concluded that in the younger stages of its development *Myxine* is masculine (protandric), but afterwards in the older stages feminine. But there besides occur, according to NANSEN, individuals that are males alone. The same investigator also gives figures of spermatozoa he had observed in *Myxine*, and asserts that those described by CUNNINGHAM are not of a true nature. The latter writer has subsequently given a new description of the spermatozoa observed by him, and insisted upon his priority with respect to the theory of hermaphroditism. As I myself too, during a series of years (since 1877), have made repeated investigations into the structure of *Myxine* and its mysterious development, I will state that, so far as I can find, no distinctly developed male individual thereof has hitherto been observed with certainty, and that there is much to be said for the CUNNINGHAM-NANSEN theory of its hermaphroditism. Considering that I have macroscopically examined a great number of Hag-fishes and have microscopically prosecuted these investigations in many instances that seemed especially remarkable as regards the point in question, and this at every season of the year, it may appear strange that I have never succeeded in finding within the cell-filled vesicles of the so-called mesorchium fully developed spermatozoa, but only lower and somewhat dubious stages thereof. Yet from preparations kindly sent me by NANSEN it would seem that the structures found by him presented in a high degree the appearance of spermatozoa. Phenomena of movement, however, have not yet been observed in them, and even their development is not fully known[c].

As for the *season* of impregnation and oviposition, these do not appear to be restricted to any fixed time of year. All the investigators who have made any minute researches into this question are apparently agreed that ripening eggs are met with in these creatures all the year round, but that at the same time in other individuals ova may be found at the most different stages, from quite small, colourless globules, hardly distinguishable to the naked eye, to the opaque, yellowish eggs 10—12 mm. long, of an elongated oval form, pointed at the ends, enveloped in a horny shell, and filled for the greater part by a large yolk. Of such ripening, but not yet fully developed eggs a number of 10—15, up to 26, are as a rule found in the same individual, all then exhibiting the same size and appearance. These ova, however, as mentioned above, are not quite ripe for deposition. There are a few instances in which specimens have been secured of fully developed eggs. In 1859 ALLEN THOMSON figured and described in Todd's Cyclopaedia of Anatomy and Physiology ova of *Myxine* that measured about 25 mm. in length, had an oval form, and were furnished with a firm, horny shell and at each end with a number of horny threads, each having hooks (barbs) at the end. Some years afterwards J. STEENSTRUP (Oversigt af d. K. Danske Vidensk. Selsk. Forhandl. f. 1863) described and figured eggs of similar appearance that had been found in a Glutinous Hag. A. W. MALM (Göteb., Bohusl. Fauna) also secured ripe eggs 19 mm. long that were met with in the stomach of a Cod (thus presumably devoured after their deposition); a couple of these were described in 1875 by W. MÜLLER in the "Jenaische Zeitschrift f. Naturwissenschaft". Furthermore I. T. CUNNINGHAM has described in the Quart. Journ. of Micr. Sc., N. S., V. 27, 1887 an egg preserved in the Edin-

[a] I. T. CUNNINGHAM, Quart. Journal of Microsc. Science, N. S., V. 27, 1887.

[b] FRIDTJOF NANSEN, Bergens Museums Aarsberetning f. 1887 (ed. 1888).

[c] See further G. RETZIUS, Biolog. Föreningens Förhandl., Bd 2, No. 8, 1889—90.

burgh Anatomical Museum (possibly the same specimen as formerly described by THOMSON). NANSEN also states that he observed in the Museum of Bergen a ripe egg which had been dredged up by D. C. DANIELSSEN at Molde. In July, 1888, while examining a large number of Glutinous Hags from Gullmar Fjord, I found in an individual 30 cm. long, containing 12 large eggs, a ripe egg furnished with threads at the ends (G. RETZIUS, Biol. Fören. Förhand., Bd. 1, Okt. 1888). This egg was still attached in the mesovarium, the third from behind in the chain of ripening ova. It was larger than the others, measuring 14 mm., had a yellower colour, was blunter at the ends, and harder on the surface, which evidently consisted of a strong, horny shell. The ends were each furnished with a horny process 4 mm. long, which proved to consist of a bunch of dense threads, all of them tipped with a button-shaped thickening armed with four barbs. One (the anterior) of these processes was attached to the connective tissue of the mesovarium: otherwise the egg hung free in the abdominal cavity. Fig. 363 represents this specimen of *Myxine* with the abdominal cavity cut open and the ripened egg (*b*) suspended from the mesovarium. Probably this egg was not quite so ripe as those described by STEENSTRUP and the other above-mentioned writers. Since that occasion I have opened and examined several thousand Glutinous Hags, but I never succeeded in finding another egg so far advanced in development.

On the 1st of January last (1895), however, Baron AXEL KLINCKOWSTRÖM (Öfvers. K. Vet. Akad. Förh. 1895, No. 1) found, in a Glutinous Hag taken together with a number of others in Gullmar Fjord by Fisherman ÅBACK a day or two before, an egg at about the same stage of development as that described by me. This egg, which was of a bright reddish yellow, almost orange-coloured, lay entirely free in the abdominal cavity and dropped out on the latter being opened. Its total length was 20·5 mm., the egg itself measuring 16 mm., and the two terminal bunches of barbed threads respectively 3 and 1·5 mm. This find is of special interest as confirming the opinion that the spawning of the Glutinous Hag is not restricted to any particular season.

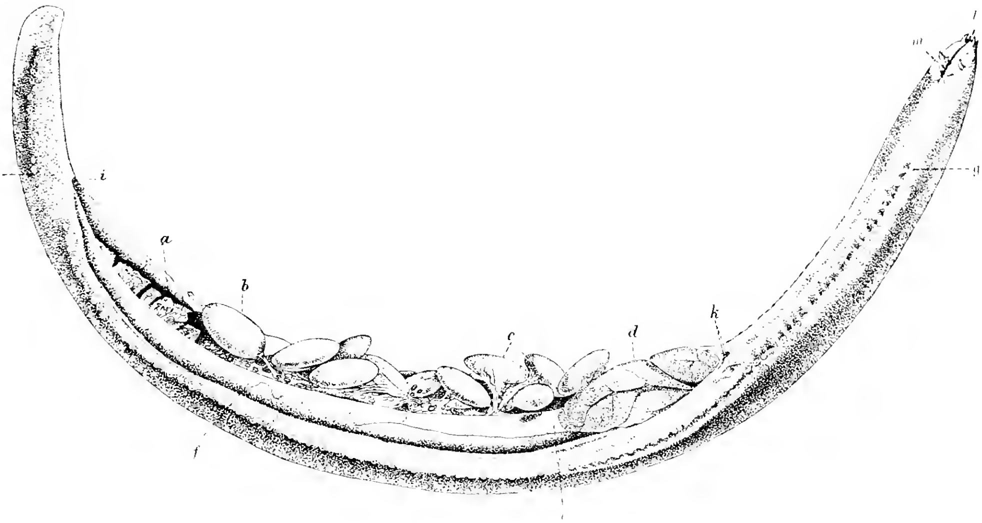

Fig. 363. A Glutinous Hag, nat. size, seen obliquely from below and from the left. Abdominal cavity cut open to show its contents. *a*, lobes of the so-called mesorchium (male organ); *b*, a large, nearly ripe egg with thick, horny shell and horny appendages at both ends, of which the anterior was still attached to the mesovarium; *c*, less ripe eggs in the mesovarium; *d*, liver; *e*, *f*, intestinal canal; *g*, apertures of the foremost muciferous glands of the skin; *h*, apertures of the hindmost group of muciferous glands; *i*, cloacal aperture; *k*, outer branchial apertures; *l*, nasal aperture; *m*, oral aperture.

This is in effect our whole knowledge of this question. Manifold endeavours have been made during the last two decennia by several investigators (W. MÜLLER, CUNNINGHAM, NANSEN, myself, THEEL, TULLBERG, KLINCKOWSTRÖM) to trace the development of the Glutinous Hag;

but hitherto they have proved all but fruitless. It has been attempted, for instances, with dredges of a special construction to collect in the clayey bottoms where the Glutinous Hag has its home deposited ova and fry in course of development. Further experiments have been made by keeping a number of Hags in aquaria, or by sinking them in corves to the depths where they live in a state of nature and examining at intervals the contents of the corves; but all to no purpose. Yet it is quite possible that the question may be solved by still more systematical and comprehensive investigations, attention being paid to the biotic conditions of the Glutinous Hag (the temperature of the water, the pressure, etc.). Or perhaps, a circumstance of which the history of science affords more than one example, a happy accident may throw light upon the mystery. In any case each new contribution to this result, each new suggestion is of value. It is not yet known with certainty whether the eggs are impregnated after or before their deposition. W. Müller and Cunningham have described a micropyle in the ripe eggs. An impregnation of the ova after their exclusion from the parent-fish is accordingly not impossible. Nor is it known how and where the eggs are laid, whether this is done on the clayey bottom, as is most probable, or perhaps among algæ on a rocky ground. It has been stated that the Glutinous Hag constructs with its slime a kind of nest in the clay for the reception of its ova; but nothing positive is known on this head. It is not known whether the embryos live in the clay or free in the sea-water. Their appearance is utterly unknown. Perhaps they are larval forms of quite a peculiar type, as the *Ammocœtes* form of *Petromyzon*. The smallest recorded specimens of the Glutinous Hag, taken alone now and then in pots baited with dead fish, measure no less than 9 cm., and they already conform in structure to the developed animal. It consequently remains for the investigator to secure them at earlier stages and, above all, to find new-laid, impregnated eggs, as well as to watch the earliest development of the embryos. This question acquires greater and greater biological importance year by year, and it is to be hoped that the solution thereof will not baffle research too long.

THE GLUTINOUS HAG OR MYXINE (SW. PIRALEN OR PILALEN).

MYXINE GLUTINOSA, Linn.

Plate LIII, fig. 5.

Supralingual teeth larger in the anterior outer than in the posterior inner row, and numbering in the former 7 or 8, in the latter 8—10, the two foremost being besides confluent at the base.

Syn. *Pihral* A. *Ingeris Pilt.* Kalm, *Resa N. Amer.*, tom. I, p. 100. *Hwid-Aal*, Ström, *Sondm. Beskr.*, pt. 1, p. 287. *Steensuer*, Olav., *Skag. Beskr.*, p. 156, tab. 3, figg. 3 et 4.

Myxina glutinosa, Lin., *Mus. Ad. Frid.*, tom. I, p. 91 (inter *Vermes*), tab. VIII, fig. 4; *Syst. Nat.*, ed. X, tom. I, p. 650 (*Myxine*); Gunnerus (*Sleep-Marken*). Trondhj. Selsk. Skr., vol. II (1763), p. 250, tab. III; Penn. (*Glutinous Hag*), *Brit. Zool.*, vol. IV (ed. 1777), p. 33, tab. XX, No. 15; A. J. Retz., Vet. Akad. Handl. 1790, p. 110, tab. IV (sim. cum Petromyzonibus inter *Vermes* et *Pisces* interm.); Fabr., *Fna Groenl.*, p. 344 (inter *Vermes*); A. J. Retz., *Fna Suec. Lin.*, p. 301 (inter *Pisces*); A. Retz., Vet. Akad. Handl. 1822, p. 233, tab. III; 1824, p. 408, tab. VI; Nilss., *Prodr. Ichthyol. Scand.*, p. 123; J. Müll., *Vergl. Anat. Myxin.*, Abh. Akad. Wiss. Berl., Phys. Cl., 1834, 1837, 1838; Sund., v. Wr., *Skand. Fisk.*, ed. 1, p. 121, tab. 28; Kr., *Danm. Fisk.*, vol. III, p. 1068; Nilss., *Skand. Fna, Fisk.*, p. 750; Stuv, Overs. D. Vid. Sels. Forh. 1864, p. 233; Couch (*Borer*), *Fish. Brit. Isl.*, vol. IV, p. 408, tab. CCXLVIII, fig. 3; Gthr, *Cat. Brit. Mus., Fish.*, vol. VIII, p. 510; Putn., Proc. Bost. Soc. Nat. Hist. 1873, p. 135; Coll., Forh. Vid. Sels. Chrnia 1874, Tillægsh., p. 220; Malm, *Gbgs. Boh. Fna*, p. 637; Winth., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 62; Mela, *Vert. Fenn.*, p. 372, tab. X; Storm, Vid. Sels. Skrift. Trondhj. 1883, p. 48; Day, *Fish. Gt. Brit., Irel.*, vol. II, p. 364, tab. CLXXIX, fig. 3; Cunningh., l. supr. c.; Nansen, l. supr. c.; G. Retz., Biol. För. Förh. Sthlm, Bd I, p. 22, tab. III; Bd II, p. 80, tab. III; Lillj., *Sv., Norg. Fisk.*, vol. III, p. 730.

Gastrobranchus cæcus, Bl., *Ausl. Fisch.*, pt. IX, p. 67, tab. CCCXIII.

Myxine limosa, Gir., Proc. Acad. Nat. Sc. Philad. 1858, p. 223.

The Hag that lives on the west coast of Sweden and in Norwegian waters has an average length of 25—30 cm. Sometimes, however, individuals measuring 45 cm. or a little more are met with.

The *body* is of almost uniform thickness, for the most part terete, Eel-like; behind the middle it shows some lateral compression, and this is increased towards the tail, which is thin, flattened, and somewhat diaphanous. The coloration is of a reddish gray, more or less strongly suffused on the back and the upper part of the sides with blackish gray, owing to the presence of subcutaneous pigment, a vague bluish violet tint being thus produced in those regions. Sometimes the pigment is unevenly distributed, giving the body a piebald appearance. On the belly the colour is of a somewhat lighter gray.

The *head* is not delimited from the body, being of about the same thickness and terete form, but it tapers in a forward direction towards the tip of the snout.

In its appearance and structure the species belonging to the Scandinavian fauna exhibits all the peculiarities enumerated above as characteristic of the genus *Myxine*, and no further description is therefore necessary.

The Glutinous Hag occurs throughout the west coast of Sweden, from the Sound upwards, and along the whole Norwegian coast up to Finmmark. In the Sound, however, it appears to be very rare. From Mount Kullen upwards, along the west coast of Sweden, and all the coasts of Norway, it is common in such localities as are congenial to its manner of life, viz. where the bottom consists of soft clay and mud, the water is of a suitable depth, about 20[a] to 50 fathoms, and preferably where there is some ground current. The Glutinous Hag is quite at home, however, in deeper water (100—200 fathoms), as has been observed off the northern most coasts of Norway. It seems besides to occur in the Arctic seas, off Greenland (FABRICIUS) and the east coast of North America, though it is apparently not common there. On the coasts of Scotland and Northern England it is also met with, but is less numerous, to judge by the statements on record, than in Scandinavian waters.

As regards its manner of life, it seems as a rule to lie embedded in the clayey bottom. This is its habit too, when kept in aquaria with a bottom of clay or mud, and supplied with running water, an experiment which I have repeatedly made. It soon burrows into the clay and remains lying there, with only the tip of the snout exposed to view. But it does not live long in captivity. As a rule the prisoners die in the course of a few hours, even if they be placed in a corf and sunk in salt water at a depth of some fathoms. At first they show great activity in their movements, wriggling like Eels, generally forwards, but sometimes backwards, and swaying the head now to one side, now to the other. In these actions they display fairly great strength, and they secrete meanwhile large quantities of slime, in which they sometimes entangle themselves. They often project the tongue and draw it in again, thus getting portions of the slimy secretion into their mouth, and the dead Hags are consequently found in many cases to have clots of slime adhering far back in the mouth cavity.

Of their habits little or nothing more is known. That they are true parasites, as was formerly asserted and is still stated in some foreign manuals, is in the highest degree improbable. At least there is no direct evidence of this. They apparently live on dead animals, principally fish. This appears distinctly from their not seldom attacking netted fish, or creeping into pots containing dead fish or fish offal and sunk in places frequented by this species. The most enticing bait seems to be Haddock or Whiting, and by this method great numbers of Glutinous Hags may be taken. In one single pot a hundred or two may sometimes be caught. On examination the intestinal canal of the captured Hags is found to be full of recently devoured morsels of fish. They apparently do not withdraw to any distance from the sea-bottom, and according to the statements of experienced fishermen they fasten upon netted or hooked fish only when this is on or close to the ground.

That the Glutinous Hag also attacks the corpses of drowned human beings, is a fact known on the west coast of Sweden.

The Glutinous Hag would thus appear strictly to feed on dead creatures. It may be regarded as a scavenger of the depths. But, guided by its powerfully developed organ of smell, it also assails hooked fish hanging on the line, and must thus be stigmatized as in some degree injurious to the fishery.

Itself it possesses no economical value. Its flesh is not good to eat and is nowhere used for food. Possibly it might be smoked for consumption, like the Lampern.

(G. RETZIUS.)

[a] The least depth at which I succeeded in obtaining it in Gullmar Fjord was 16—17 fathoms, but, according to statements given by fishermen, the animal lives during the winter at a still less depth (10—11 fathoms).

PISCES LEPTOCARDII.

Fishes whose unaltered notochord extends further forward than the spinal cord, which is of uniform thickness and without true brain. No head proper; no true heart. Respiratory apparatus a large, retiform branchial basket.

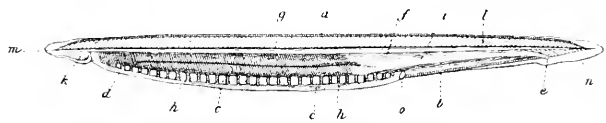

Fig. 364. *Lancelet* (*Branchiostoma lanceolatum*), seen from the left, with the skin and muscles removed from this side. About 3 times nat. size. After VOGT and YUNG.

a, dorsal, *b*, ventral fin-ray growths; *c*, organs of generation; *d*, branchial basket; *e*, anal aperture; *f*, notochord; *g*, spinal cord; *h*, intestinal appendage (hepatic caecum), situated on the right side, seen through the branchial basket; *i*, intestine; *k*, mouth; *l*, great lateral muscle; *m*, rostral fin; *n*, caudal fin; *o*, abdominal pore.

Here it may be questioned even more than in the preceding order whether these creatures are vertebrates or invertebrates. It is not only the low rank occupied by this order in comparison with the preceding ones; we shall besides find here an asymmetry that strongly reminds us of certain invertebrates.

JOHANNES MÜLLER interpreted this order as a separate subclass among fishes — but so he also regarded the Cyclostomes and Elasmobranchs — and gave it the name of *Leptocardii*[a]. Under the name of *Cirrostomi* the order was coupled by OWEN[b] together with the Cyclostomes in a subclass, *Dermopteri* (with fins in the form of dermal folds). Others have gone still further and regarded the order as a separate class among the vertebrates. So the *Leptocardii*, under the same name, were conceived by GILL[c]; and E. HECKEL called them[d] *Vertebrata Acrania*. Others[e] have indeed considered these creatures to be the lowest vertebrates, but have assumed that they attained this position by a retrograde development (degeneration) from better equipped vertebrates, which have now disappeared. Others again have ranged them beside the *Tunicata*, and regarded them as one of the types for the predecessors of the protovertebrates (the supposed ancestors of the vertebrates). Thus BALFOUR called them[f], together with the Tunicates, *Protochordata* (primordial forms among the animals furnished with permanent notochord), and conferred upon them the special name of *Cephalochorda* (with notochord in the head), a reference to the forward extension of the notochord in that part which answers to the head of the vertebrates, as distinguished from the Tunicates (*Urochorda*), which have a notochord only in the tails of the larvæ. The significance of these divergent opinions is best appreciated after we

[a] *Üb. d. Bau u. d. Grenzen der Ganoiden*, Abh. Akad. Wiss. Berl., 1844. Physik. Abh., p. 204. λεπτός, *thin* and καρδία, *heart*.
[b] *Comp. Anat., Phys. Vertebr.*, vol. I, p. 7.
[c] *Arr. Fam. Fish.*, Smiths. Misc. Coll., No. 247, p. IX.
[d] *Gener. Morphol. Organ.*, Bd 2, p. CXIX.
[e] DOHRN, *Ursp. Wirbelth.*, Leipz. 1875, pp. 51—55.
[f] *Comp. Embryol.*, vol. II, p. 271.

have gained an insight into the structure and development of the Leptocardians.

The few forms of the order belong to a single family, the

FAM. AMPHIOXIDÆ[1],

whose characters thus coincide with those of the order. Nor have reasons been discovered for the establishment within this family of more than one genus.

GENUS BRANCHIOSTOMA.

Body more or less elongated, lanceolate, pointed and laterally compressed at both ends, intermediately triangular in section. Mouth ventral, elliptical, fringed with tentacles, but jawless. A dermal fold edges the body from the mouth round the tip of the snout, along the back and round the tip of the tail, and, usually[2], forward along the ventral margin to the abdominal pore, whence two lateral folds extend to the mouth. Anus situated far back, beside the ventral margin.

This genus is probably dispersed throughout the temperate and tropical coasts of all the oceans, but sporadically. It is known from Europe, Australia, Peru, Brazil, and the east coast of North America. Where it occurs, it is generally met with in numbers. Usually it lives on sandbanks, where it has shelter and plenty of food. Its diet appears to consist exclusively of *Infusoria* and similar minute creatures or the lowest vegetable forms. If a *Branchiostoma* (Pl. LIII, fig. 6) be placed in a vessel of seawater with a little sand on the bottom, it will perhaps lie still on its side for a long while, as if dead; but on being touched it leaps up and tosses itself to and fro with swaying movements, until it eventually lies down to rest again on the sand or buries itself in the bottom. This is done with great rapidity, in a moment; and afterwards it only sticks the oral end up into the water, opens its wreath of tentacles, and commences in its mouth cavity the ciliary motion that conducts water and food into the respiratory cavity, which also serves as an œsophagus.

That which first gives this animal, in contradistinction to the rest of the vertebrates, a singular position in the system, is, as mentioned above, its almost entire lack of that we call head. With the same justice as we call a mussel a headless mollusk, we may also describe *Branchiostoma* as a headless vertebrate.

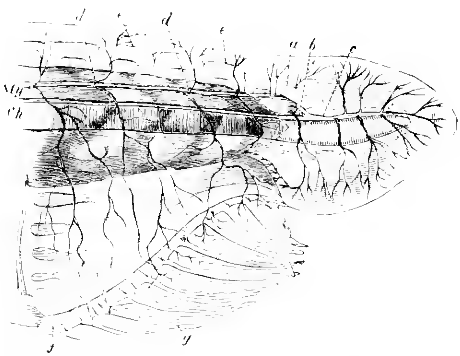

Fig. 365. Anterior end of the body of the Lancelet, seen from the right, magnified.

a, site of the olfactory organ (situated on the left side); *b*, site of the eye (pigment spot); *c*, second pair of nerves, counting from in front; *d*, spinal nerves; *e*, homologues of the upper spinous processes of vertebræ; *f*, cartilaginous ring, supporting the external mouth aperture; *g*, cirri; *My*, spinal cord (*myelon*); *Ch*, notochord (*chorda dorsalis*). After QUATREFAGES and HUXLEY.

Throughout the length of the body — excepting the extreme tips of the snout and tail — there run in *Branchiostoma* (fig. 365) a spinal cord (*My*) and a notochord (*Ch*), the latter representing a structure present in the embryos of all other vertebrates. But in them the notochord terminates anteriorly under the swelling of the medullispinal canal, the rudimentary

[1] *Amphioxini*, J. MÜLLER, l. c. Afterwards the family was called *Branchiostomida* in BONAPARTE, *Cat. Met. Pesci Europ.* (1846), pp. 9 and 92.

[2] In the Australian *Branchiostoma* (*Epigonichthys*) *cultellus* described by PETERS this part of the dermal fold is said to be rudimentary, the anus of this species being accordingly situated in the median ventral line.

brain. Here in *Branchiostoma* there is hardly any such swelling: — the spinal cord is a string of almost uniform thickness, gradually tapering backwards, and only slightly dilated at its anterior end (fig. 366, *a*) so as

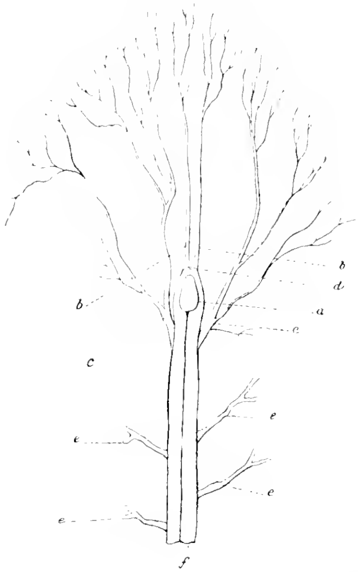

Fig. 366. Anterior end of the spinal cord and the nerves thereof in *Branchiostoma lanceolatum*, seen from above and magnified. After Vogt and Yung.

a, medullispinal swelling and its cavity; *b*, first, *c*, second pair of nerves; *d*, pigment spot (eye spot?); *e*, third and fourth pairs of upper (posterior, sensory) nerves; *f*, spinal cord.

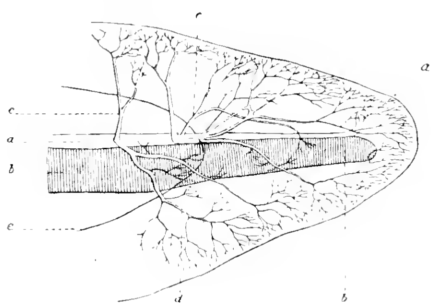

Fig. 367. Caudal end of *Branchiostoma lanceolatum*, seen from the left and magnified. After Vogt and Yung.

a, spinal cord; *b*, notochord; *c*, upper ramifications of the sensory nerves; *d*, lower ramifications of the same; *e*, hindmost myocomma (boundary of the hindmost myomere).

to form a kind of cerebral vesicle. And the notochord tapers to a pointed termination at each end of the body. A peculiarity never seen in any vertebrate higher than *Branchiostoma*, is that the notochord (fig. 365, *Ch*) projects forward beyond the anterior end of the spinal cord (*My*) and in front of the mouth aperture (*f* and *g*). At the posterior end of the body the case is different. There (fig. 367) we find an upcurved dilatation of the medullispinal canal (*a*), reminding us of *Myxine* (fig. 354).

The mouth is of a curious structure for a vertebrate. It is neither a prehensory nor a suctorial mouth; it is, so to say, merely a deglutitory mouth, edged with a ring of small cartilages (fig. 365, *f*), in texture resembling the notochord. Each one of these cartilages gives out a process (*g*) to form a support in one of the so-called cirri which surround the oral aperture

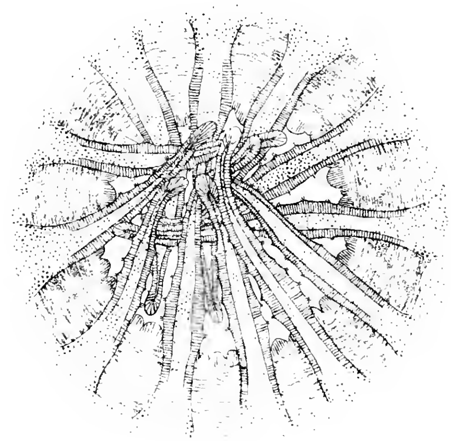

Fig. 368. Posterior wall of the mouth cavity (postoral sphincter or *velum*) with its twelve centripetally meeting cirri, which are furnished with the sensory bodies first described by Langerhans, bundles of sense-hairs on thickened parts of the epithelium. After Ray Lankester.

outside, but are folded inwards when the mouth is closed. These cirri are almost exactly similar to the sense-filaments or tentacles possessed by many of the lower animals. At their base they are united to a membrane coursed by muscular fibres; and their surface is clothed with a cylindrical epithelium, among whose cells some are ciliated, others prolongated outwards into stiff setae, which are collected in verruciform bundles, and connected inwards with nerve fibrillæ, whence they have been interpreted as organs of taste.

Within the mouth is a buccal (pharyngeal) cavity, the inner surface of which displays active ciliary motion, especially along the margins of a number of digitiform (process-like) thickenings (fig. 365, vertically above *f*); and a constant current of water is thus kept up into the branchial sac (respiratory cavity, fig. 364, *d*). The mouth cavity is delimited from this sac by a circlet of cirri (fig. 368), similar to those of the oral margin.

The walls of the respiratory cavity, which also serves, however, as a pharynx or rather perhaps an œsophagus, are laterally constructed of a network of cartilaginous rods (fig. 369), closely resembling the homologous structure in the Ascidians; but above and below the respiratory cavity has a continuous groove, the upper known as the epibranchial, the lower as the hypobranchial groove. The obliquely vertical rods set transversely in the body are rib-like growths on both sides, connected above with the outer sheath of the notochord (the so-called skeletogenous layer), the most primitive rudiment of an axial skeleton. Below (towards the ventral side of the animal) these rods are free, some (the so-called primary bars) bifurcated, others (the so-called secondary bars or tongue-bars) single. The connecting rods between them stand in the longitudinal direction of the body. Thus a network is formed, and this is faced everywhere, as the two grooves are also lined, with an epithelium of ciliated cells, exactly similar to those we have just seen in the mouth cavity. But the meshes of the net are minute, hardly visible even under a high magnifying power and under ordinary circumstances do not transmit anything but the clearest, purest water. In the adult state of the animal this water, which has now served its respiratory purpose, passes out on the sides of the respiratory cavity and into a special chamber, a secondary compartment of the abdominal cavity. This chamber, which has been named by RAY LANKESTER[a] the *atrium*, surrounding the respiratory cavity on the sides and underneath and extending some way behind it, has a special aperture (the abdominal or atrial pore) behind on the ventral side (fig. 364, *o*) for the discharge of the water. Everything else that has accompanied the water into the respiratory cavity, and especially the food — *Infusoria* and other minute creatures — finds its way through the œsophagus proper, a tubiform prolongation of the epibranchial groove, into a kind of stomach (fig. 364, just in front of *i*) with a long cæcal appendage (*h*), and all the useless matter now passes out through the straight intestine (*i*) and the anal aperture (*e*). The cæcal appendage projects forward on the right side into the atrium, pressed close to the respiratory cavity. The whole digestive canal, the stomach and intestine, is lined with an epithelium of ciliated cells and exhibits a vibratile motion, just as the intestinal canal of the worms.

The blood of *Branchiostoma* is colourless; and the circulation, of which little is yet known with certainty, may indeed be referred to the piscine type, for the vascular system is divided into certain regions which apparently lend themselves to a comparison with the heart and the great bloodvessels of fishes; but here too we are reminded of the worms. Under the respiratory cavity runs a long contractile canal with a contractile vesicle to each ascending rod in the branchial network. This

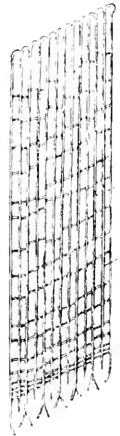

Fig. 369. A portion of the right side of the branchial basket in *Branchiostoma lanceolatum*, seen from without and powerfully magnified. After VOGT and YUNG.

a, secondary rods, so-called tongue-bars; *b*, primary rods.

canal has been compared to the venous heart of fishes. Another contractile tube, anteriorly double (one on the right side, one on the left), posteriorly single, runs along the dorsal margin of the abdominal cavity, under the notochord. This canal has been compared to the aorta of fishes. Another similar canal, according to J. MÜLLER, connects on each side these two canals in front, and this has been compared to the so-called *ductus arteriosus Botalli* of the lower vertebrates and of the higher vertebrates in their embryonic stages. Along the intestinal canal run two ducts of a venous nature. The

[a] Quart. Journ. Micr. Sc., n. ser., No. LIX (July, 1875), p. 267; No. CXVI (Apr., 1889), p. 365.

one, which is said to have its roots in the capillaries of the intestinal canal, runs under the stomach and caecum, there ramifying into a capillary network between the green cells in the wall of the caecum, which is said to functionate as a kind of liver. Here the blood, it is stated, is again collected, on the upper side of the caecum, in the other, superior canal, whose contractions run backwards in the opposite direction, to the exit of the caecum from the stomach, and convey the blood to the heart: — and we should thus have found here a portal vein (the inferior canal) and an efferent hepatic vein (the superior canal). Descriptions have besides been given of a separate, but wall-less lymphatic system, filling all the cavities of the body and ramifying into the smallest lacunae between the organs. But in all the said contractile canals there appear distinct traits of the typical arrangement of the vessels in a worm. In those paired connecting vessels between the upper vessel and

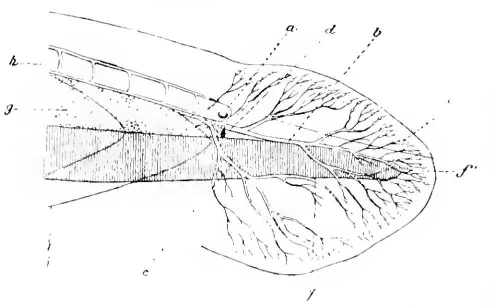

Fig. 370. Anterior end of a *Branchiostoma lanceolatum*, seen from the right and magnified. After VOGT and YUNG.

a, olfactory depression; *b*, first, *c*, second pair of nerves; *d*, eye spot; *e*, peripheral ganglion cells in the skin; *f*, notochord; *g*, spinal cord; *h*, fin-ray growths (spinous processes?); *i*, myocomma.

the lower which are most plentiful in the forepart of the worms (*Annulata*), we may well seek a parallel to the respiratory system of *Branchiostoma*. And the two contractile vessels that run bulging in the latter along the upper and lower sides of the intestinal canal also functionate in the worm for the first sucking up of the alimentary juice and its conversion into nutritive fluid.

The vertebral segmentation of the body is indeed subindicated even in *Branchiostoma* by a transversal division of the membrano-cartilaginous sheath that envelops the notochord, expands both around the neural canal and the haemal cavity, and breaks up at the base of the vertical dermal fin-fold along the dorsal and the posterior part of the ventral margin into pieces resembling fin-rays (fig. 364, *a* and *b*; fig. 370, *h*) — though far more numerous than the muscle flakes. But the muscular and nervous systems are the organs that here most distinctly call to mind the vertebrate type.

That portion of the muscular system which answers to the great lateral muscles of fishes is divided into transverse bands (*myomeres*), which are angular, with the angle directed forwards; and each myomere is composed of bundles of muscle fibre extended between tendinous expansions of the notochordal sheath (*myocommata*), just in the manner of the said piscine muscles. Along the ventral side of the abdominal region, between the mouth and the atrial pore, extends an horizontal muscular plate, composed of transversal muscle fibres. Its function, consisting of rhythmical contractions, is mainly subservient to the respiration, and its posterior part, at the atrial pore, swells into the so-called abdominal papilla, coursed by muscle fibres in all directions.

The nervous system shows the peculiarity that the spinal nerves (except the first two pairs) do not issue in pairs, exactly opposite each other, but alternately, the nerves of one side in front of those of the other (fig. 366, *e*), and that only the basal parts of the dorsal branches (sensory nerves) are entire, those of the ventral (motory) nerves being broken up into fibres. In the spinal cord there appear, as in the preceding order, besides the ordinary ganglion cells, large so-called colossal cells. Among the organs of sense A. RETZIUS was the first[a] to discover a black pigment spot (fig. 370, *d*) on the anterior end of the spinal cord. This spot is interpreted as an eye of the most rudimentary description. It is comparatively larger in young specimens than in old, which suggests a still advancing reduction; and its visual function is somewhat dubious, for similar spots also occur in a row on each side along the greater part of the spinal cord. Above the anterior end of the spinal cord, but on the left side of the body, KÖLLIKER[b] and, after him, QUATREFAGES[c] found a ciliated depression (fig. 370, *a*), the simplest form of an olfactory apparatus. The organs of taste we have already remarked on the cirri of the mouth aperture and the postoral velum; and a similar cell structure also appears

[a] Monatsber. Akad. Wiss. Berlin, 1839, p. 198.

[b] Müll. Arch. Anat., Physiol., 1843, p. 32.

[c] Ann. Sc. Nat., ser. 3, Zool., tome IV (1845), p. 226.

in the hypobranchial groove. LANGERHANS described[a] as sensory cells a number of cylindrical epithelial cells scattered in the skin and most numerous on the foremost part of the body, furnished distally with a long, stiff hair, proximally with a process to which the peripheral end of a nerve fibrilla attaches itself. In the vertical dermal fin around the anterior end of the body VOGT and YUNG remarked[b] small, round or oval, transparent ganglion cells, situated oftenest in the fork between two nerve twigs (fig. 370, *e*).

These organs of sense have indeed scarcely been submitted as yet to adequate investigation; but so much is known, that the rudimentary eye has the same structure as in the lower Polychaetous worms, and the olfactory depression also finds its nearest anatomical homologue in Nemertines, Turbellarians, and some other worms. There is this difference, however, that in *Branchiostoma* both these organs are single, and that the olfactory organ is asymmetrical, situated on the left side of the body. The only further reason which might be adduced for calling the anterior end of *Branchiostoma* a rudimentary head, is that the spinal cord, as mentioned above, dilates in front, though but slightly, into a vesicle from which there originate two fairly symmetrical pairs of nerves, the second pair larger and more numerously ramified than the other spinal nerves. It is therefore not surprising that some have proposed to separate this animal into a distinct class, and have said: it is neither a vertebrate nor an invertebrate, it is something between the two.

The organs of generation (fig. 364, *c*) are a row of saccate vesicles, free from each other and usually numbering 26—28 on each side in full-grown individuals, between the abdominal wall and the atrium. The male and female can be distinguished only by the contents of the vesicles[c]; and the sexual products are probably emitted, as a rule, through the atrial pore. KOWALEWSKY[d] and HATSCHEK[e], however, saw these products discharged through the mouth aperture; and one of the females received by us from Bohuslän had several ripe eggs in the mouth cavity, where they may easily arrive, as HATSCHEK has pointed out, after first being liberated, by the bursting of the generative sacs, in the atrium and then passing, through the clefts of the branchial sac, into this cavity and out at its anterior (sphincterial) aperture.

As excretory organs in the full-grown *Branchiostoma* WEISS has adduced a large amount of the epithelial lining of the atrium, especially on two tubiform prolongations of the said cavity which project into the abdominal cavity proper or coelom (atrio-coelomic funnels). In this connection he also draws attention to his own discovery of small, tubular glands (kidneys?) situated at the top of the branchial tongue-bars (secondary cartilaginous rods) and opening on the outer side thereof into the atrium.

The character of the genus and its relation to other animals are best explained, however, by the history of evolution[g]. *Branchiostoma* deposits its ova (fig. 371, *A*).

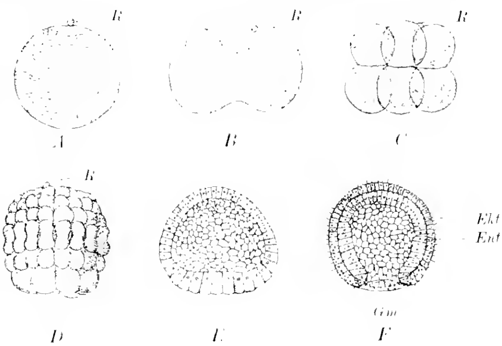

Fig. 371. *A*, an unimpregnated egg, with the so-called polar body (Richtungskörper, *R*), a small body liberated from the egg and marking that pole thereof at which the segmentation is most active. *B*, an impregnated egg, with two cleavage-cells not yet quite divided from each other. *C*, an egg segmented into 8 parts. *D*, an egg with 8 large cells round the inferior pole and 5 sixteen-celled circles higher up. *E*, optical section at the *Blastula* stage (simple sacculation), with the inferior pole flattened, the commencement of its upward invagination towards the inside of the wall of the upper pole. *F*, optical section of an embryo in the *Gastrula* stage, with the above-mentioned invagination completed. Each cell of the ectoderm (*Ekt*) is furnished with a flagellum. *Ent*, entoderm, answering to the lower part of the *Blastula* wall in the preceding stage. The *Gastrula* mouth (*Gm*) is the downward opening. After HATSCHEK. × 140.

[a] Arch. Mikrosk. Anat., Bd. XII (1875—76), p. 303.

[b] *Lehrb. prakt. vergl. Anat.*, Bd. 2, p. 361.

[c] And also, according to VOGT and YUNG (l. c., pp. 375, 376) by the inner epithelial investment of the transverse ventral muscle, this being developed into a kind of support for the organs of generation (deferent grooves?), different in males and females.

[d] Mem. Acad. Sc. Petersb., ser. VII, tome XI, No. 4, p. 1.

[e] *Stud. ub. Entw. d. Amphioxus*, Arb. Zool. Inst. Univ. Wien, tom. IV, H. 1, p. 14

[f] Quart. Journ. Micr. Sc., n. ser., No. CXXIV (Nov. 1890), p. 489.

[g] KOWALEWSKY, l. c., and Arch. Mikr. Anat., Bd. XIII (1876—77), p. 181; HATSCHEK, l. c., RAY LANKESTER and WILLEY, Quart. Journ. Micr. Sc., n. ser., No. CXXIII (Aug. 1890), p. 445

enveloped in a transparent membrane, free in the water, where they are impregnated. When one of these eggs has undergone its total segmentation, it hollows itself out — it becomes a vesicle or rather an entirely closed sac (fig. 371, *E*), the cavity of which answers to the segmentation cavity (under the blastoderm) in the ova of the higher vertebrates and, like the said cavity, is principally obliterated, the sac being flattened (*E*), so that the lower wall comes nearer to the upper and at last lays itself close up to the same (*F*). The original sac has now become a bowl; and the rim hereof is contracted into a narrower and narrower aperture (*Gm*). Meanwhile the external layer of the bowl (*Ekt*) has developed small mobile bristles (flagella) on its cells, one to each cell (Germ. *Geisselcell*): — the egg has attained a stage of development common to most of the invertebrates and called by HÆCKEL the *gastrula*. Now it dances briskly about within its egg-shell (vitelline membrane). The two layers of which the body of this gastrula is composed correspond to the first two germinal layers of the higher vertebrates. The structure is the same, though the manner of life is widely different, for this gastrula has no vitellus on which to rest, or from which to derive its nourishment. On the other hand, it has a stomach, which it has acquired by the invagination of the lower (eventually inner) part of its wall (*Ent*). In the embryos of the highest vertebrates the intestinal canal indeed has quite a different appearance — though fundanentally constructed on the same principle — and is not formed until after a considerable alteration of the original germ; but in the batrachians the development of the said canal calls to mind the above-mentioned invagination, although the batrachian embryo, like the mammalian, has been supplied by the transformations of the egg with a kind of nutritive yolk under it.

The gastrula of the future *Branchiostoma* elongates its form of body (fig. 372), thus acquiring an anterior and a posterior end. In the latter lies its mouth. Soon it acquires a dorsal and a ventral side, for on the former a primitive groove appears, which becomes a cerebrospinal canal, following the same manner of deve-

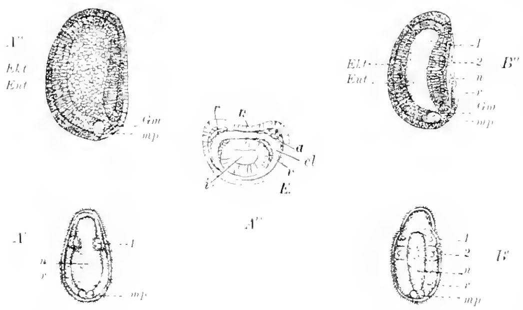

Fig. 372. *A'*, an embryo, prolongated and with the rudiments of the first protovertebræ (one on each side of the intestinal canal) seen from the dorsal side. After HATSCHEK. × 77. *A''*, transverse section of a similar embryo. After KOWALEWSKY. *A'''*, optical longitudinal section through the middle of *A'*. After HATSCHEK. × 140. *B'*, a larva with two pairs of protovertebræ, seen from the dorsal side. After HATSCHEK. × 77. *B''*, optical longitudinal section through the middle of a similar larva. After HATSCHEK. × 140.

At the stage *A* (after HATSCHEK) the embryo quits the egg by bursting the membrane thereof. The gastrula mouth is still present, but is overgrown from below (see *B''*) by the ectoderm, which has besides raised itself on the sides of the back, thus forming a wide groove (*n*), the edges of which (dorsal ridges, *r*) grow more and more together to form a canal (the future central canal of the spinal cord; cf. *nc* in fig. 380). In *A* the first protovertebra (*1* — on each side a vesicular dilatation of the entoderm) has begun to differentiate itself, after the appearance between the first two germinal layers (ectoderm, *Ekt* and entoderm, *Ent*) of the middle (third) germinal layer (mesoderm, fig. *A''*, consisting of the animal (*a*) and the vegetative (*v*) lamina). According to HATSCHEK the mesoderm is developed from the entoderm, in the hindmost part of which two cells, larger than the rest, indicate the posterior limit of the mesodermal growth and have therefore been named *the polar cells of the mesoderm* (*mp*). Simultaneously with the formation of the mesoderm and its division into an outer (animal) and an inner (vegetative) lamina, a body-cavity (cœlom, *cl*) has arisen round the intestinal canal. The lumen (internal space) of the latter is indicated by *i*. In *B* the rudiments of two pairs of protovertebræ (*1* and *2*) have appeared.

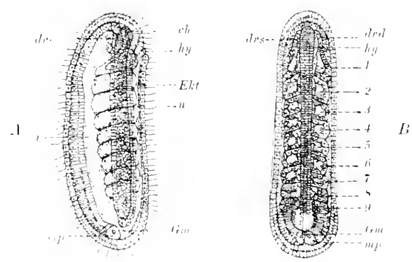

Fig. 373. Two optical longitudinal sections of a larva with 9 protovertebræ (somites, *1*—*9*), seen from the left (*A*) and from the dorsal side (*B*). After HATSCHEK. × 140. The cerebrospinal canal (*n*) has now been formed and is separated from the ectoderm, but in front (at *hy*) open and behind (through the original gastrula mouth, *Gm*) continuous with the intestinal canal (*i*). This has dilated anteriorly to the right (*drd*) and the left (*drs*). Under the cerebrospinal canal the notochord (*ch*) has appeared, and in the protovertebræ muscle cells begin to develop. In *B* it appears that the protovertebræ are set obliquely opposite each other, the right a little further back than the left; but the anterior lateral dilatations of the intestinal canal are still of equal size (symmetrical).

lopment as in the higher vertebrates[a]. Between the first two germinal layers an intermediate layer (the *mesoderm*, fig. 372, *A'*) is formed; and now that the intestinal canal and an incipient abdominal cavity have begun to differentiate themselves, there develop a *notochord* and, by means of bulgings and constrictions of the intestinal canal, *primitive vertebræ* (*protovertebræ*), which increase their number backwards from in front. The foremost bulges (figs. 373 and 374) meet with a singular fate. The right (*dcl*) dwindles into the hollow at the tip of the snout. The left, on the other hand, develops into a funnel-shaped, ciliated organ, probably an organ of smell, which disappears, however, at the termination of the larval period. A special bulge (*gl*) on the right side of the intestinal canal becomes a gland which also disappears at the close of the larval period, and whose outer efferent duct bends round below to the left side of the body (fig. 375). But in the median ventral line the intestinal canal coalesces at one point after another, backwards from in front, with the wall of the body, becomes thickened there (fig. 374, at I), and eventually opens into gill-slits (fig. 375), which are first moved up to the right, but afterwards migrate to the left side of the body. In the meantime, however, new gill-slits (fig. 378) have been similarly formed in a row higher up on the right side, and these become the permanent gill-slits on that side. This only applies, however, to the anterior part of the branchial

Fig. 374. Optical section of a larva with its protovertebræ, seen from the right. After HATSCHEK. × 280.

Here the lateral dilatations of the foremost part of the intestinal canal have diverged widely; the right (*dcl*) is elongate and thin-walled, the left (*des*, which from that side shines through in the figure, at about the middle of the former) has thicker walls (deeper cells) and is round. Both separate by constriction from the intestinal canal, the anterior end of which is thereby thrust further back. A glandular growth (the so-called *club-shaped gland* of HATSCHEK, *gl*) has besides begun to develop on the inside of the intestinal canal by means of a transversal constriction, first canaliculate and afterwards, owing to the coalescence of the edges of the groove, tubiform, of the right side of the intestinal wall behind the said lateral dilatation. Behind this gland the wall of the intestinal canal has been thickened in the inferior (ventral) median line of the larva and has coalesced with the ectoderm at a point (*I*) where the first gill-opening afterwards appears. As yet there is no true mouth; and the intestinal canal is continuous behind with the cerebrospinal.

Fig. 375. A larva $1^1/_2$ mm. long, seen from the left. After RAY LANKESTER and WILLEY.

Of the four gill-slits, which are situated on the right side (*I—IV*), the foremost three are rather large, the fourth is rudimentary. The first is visible through the posterior part of the semioval mouth aperture, which belongs to the left side of the body. Through the anterior part of this aperture are visible, also from the right side of the body, both the club-shaped gland (*gl*), the outer orifice of which may be seen below, on the wall of the body below the mouth aperture, and, just in front of the said gland, a transversal, but curved thickening (*end*), bisected along the middle by a groove, the future endostyle. Before the upper edge of the mouth aperture appears the opening of the funnel-shaped, ciliated organ (*cil*). Above this and from the anterior to the posterior end of the body (in front of the caudal fin) lies the notochord (*ch*), divided into its numerous transverse disks. Above the notochord, and posteriorly round the termination thereof, the spinal cord (*m*) is extended, with the large pigment spot (ocular rudiment, *oc*) at its anterior end and some smaller sparse pigment spots on its sides. In the lanceolate caudal fin a sparse collection of pigment spots is also visible. The number of the myomeres is 36; the first myocomma runs obliquely across the anterior edge of the ocular rudiment and down along the subjacent part of the notochord. In the posterior half of the intestinal canal (below the 15th and 16th myomeres) the wall of this canal is thickened (*e*), an indication of the rudimentary stomach. The anal aperture (*an*) lies on the left side of the body.

[a] *Branchiostoma* differs, however, from the higher vertebrates in that the rudiment of the spinal cord is separated from the circumjacent cells of the ectoderm before the canal is closed above (HATSCHEK).

[b] See WILLEY, Quart. Journ. Micr. Sc., n. ser., vol. XXXII, pt 2 (No. CXXVI, March 1891), p. 209

basket. Some of the first-formed gill-openings close again; and the posterior part of the branchial basket has its slits symmetrically arranged after the termination of the larval period. The mouth appears on the left side, first as a fine slit, afterwards as a large, elliptical aperture with tumid margin (fig. 375). A true anus opens, also, as a rule, on the left side, and the original gastrula mouth grows together, the connexion between the intestinal canal and the cerebrospinal canal being thus cut off. As yet the larva moves only with the aid of the dermal cilia; but it has begun to bend its body, since the rostral and caudal fins have become sharpened. Over the gill-slits there grows from above (fig. 377) a longitudinal fold from the walls of the body (somatopleures, the outer parts of which grow into the so-called metapleures or abdominal fins, *met*, figs. 379 and 380) on each side, first on the right; and between these folds the atrium is formed, first only on the ventral side and growing forwards from behind. The construction of the branchial basket is continued (figs. 376, 378, and 379) by the addition of epibranchial and hypobranchial grooves. The former (*ep*) originates, so far as we have been able to see, as a fold-like incurvature, advancing in its development forward from behind along the lower wall of the intestinal canal, which at the hindmost rudimentary gill-slit grows upwards and forwards over the tops of the branchial slits. The latter (*end*, with its supporting rods, the so-called *endostyle*, with a right and a left part), on the other hand, follows, according to WILLEY, an opposite direction of development, backwards from in front, originating in a thickening, at first transversal (figs. 375—379, *end*), of the intestinal wall beside the club-shaped gland. The first rudiment of the atrium appears (fig 380, *A*, *sar*) where the atriopore afterwards has its place, and presents the appearance of two horizontal ridges, growing to meet each other (fig. 380, *B*), on the inside of the above-mentioned dermal folds (*met*), whose inferior margin subsequently becomes on each side of the body a longitudinal lateral ridge (abdominal fin or metapleure). Afterwards the atrium expands upwards, encroaching upon the region of the abdominal cavity on the sides of the branchial basket, and continued within the abdominal cavity even behind the atriopore, beside the intestine.

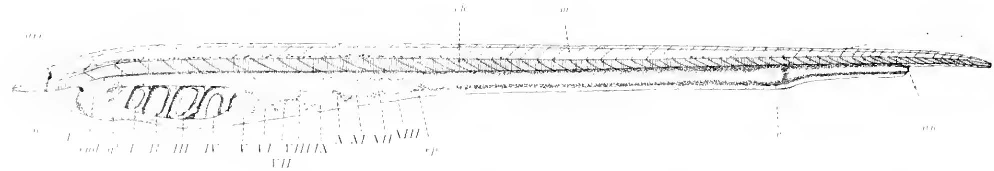

Fig. 376. A larva 3 ½ mm. long, taken swimming freely in the sea, between 1 and 4 fathoms below the surface, at Kristineberg (Bohuslän), August 17, 1894. Seen from the left. Letters and numerals as in the preceding figure; besides: *am*, the ciliated mouth of the cerebrospinal canal; *ep*, the forward growth on the inside of the intestine, a fold originating from the inferior wall of the intestinal canal. Number of the myomeres here 61. Gill-slits and their rudiments visible here to a number of 13 (*I—XIII*).

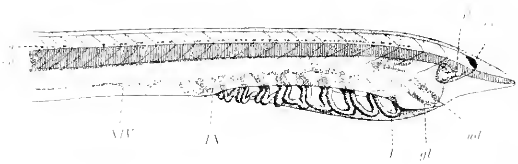

Fig. 377. Forepart of a larva 3 ½ mm. long, seen from the right. After RAY LANKESTER and WILLEY. Here it appears how the wall of the body from the ninth gill-slit forward lies like a leaf outside the upper parts of the slits, and further forward is continued in a sharp, free edge, forming an upward curve on the right side of the head. Letters and numerals as in the preceding figure.

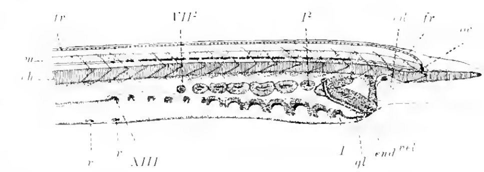

Fig. 378. Anterior end of a somewhat larger larva, seen from the right. After WILLEY. Here a series of seven secondary gill-slits (I^2—VII^2) has appeared on the right side, above the inferior ends of the primary slits (*I—XIII*), which have been translated for the most part to the left side, and among which the thirteenth (hindmost) has been obliterated, and the first has almost suffered the same fate. The endostyle (*end*) has grown backwards, and its posterior extremity extends behind the club-shaped gland (*gl*). Further forward the velum of the mouth cavity (*vel*) has begun to develop. In the skeletogenous layer (chordal sheath) a series of so-called fin-rays (*fr*) has appeared. On the atrial floor two so-called renal organs (*r*) may be seen. Letters and numerals otherwise as in the preceding figure.

The details of this development should be easy of comprehension with the aid of the figures which we give here and their explanations. In the last stages the external form of the body is almost complete. But it still remains for the mouth to assume its ventral position and its wreath of tentacles instead of the long vibratile hairs (not included in our figures) which are set during the larval period on a verruciform thickening just in front of the mouth-aperture.

Branchiostoma besides teaches us the appearance presented by the locomotive organs of the vertebrates in their simplest form. The locomotive organ proper is the hind part of the body, edged above and below by a kind of caudal fin or rather a compound of rudiments of the posterior part of a dorsal fin, a caudal fin, and an anal fin. Before the anus this fin-growth

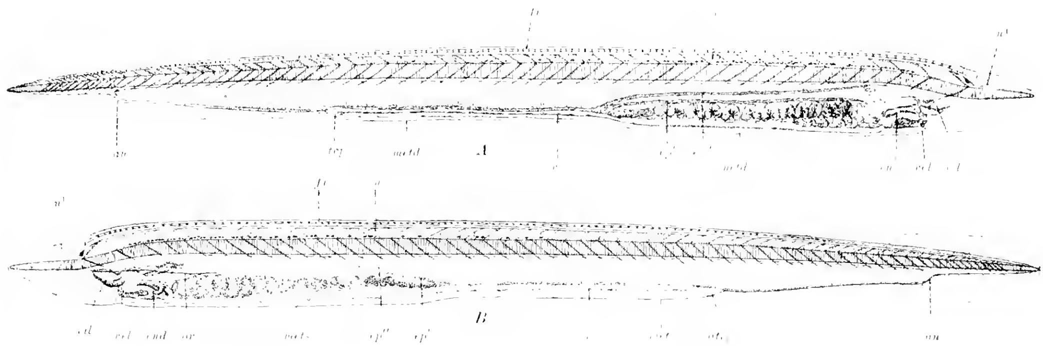

Fig. 379. A larva 5 mm. long, taken together with the original of fig. 376. From a preparation briefly treated with a weak solution of osmium bichromate by Prof. G. RETZIUS and preserved in glycerine. *A*, from the right; *B*, from the left. Here the above-mentioned fold (*ep*) originating in the inferior wall of the intestinal canal to form the epibranchial (hyperbranchial) groove has divided into two parts, the one (*ep'*) following the tops of the branchial arches, the other (*ep''*) taking its course up towards the root of the abdominal cavity. In *B* the larval mouth shows the commencement of its alteration and translation from the left side of the body to the ventral margin. A dermal fold (*or*) has laid itself over the upper part thereof; and the superior margin shows signs of dissolution. *atrp*, atriopore; *metd*, edge of right, *mets*, of left metapleure; n^1, first pair of nerves, with a few ganglion cells (cf. fig. 370, *c*) visible; other letters as in the preceding figure.

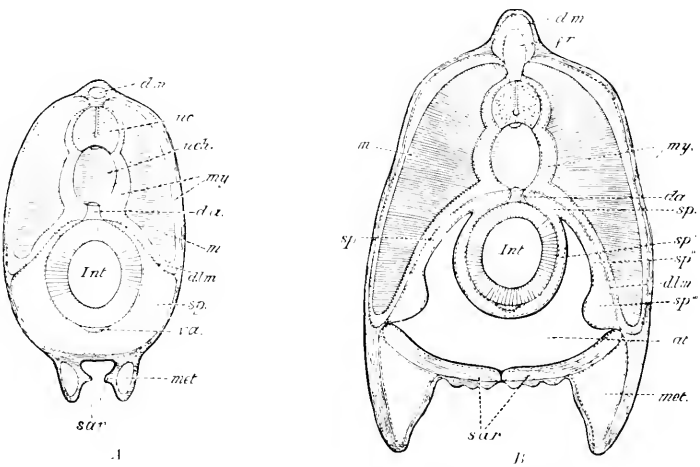

Fig. 380. Diagrammatical transverse section, *A*, through a larva of *Branchiostoma lanceolatum*, with 11 or 12 primary gill-slits, and *B*, through a full-grown specimen of the same species. Enlarged. After RAY LANKESTER and WILLEY.

dm, myocœl of the dorsal fin (that part of the body-cavity (cœlom) which belongs to the dorsal fin-lobe); *fr*, series of fin rays; *m*, great lateral muscles; *my*, muscle cœlom, myocœl (that part of the body-cavity which belongs to the lateral muscles); *nc*, spinal cord, with its central canal; *nch*, notochord; *d. a.*, dorsal aorta; *v. a.*, ventral vessel; *Int*, intestine; *sp*, splanchnocœl (intestinal part of the abdominal cavity), which (in *B*) is divided by the ingrowth of the atrial chamber into an inner (*sp'*) and an outer (*sp'*) cavity; *sp''* (in *B*), perigonadial dilatation of the splanchnocœl; *d. l. m.*, double-layered membrane separating the myocœl from the splanchnocœl; *at*, atrium; *met*, metapleure, one on each side of the body, its cavity, according to RAY LANKESTER, not in open communication with the cœlom; *s. a. r.*, floor of the atrial chamber.

advances on the ventral margin forward to the atriopore, but there it has a double series of supporting cartilages (fin-rays), instead of the single row in the other parts of the vertical fin. In front of the atriopore are the two lateral ridges (metapleures) answering to the first rudiment of or at least foreshadowing lateral extremities, whether they represent both extremital pairs of the other vertebrates, being not yet differentiated into an anterior and a posterior pair, or correspond to the pectoral fins alone, in which case the double series of rays in the atrio-anal fin would appear to have some homology with ventral fins. But as yet they are merely steering organs. This is a function, however, which is for the most part retained by the unpaired fins of the back and belly, and indeed by the lateral fins, even in the highest evolutional grades of the piscine type.

The structure and development of *Branchiostoma* have now shown us a creature with the vertebrate division of the body into a neural and a haemal canal, with a notochord and the membranous elements of an axial skeleton between and around those canals, and with the vertebrate type expressed in musculature, spinal nerves, respiratory, excretory, and generative organs. But in other respects we have seen an asymmetry, partly persistent, partly temporary, which is distinctly foreign to the vertebrates, but common among the mollusks: the respiratory organs present a striking resemblance to those of the Ascidians; and the most important organs of nutrition and circulation, though comparable with the vertebrate type, retain much of their structure in the worms. Hence the great morphological interest attached to this genus, which in other respects is not especially remarkable. Its forms are so similar that in his famous *Catalogue* GÜNTHER recognised only a single species. SUNDEVALL, however, had already (1852—53) distinguished between three species, with characters derived from the form of body and the number of myomeres. At a more recent date GÜNTHER has decided, basing his conclusions in the main on the same characters, that six different species deserve recognition within the genus. Only one of these belongs to the seacoasts of Europe.

THE LANCELET (SW. LANSETTFISKEN).

BRANCHIOSTOMA LANCEOLATUM

Plate LIII, fig. 6.

Greatest depth of the body about 9—10½ %[a], greatest breadth (thickness) thereof about 6—8 %[b], of the length of the same. Distance from the tip of the snout to the posterior limit of the mouth aperture about 8 %[c], to the atriopore about 70 %[d], to the rent about 88 %[e], of the length of the body. Number of myomeres 60—62, 11—13 situated behind the rent.

Syn. *Limax lanceolatus*, PALL., *Spicil. Zool.*, fasc. X, p. 19, tab. I, fig. 11; (*lanceolaris*), *Naturg. Merkw. Th.*, Samml. X, p. 24, tab. I, fig. 11; YARR. (*Amphioxus lanceolatus*), *Brit. Fish.*, ed. 1, vol. II, p. 468; FR., Vet. Akad. Handl. 1838, p. 336, tab. 4, fig. 3; SUNDEV., F., Forh. Skand. Naturf. Kbhvn 1840, p. 280; SUNDEV., C. J., Arsber. Zool. Framst. 1840—42, Vertebr., p. 287; Öfvers. Vet. Akad. Förh. 1852, p. 148; 1853 (*Branchiostoma*), p. 12; QUATREF., Ann. Sc. Nat., ser. 3, Zool., tom. IV, p. 197, tabb. 10—13; KR., *Danm. Fisk.*, vol. III, p. 1087; NILSS., *Skand. Fna, Fisk.*, p. 753; COUCH (*Amphioxus*), *Fish. Brit. Isl.*, vol. IV, p. 415, tab. CCXLVIII, fig. 4; GTHR (*Branchiostoma*), *Cat. Brit. Mus., Fish.*, vol. VIII, p. 513; Rep. Zool. Coll. Alert (Brit. Mus. Nat. Hist. 1884), p. 32; COLL., Forh. Vid. Sels. Chrnia 1874, Tillægsh., p. 222; N. Mag. Naturv., Bd 29 (1884), p. 123; MALM, *Gbgs, Boh. Fna*, p. 641; WINTH., Naturh. Tidskr. Kbhvn, ser. 3, vol. XII, p. 62; MOR., *Hist. Nat. Poiss. Fr.*, tom. III, p. 618; STORM, N. Vid. Sels. Skr. Trondhj. 1883, p. 48; DAY, *Fish. Gt. Brit., Irel.*, vol. II, p. 366, tab. CLXXIX, fig. 4; PTRS, Vid. Meddel. Naturh. For. Kbhvn 1884—86, p. 160; RETZ., G. (*Amphioxus*), *Biol. Unters.*, N. F., vol. II, p. 29, tabb. XI—XIV; CAR. (*Branchiostoma*), *Prodr. Fna Medit.*, vol. II, p. 498.

Branchiostoma lubricum, COSTA, *Cenni Zool.* (1834), p. 49; *Fna Regn. Nap., Pesci*, part. II, tav. XXX; J. MÜLL., Abh. Akad. Wiss. Berl. 1842, Physik. Abh., p. 79.

Gasterobranchus glutinosus?, RASCH, Mag. Naturv. Chrnia, Bd 12 (1836), p. 325.

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[a] 8·9—10·6 % according to our measurements of specimens 43—48 mm. long.

[b] 5·8— 8·3 % according to our measurements

[c] 7·5— 8·8 % „ „ „ „

[d] 67 —71 % „ „ „ „

[e] 86·5—90 % „ „ „ „

The Lancelet attains in Scandinavia a length of about ½ dm. LILLJEBORG's largest specimens were 52 mm. long. According to CARUS it sometimes measures at least 70 or even 100 mm.[a] During life the body is of a jelly-like transparency; through the skin and muscles may be perceived the light green notochord, the somewhat darker caecum, and the stomach with intestine, the last-mentioned organs more or less dark according to the nature of their contents. In a certain light the skin appears somewhat iridescent, and a handsome appearance, as of a row of white, transparent rings, is presented by the plate-like rudimentary fin-rays. When the seminal or ovarial sacs are full, they are perceivable on each side as a series of white or green globules, the green egg-sacs each with a dark dot.

The habits of the Lancelet have been sketched above. Its breeding-time lasts throughout the summer; but in wet and chilly weather it does not spawn. THEEL obtained at the beginning of July a large number of specimens which were placed in the aquaria of Kristineberg and laid eggs that developed normally. At Haugesund in Norway LILLJEBORG received at the beginning of August specimens not yet quite ripe. On the west coast of France and in the Mediterranean the Lancelet commences spawning in March. According to HATSCHEK, as well as RAY LANKESTER and WILLEY, who made their observations in the well-known lagoon of Pontano, near Messina, the spawning always takes place in the evening, segmentation commencing between 7 and 8 p. m. At 11, say the latter writers, the gastrula begins to develop, and at 1 a. m. it is complete. At 3 a. m. it begins to revolve by cilia within the egg-membrane, and at 5 a. m. it already has two pairs of myocœlomic pouches, when it bursts the egg-membrane and becomes free-swimming. Thirty-six hours after the commencement of segmentation the embryo has acquired a mouth and a rudimentary gill-slit. Soon afterwards the anus opens, and the larval period now begins. The larvæ swim both at the surface, where MALM found them off Gasö Island (Bohuslän), and deeper down, at a depth of 15—20 fthms., according to RAY LANKESTER and WILLEY. Here they are found in countless myriads together with other minute marine creatures (*Noctilucæ*, *Beroë*, *Sagittæ*, *Calani*) and their larvæ, amongst that mass (HENSEN's *plankton*) which the Norwegians call *Aat*[b]. The development of the larva progresses much more slowly than that of the embryo. A fortnight is said to elapse before the formation of the second gill-cleft; and the remainder of the development, until the atrium is complete, and the Lancelet begins to bury itself in sand or mud, is said to take months (HATSCHEK). The course of the development is besides very irregular, and it may be so protracted, at least in the North, that Dr. C. W. AURIVILLIUS found larvæ 5 mm. long swimming freely at a depth of 15—30 m. below the surface of Gullmar Fjord, in the middle of November.

In its hiding-place at the bottom the Lancelet leads the life of the worms, and to escape danger it buries itself deeper down, for MALM remarks that, unless the dredge — the instrument most generally employed in the capture of marine animals at the bottom — takes a sufficient hold in the gravel, sand, or mud, there is little hope, even in places known to be frequented by the Lancelet, of securing a single specimen. Few fishes are so tenacious of life; and even if the body be cut into pieces, the ciliary motion does not cease at once in the severed parts. In salt water changed from time to time, it may be kept alive for months; and LILLJEBORG relates that a number of Lancelets which he had dredged up at Haugesund on the 2nd of August, in a quantity of shellsand, and thrown on the dry rock, were alive three days afterwards, though the moisture of the sand was not very great, and though rain had fallen in the interval. In spite of the sluggish life it usually leads, the Lancelet is quick of movement when disturbed, wriggling about in the aquarium like a young Eel, but with either end foremost. Its endurance is not great, however; if the observer should desire to induce the captive to lie still for examination, it may easily be tired out, and it will then suffer itself without more ado to be conveyed where a closer view may be obtained, provided only that it has no soft bottom in which to hide itself. In the day-time it lies motionless. At night it moves about; but if a light be brought near the aquarium, it hastens to conceal itself. As human food it is worthless; but it has enemies, no doubt, in plenty.

[a] CARUS, however, combines this species with the Pacific *Branchiostoma*, and his account of Lancelets 1 dm. long may perhaps depend on that fact.

[b] See above, pp. 970, 971.

Bih. Vet. Akad. Handl., Bd 20, Afd. IV, No. 3, p. 11

The Lancelet was first described in 1774 by PALLAS, who had received a specimen from the Cornish coast. He took the ventral side between the metapleures to be a creeping-disk, and therefore referred the animal to the genus *Limax*. His figure was copied in Pl. 80, among the *vers mollusques*, in the *Encyclopédie Méthodique;* but the Lancelet remained otherwise unknown for nearly sixty years. The species was then rediscovered at no great intervals of time in four localities, and was shown to be a fish. COUCH found it in 1831 on the shore near Polperro, RASCH in 1833 on the Norwegian coast, COSTA in 1834 at Naples, and FR. SUNDEVALL and S. LOVÉN in the same year on the Weather Islands (Bohuslän). In 1838 our figure was painted by v. WRIGHT for FRIES, with a view to a description which death prevented the latter from completing. The specimens collected by FRIES, however, came into the hands of C. J. SUNDEVALL, his successor at the Royal Museum, and ANDERS RETZIUS, and suggested the first scientific examination of the fish, an undertaking which was carried out on the coast of Bohuslän in RETZIUS's company by JOHANNES MÜLLER. In later times the most important contributions to our knowledge of the Lancelet have come from Messina and the Zoological Station at Naples. On the west coast of France and the English coast the species is also common enough in suitable localities, on a bottom of sand and gravel, preferably shell-sand, from the tide-mark to a depth of some tens of fathoms. In Scandinavian waters it is dispersed from Trondhjem Fjord (STORM) and along Southern Norway into the Cattegat, where it is commonest, according to WINTHER, in 5—9 fathoms of water, but has also been found at a depth of $17^1/_2$ fathoms. The southern limit of its known range in Scandinavia is the north of the Sound, at Hellebæk in Zealand (LÜTKEN) and on both sides of Samsö, between Zealand and Jutland. On the coast of Bohuslän it is plentiful, according to MALM and THÉEL, in the fine shell-sand of the eastern harbour on Storö, one of the Weather Islands, where it was found first by LOVÉN and SUNDEVALL. THÉEL found numerous specimens of the Lancelet on the skerry of Bonden, and MALM a few on Flatholm, several on Gåsö (all three localities at the entrances of Gullmar Fjord), and a few on Paternoster Skerry, north of Marstrand. The specimens collected on Bonden by THÉEL at the end of June, 1894, were kept for some days at Kristineberg in a glass bowl with fine sand at the bottom, before being sent alive to the Royal Museum. In the meantime (till the 30th of June) they had deposited quantities of eggs, which had already attained or passed the gastrula stage. Some days afterwards larvæ $1^1/_2$ mm. long were taken in the aquarium, their stage of development being that shown above in fig. 375. Afterwards numerous larvæ $3^1/_2$—5 mm. long were caught, at the stages represented in our figures 376 and 379, swimming freely in the sea at Kristineberg, close up to the jetties on the shore, at a depth of 1—4 fthms. below the surface. These larvæ too were forwarded without difficulty alive to the Royal Museum.

INDEX.

Ia, 859.

jacksoniensis (Regalecus, Trachypterus), 314.

Kabeljaauw, 476.

Errata.

Page 594, column 2, line 12 from above: *commensual*, read *commensal*

Page 623, column 2, line 23 from above: *aponeuros*, read *aponeurosis*

Page 1031, column 1, line 23 from above: 6—8 mm. (quoted from JACOBY) should probably be 6—8 cm., so note *c* on the following page should be omitted.

Plate XXVIII.

Figs. 1 and 2: *Three-spined Stickleback* (*Gasterosteus aculeatus*), nat. size, fig. 1, ♀, in winter-dress; fig. 2, ♂, in summer-dress; figures without any indication of locality, but specimens probably from the Baltic.

Figs. 3 and 4: *Ten-spined Stickleback* or *Tinker* (*Gasterosteus pungitius*), nat. size; fig. 3, ♀, in summer-dress, from Haparanda (N. Baltic), June, 1832; fig. 4, ♂, black dress.

Fig. 5: *Fifteen-spined Stickleback* (*Gastræa spinachia*), $^{7}/_{10}$ nat size, specimen probably from the Baltic.

Figs. 6—8: *Lesser Pipefish* (*Syngnathus rostellatus*), three specimens caught at the surface of the sea in Koster Fjord (Bohuslän), July, 1887; figs. 6—8, *a*, nat. size; fig. 8, *b* from the same specimen as fig. 8, *a*, but × 2.

Plate XXIX.

Fig. 1: *Deep-nosed Pipefish* (*Syngnathus typhle*), ♀, 1₁
painted from living specimen in Bohuslän, on the 30th of June, 1837.

Fig. 2: *Æquoreal Pipefish* (*Nerophis æquoreus*), ♀, $^{1}/_{2}$ nat. size, from Bohuslän, 1833.

Fig. 3: *Straight-nosed Pipefish* (*Nerophis ophidion*), ♀, nat. size, probably from the Baltic.

Fig. 4: *Worm Pipefish* (*Nerophis lumbriciformis*), ♂, nat. size, from Bohuslän; fig. 4, *a*, fry of this species, × 3, see Vet. Akad. Handl., 1837, pl. IV.

Plate XXX.

Fig. 1: *Sheatfish* (*Silurus glanis*), ♂, $^{1}/_{8}$ nat. size, caught in Lake Båfven (Södermanland), on the 24th of May, 1889.

Figs. 2 and 3: *Crucian Carp* (*Cyprinus carassius*), ♂♂ from Mörkö (in the Baltic); fig. 2, *Lake Crucian Carp*, $^{7}/_{10}$ nat. size; fig. 3, *Pond Crucian Carp* (= *Cyprinus gibelio*, Bl.), nat. size.

Plate XXXI.

Fig. 1: *Carp* (*Cyprinus carpio*), of the variety *Mirror Carp*, $^1/_3$ nat. size, from Lake Mälar, June, 1888.

Fig. 2: *Goldfish* (*Cyprinus auratus*), nat. size, cultivated and purchased in Stockholm, April, 1891.

Fig. 3: *Gudgeon* (*Gobio fluviatilis*), ♀, nat. size, from Lake Finja (Scania), painted from living specimen on the 13th of June, 1891.

Fig. 4: *Spined Loach* (*Cobitis tænia*), ♀, nat. size, from the River Skena (Ostrogothia), 1842.

Fig. 5: *Loach* (*Cobitis barbatula*), ♀, nat. size, from Finland

Plate XXXII.

Fig. 1: *Ide* (*Leuciscus idus*), ♂, $^1/_2$ nat. size, from the Baltic.

Fig. 2: *Dace* (*Leuciscus grislagine*), nat. size, from the north of Sweden.

Fig. 3: *Chub* (*Leuciscus cephalus*), $^7/_{10}$ nat. size, from the River Motala, at Norrköping.

Plate XXXIII.

Fig. 1: *Roach* (*Leuciscus rutilus*), ♂, nat. size, probably from the neighbourhood of Stockholm.

Fig. 2: *Rudd* (*Scardinius erythrophthalmus*), $^7/_{10}$ nat. size, probably from the same locality.

Fig. 3: *Minnow* (*Phoxinus aphya*), ♂ and ♀, nat. size, probably from the same locality.

Plate XXXIV.

Fig. 1: *Zope* (*Abramis ballerus*), $^1/_2$ nat. size, figure without any annotation on locality, but specimen probably from Lake Mälar.

Fig. 2: *Bream* (*Abramis brama*), ♂, $^1/_2$ nat. size, probably from the neighbourhood of Stockholm.

Plate XXXV.

Fig. 1: *Ide* (*Cyprinus idus*), young specimen, nat. size, from Mörkö (in the Baltic), type-specimen for *Cyprinus microlepidotus*, Ekström.

Fig. 2: *White Bream* (*Abramis blicca*), ♀, nat. size, probably from Lake Mälar.

Fig. 3: *Zärthe* (*Leucabramis vimba*), ♂, 1/2 nat. size, caught in the River Motala, at Norrköping, on the 28th of June, 1834.

Plate XXXVI.

Figs. 1 and 2: *Asp* (*Aspius rapax*), 1/4 nat. size; ♂ (fig. 1), from Lake Mälar; ♀ (fig. 2), from the Baltic island-belt off Stockholm.

Fig. 3: *Bleak* (*Alburnus lucidus*), nat. size, probably from the neighbourhood of Stockholm.

Plate XXXVII.

Figs. 1 and 2: *Charr* (*Salmo umbla*), 1/3 nat. size, ♂ (fig. 1) and ♀ (fig. 2), caught in the north part of Lake Wetter, on the 23rd of October, 1885.

Figs. 3 and 4: *Salmon* (*Salmo salar*), 1/5 nat. size, ♀ (fig. 3) and ♂ (fig. 4), in the beginning of the spawning-time, at Elfkarleby (R. Dal); figures from H. Widegren's posthumous papers.

Plate XXXVIII.

Fig. 1: *Salmon* (*Salmo salar*), 1/6 nat. size, ♂ in sea-dress, probably from Norrköping.

Fig. 2: *Silver Salmon* (*Salmo salar*, var. *trutta*), 1/2 nat. size, sterile specimen from Lake Wetter.

Fig. 3: *Tajmen* (*Salmo salar*, var. *trutta*), figure labelled by W. v. Wright: "Tajmen from Torneå".

PLATE XXXIX.

Figs. 1 and 2: *Trout* (*Salmo salar*, var. *trutta*), ♀ (fig. 1), $^{5}/_{18}$ nat. size, and ♂ (fig. 2), $^{1}/_{2}$ nat. size, in the beginning of the spawning-time, at Elfkarleby (River Dal); figures from H. WIDEGREN's posthumous papers.

Fig. 3: *Sea Trout* (*Salmo salar*, var. *trutta*), ♀ in fresh-water dress.

PLATE XL.

Fig. 1: *Parr* (*Salmo salar*, juv.), nat. size.

Fig. 2: *Forell* (*Salmo salar*, var. *trutta*, juv.), nat. size.

Fig. 3: *Trout* (*Salmo salar*, var. *trutta*), $^{5}/_{16}$ nat. size, from Bohuslän.

PLATE XLI.

Fig. 1: *Smelt* (*Osmerus eperlanus*), nat. size, probably from the outlet of Lake Mälar, at Stockholm.

Figs. 2 and 3: *Capelin* (*Mallotus villosus*), nat. size, ♂ (fig. 2) and ♀ (fig. 3), from Trondhjem Fjord, April, 1892.

Fig. 4: *Tench* (*Tinca vulgaris*), ♂, $^{7}/_{10}$ nat. size, probably from Södermanland.

PLATE XLII.

Fig. 1: *Grayling* (*Thymallus vulgaris*), $^{1}/_{2}$ nat. size.

Fig. 2: *Vendace* (*Coregonus albula*), ♀, $^{1}/_{2}$ nat. size, from Savolax, Kalavesi (Finland).

Figs. 3 and 4: *Gwyniad* (*Coregonus lavaretus*) in two varieties: *Blue Gwyniad* (fig. 3), $^{3}/_{4}$ nat. size, caught in Lake Lax (Dalsland), in the month of December; *Gray Gwyniad* (fig. 4), $^{1}/_{2}$ nat. size, in spawning dress, from unknown locality.

Plate XLIII.

Fig. 1: *Common Herring* (*Clupea harengus*), $^3/_4$ nat. size, from Bohuslän, January, 1887.

Fig. 2: *Shad* (*Clupea alosa*), ♀, $^1/_2$ nat. size, from Bohuslän, June, 1887.

Plate XLIV.

Fig. 1: *Baltic Herring* (*Clupea harengus*, var. *membras*), ♂, nat. size, caught at Vaxholm (island-belt of Stockholm) on the 16th of May, 1889.

Fig. 2: *Sprat* (*Clupea sprattus*), nat. size, probably from Bohuslän.

Fig. 3: *Boreal Pearl-side* (*Maurolicus Mülleri*), nat. size, from Bohuslän.

Fig. 4: *Pike* (*Esox lucius*), $^1/_2$ nat. size, from unknown locality.

Plate XLV.

Fig. 1: *Common Eel* (*Anguilla vulgaris*), $^1/_2$ nat. size.

Fig. 2: *Conger* (*Conger vulgaris*), $^1/_3$ nat. size, from a depth of 60 fathoms, in Koster Fjord (Bohuslän), on the 13th of February, 1888.

Plate XLVI.

Fig. 1: *Common Sturgeon* (*Acipenser sturio*), ♂, $^1/_8$ nat. size, caught in the Baltic, at Dalarö, on the 18th of June, 1890.

Figs. 2 and 3: *Northern Chimæra* (*Chimæra monstrosa*), $^1/_4$ nat. size; ♂ (fig. 2), caught in Trondhjem Fjord, on the 4th of March, 1891; ♀ (fig. 3), from Säcke Fjord (N. Bohuslän). Below the last figure the left pectoral and ventral fins of the female specimen are to be seen, from above.

Plate XLVII.

Figs. 1 and 2: *Thornback* (*Raja clavata*), from Bohuslän; ♀ (fig. 1), $^1/_3$ nat. size; ♂ (fig. 2), $^1/_4$ nat. size.

Fig. 3: *Starry Ray* (*Raja radiata*), ♀, $^1/_3$ nat. size, from Bohuslän.

Plate XLVIII.

Common Skate (*Raja batis*), ♀ (fig. 1), $^1/_4$ nat. size, from the North Sea, on the 9th of December, 1891, dorsal and ventral aspects; ♂ (fig. 2), $^1/_6$ nat. size, light-spotted variety, from Gullmar Fjord (Bohuslän).

Plate XLIX.

Long-nosed Skate (*Raja oxyrhynchus*), ♂, $^1/_6$ nat. size, caught in Koster Fjord (N. Bohuslän), on the 14th of November, 1889; dorsal and ventral aspects.

Plate L.

Fig. 1: *Shagreen Skate* (*Raja fullonica*), ♀, $^1/_5$ nat. size, from Bohuslän; ventral aspect.

Fig. 2: *Tope* (*Galeorhinus galeus*), ♂, $^1/_5$ nat. size, from Bohuslän.

Fig. 3: *Blue Shark* (*Carcharias glaucus*), fœtus, $^2/_3$ nat. size, from the Indian Ocean.

Plate LI.

Fig. 1: *Porbeagle* (*Isurus cornubicus*), ♀, $^1/_6$ nat. size, from Bohuslän.

Fig. 2: *Black-mouthed Dog-fish* (*Pristiurus catulus*), ♀, $^1/_3$ nat. size, specimen caught in Ramsö Fjord (N. Bohuslän), on the 25th of September, 1889.

Fig. 3: *Sagre* (*Etmopterus spinax*), ♂, $^1/_2$ nat. size, specimen caught at a depth of 40—50 fathoms, in Strömstad Fjord, on the 10th of November, 1881.

Fig. 4: *Rough Hound* (*Scylliorhinus canicula*), ♀, $^3/_{10}$ nat. size, from the North Sea, 4th November, 1889.

Plate LII.

Fig. 1 and 2: *Picked Dog-fish* (*Squalus acanthias*), from Bohuslän; ♂ (fig. 1), $^1/_4$ nat. size, caught in the month of November, 1886; ♀ (fig. 2), $^1/_5$ nat. size.

Fig. 3: *Greenland Shark* (*Acanthorhinus carcharias*), ♀, $^1/_{18}$ nat. size, from Bohuslän.

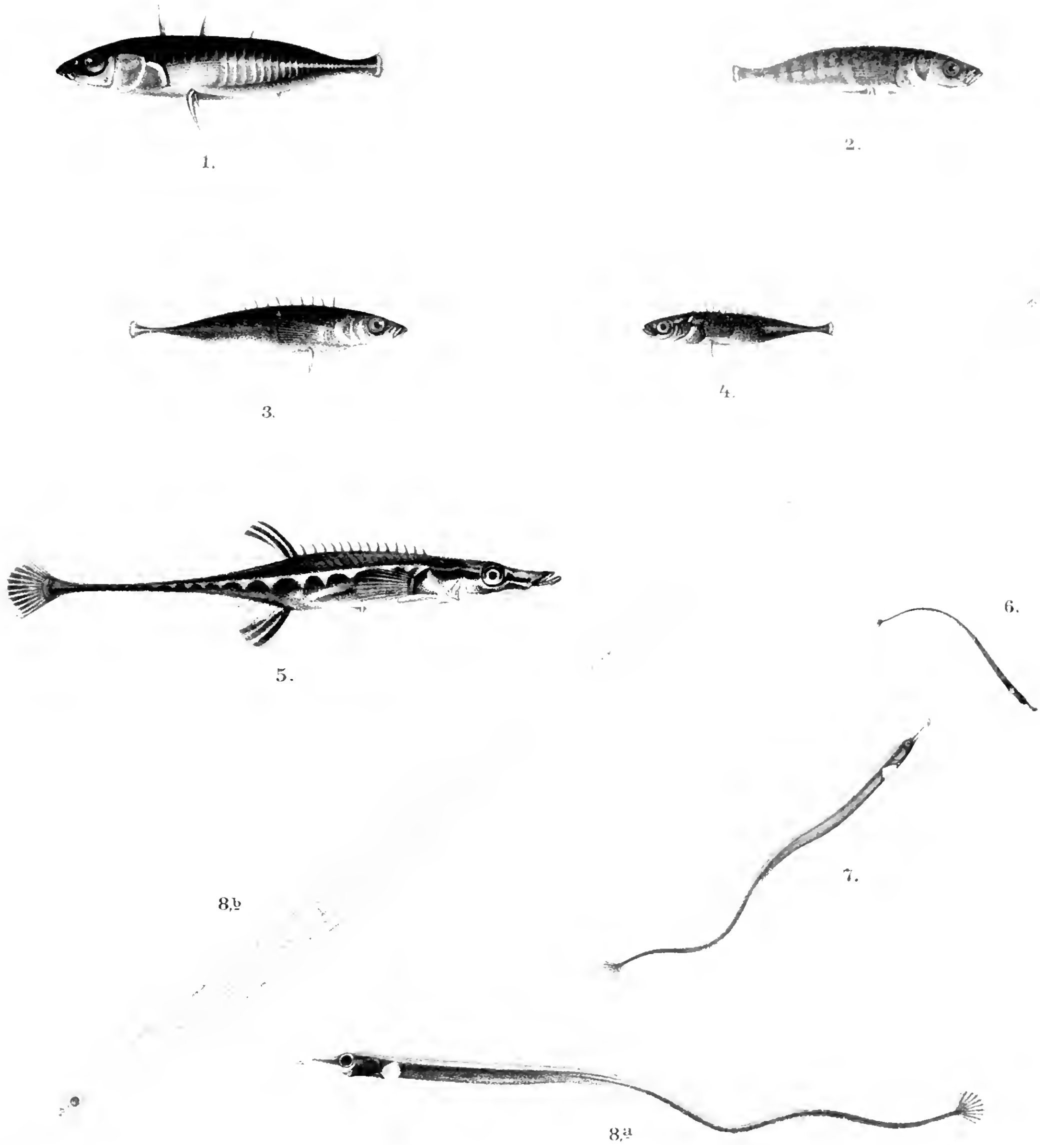
Plate LIII.

Fig. 1: *Lamprey* (*Petromyzon marinus*) ♀, $^1/_3$ nat. size, caught at Ringkjöbing (Jutland), on the 19th of May, 1890.

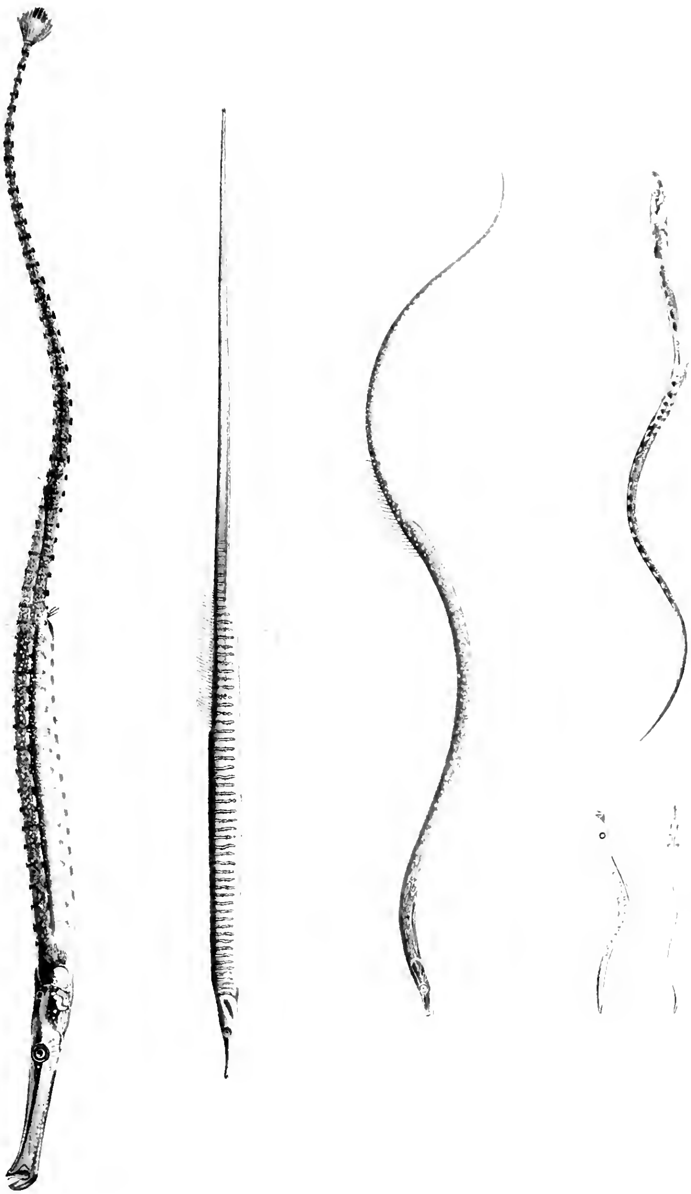
Fig. 2—4: *Lampern* (*Petromyzon fluviatilis*), from Elfkarleby (River Dal), caught early in October, 1891. Fig. 2: adult ♀, $^1/_2$ nat. size; below the figure may be seen the oral (sucking) disk, nat. size, with its teeth: *at*, anterior (maxillary) teeth; *pt*, posterior (mandibulary) teeth; *alt*, anterior, *mlt*, middle and *plt*, posterior lateral teeth; *aln*, anterior lingual teeth; *est*, external and *ist*, internal suctorial teeth. Figs. 3 and 4: two larvæ (Prides, *Ammocœtes*) caught together with the preceding specimen.

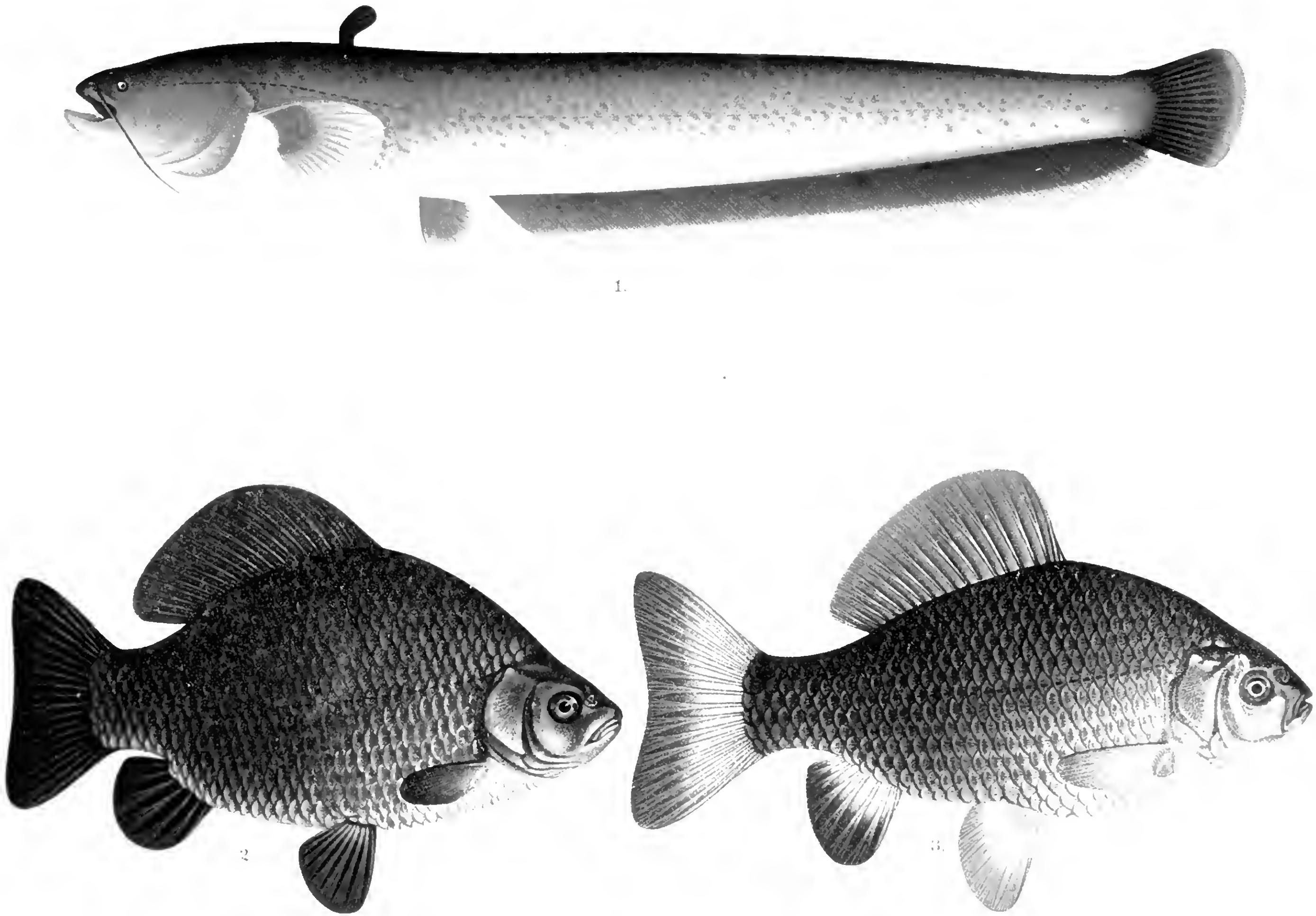
Fig. 5: *Glutinous Hag* (*Myxine glutinosa*), $^3/_4$ nat. size, from Bohuslän.

Fig. 6: *Lancelet* (*Branchiostoma lanceolatum*), nat. size, from Bohuslän, 23rd May, 1838.

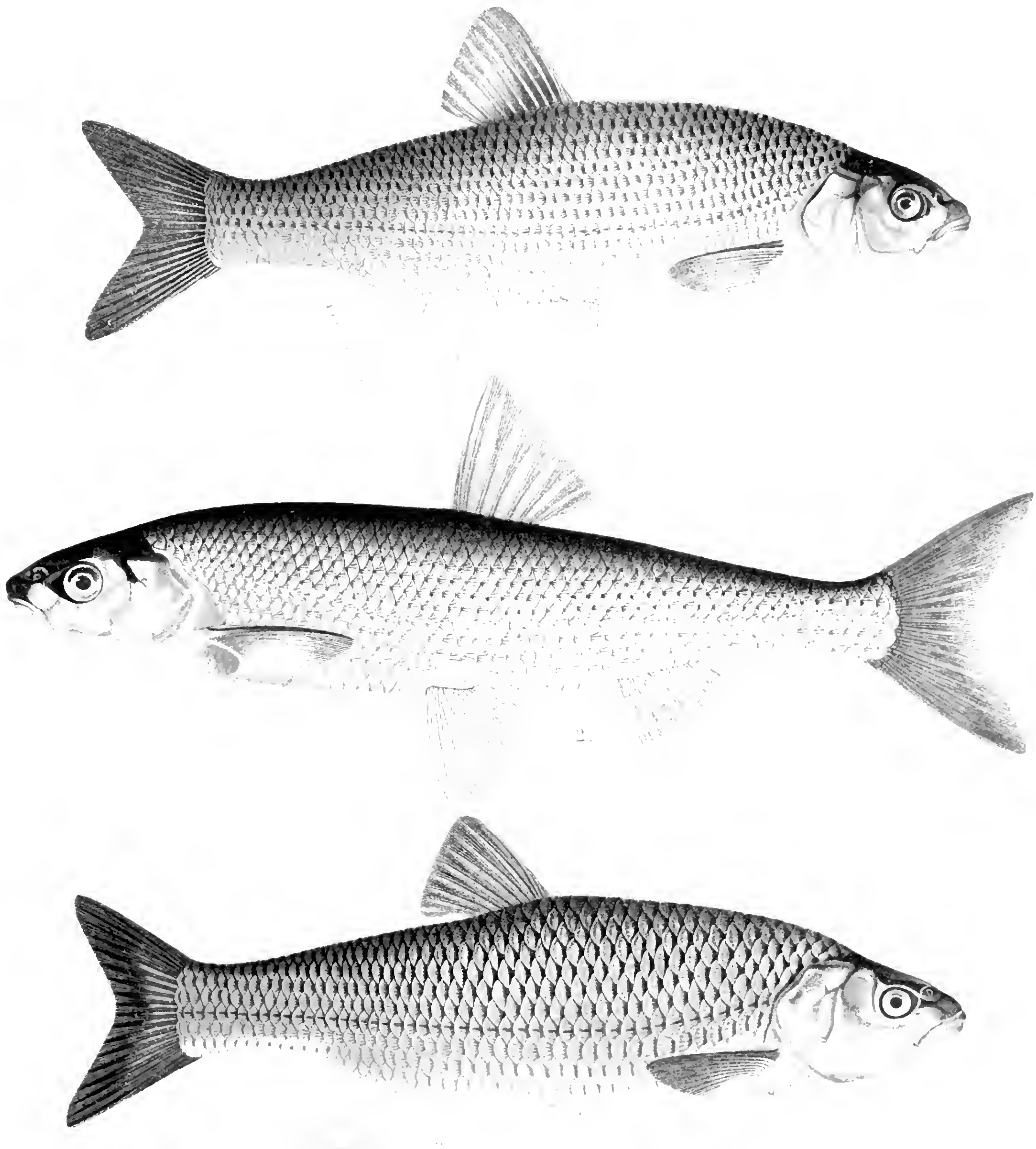


1 et 2: Gasterosteus aculeatus; 3 et 4: Gast. pungitius; 5: Spinachia vulgaris; 6–8: Syngnathus acus.

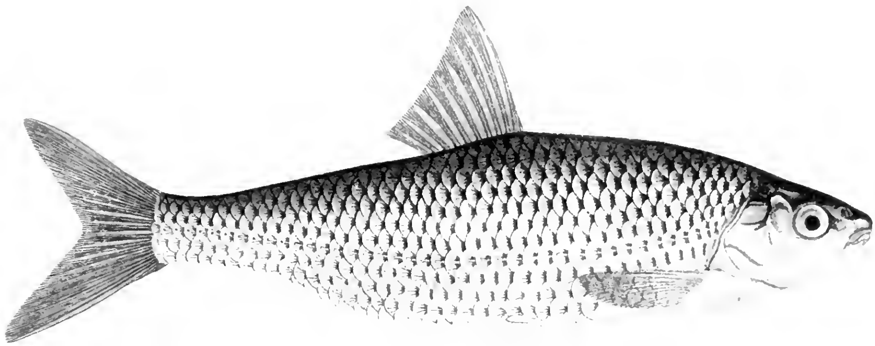




1: Silurus glanis, 2 et 3: Cyprinus carassius



1: Leuciscus idus; 2: Leuciscus grislagine; 3: Leuciscus cephalus.



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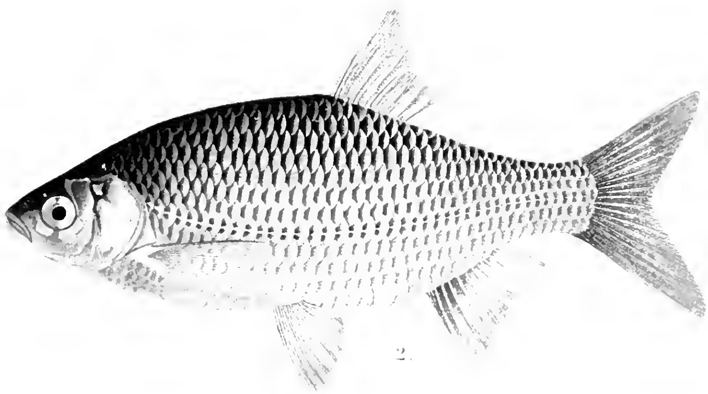

2.

3.

1: Leuciscus rutilus; 2: Leuciscus erythrophthalmus; 3. Phoxinus aphya.

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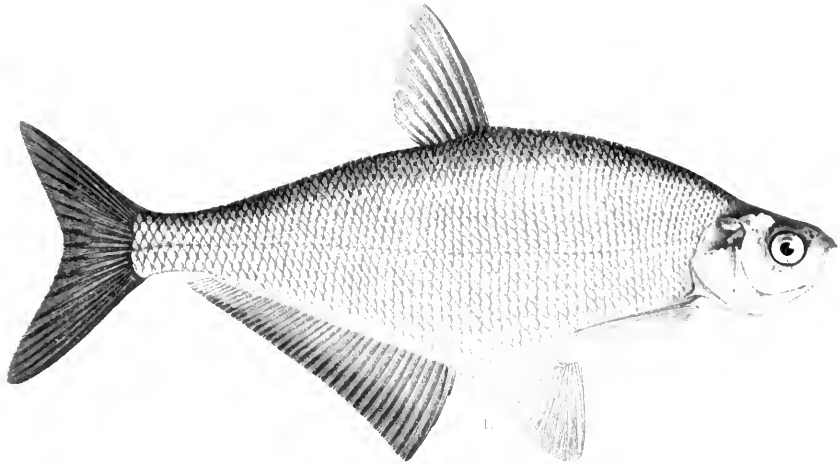

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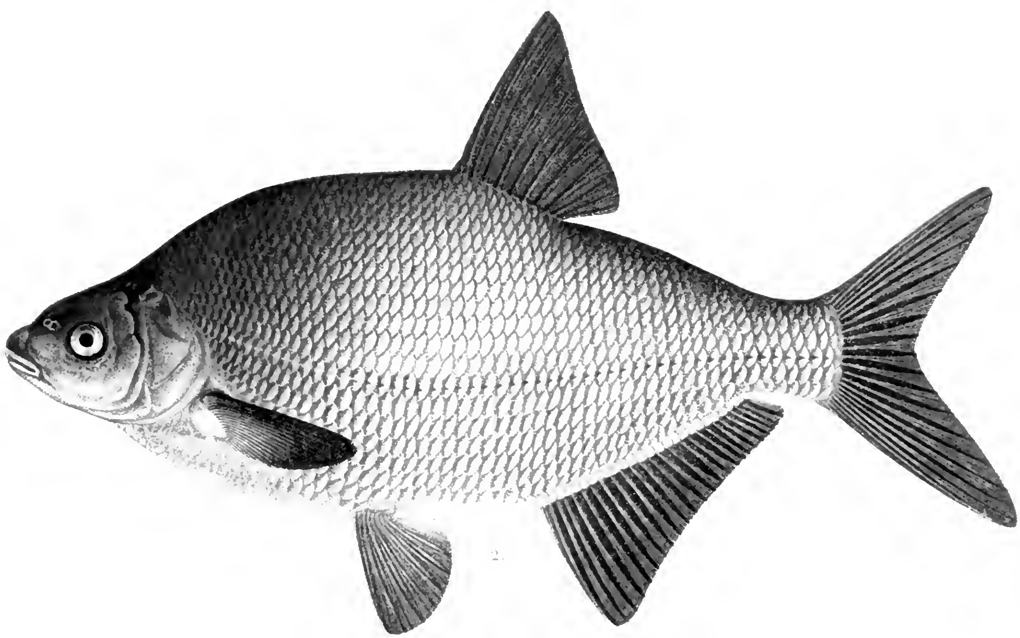
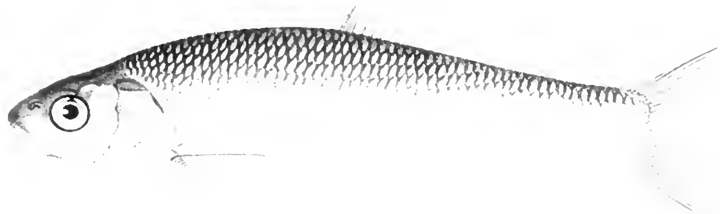
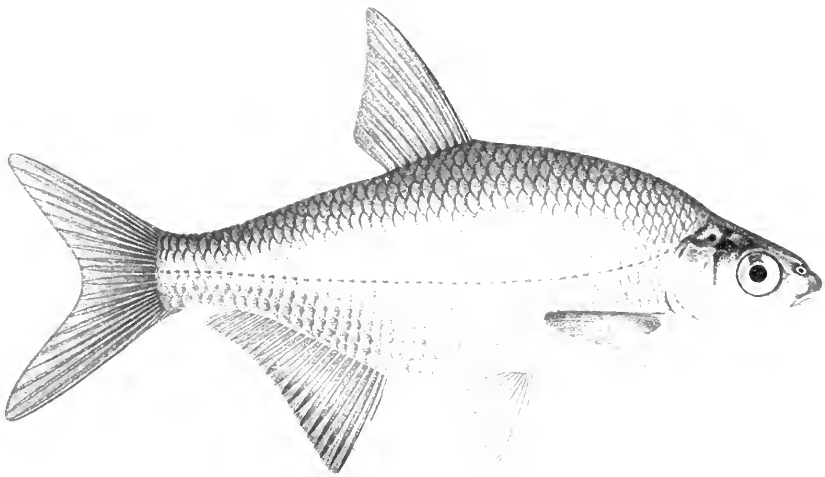
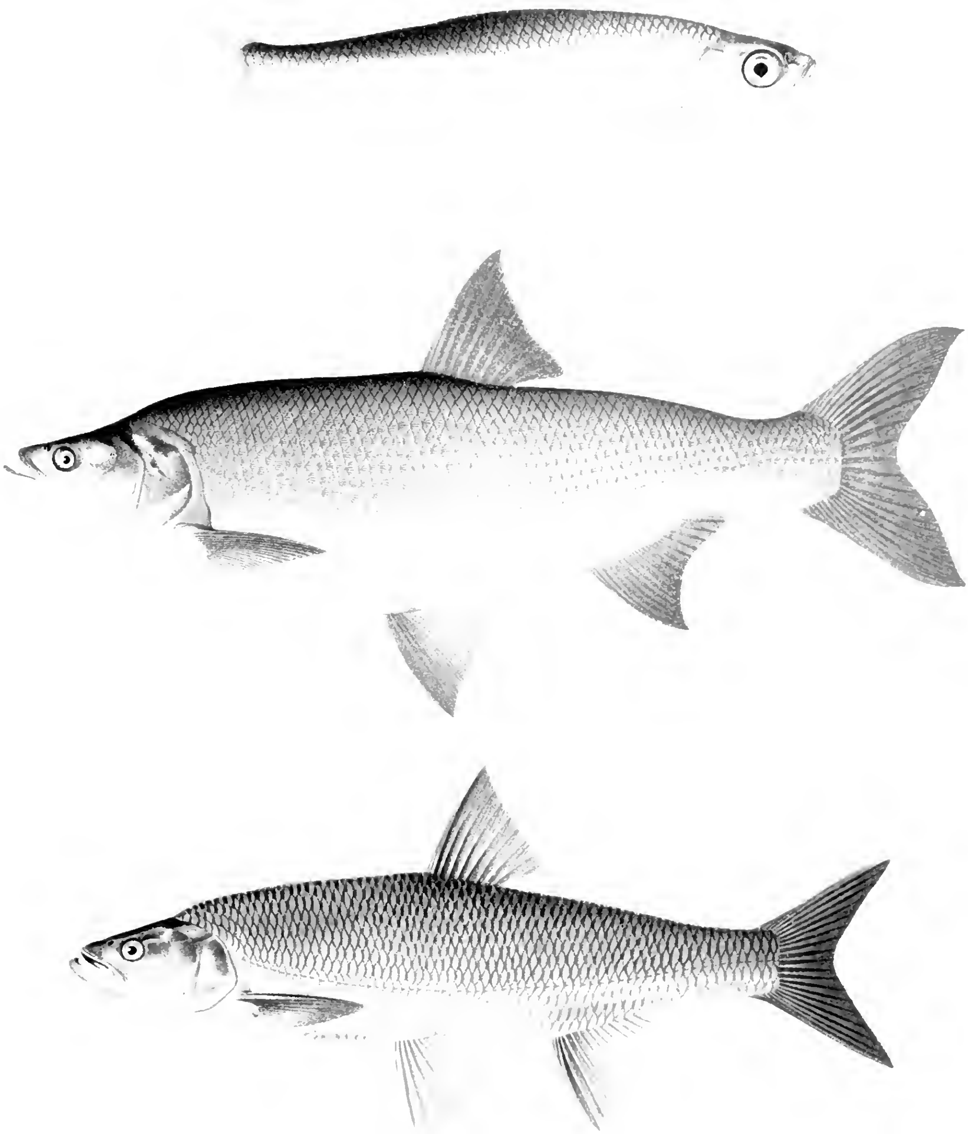


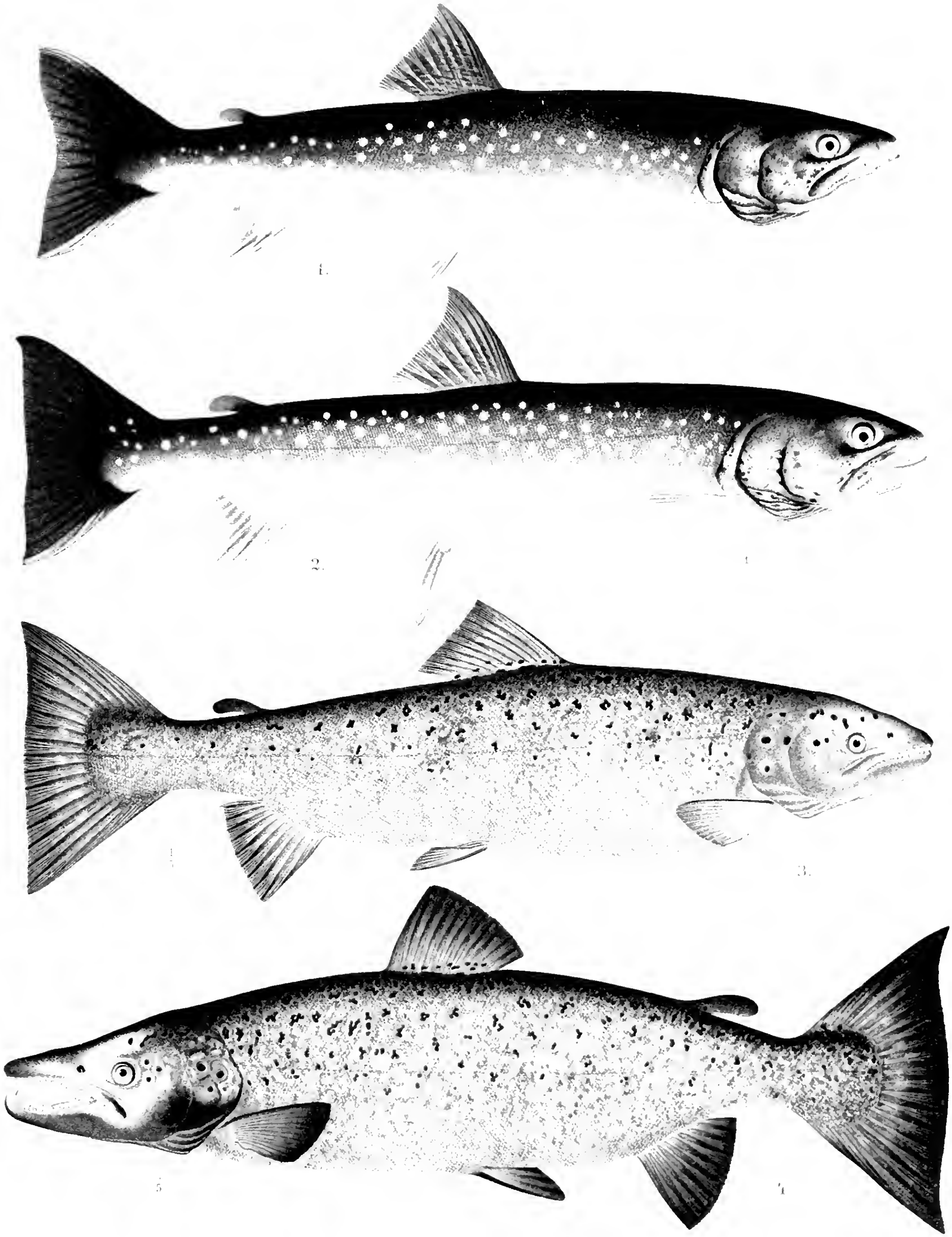
2.

1. Abramis ballerus 2. Abramis brama

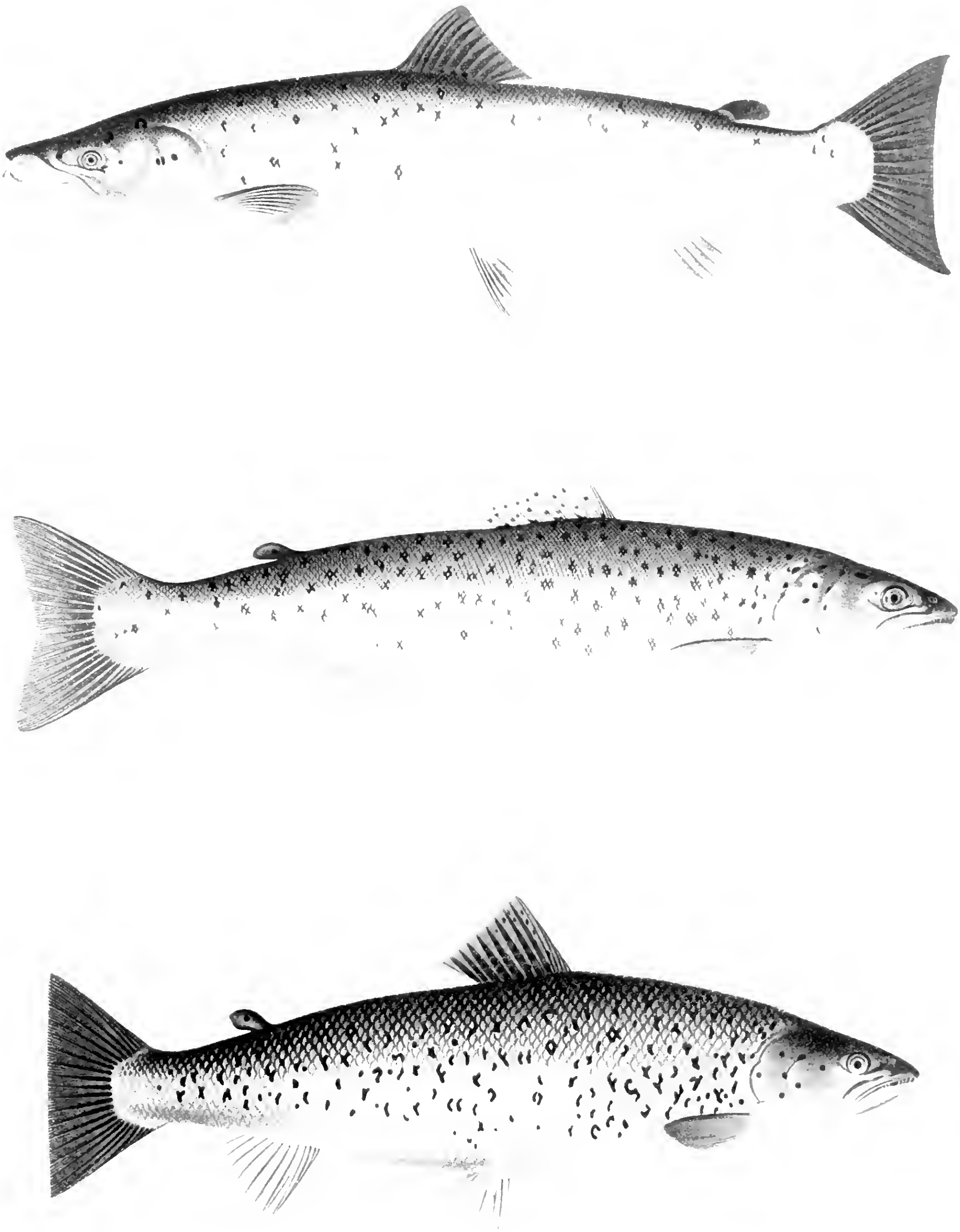


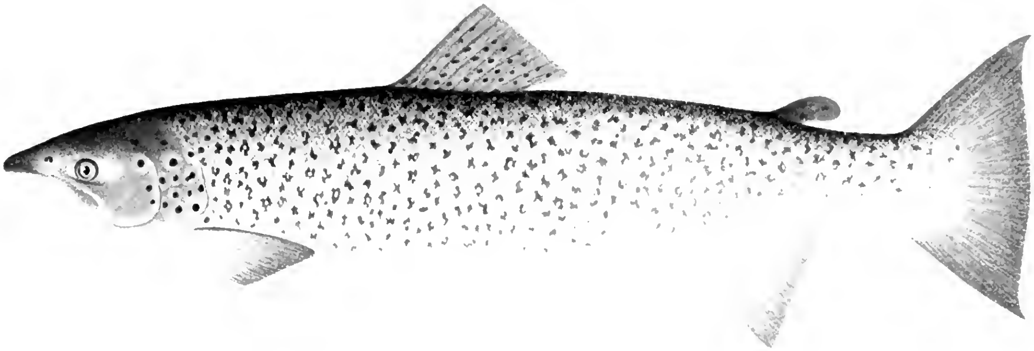


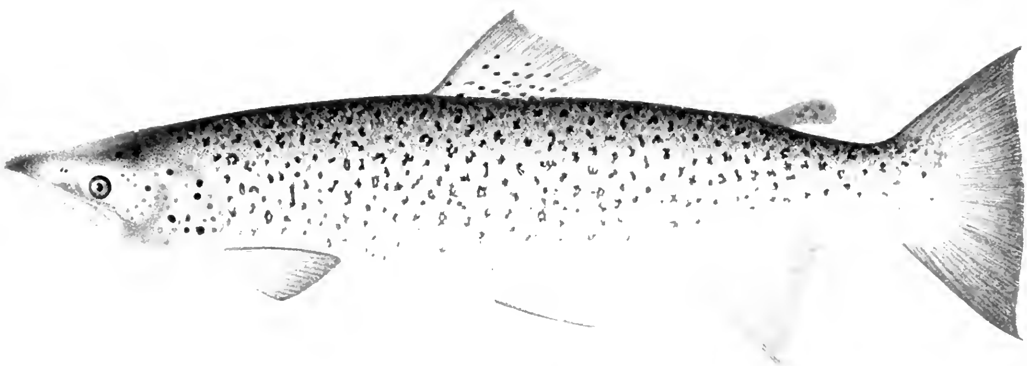


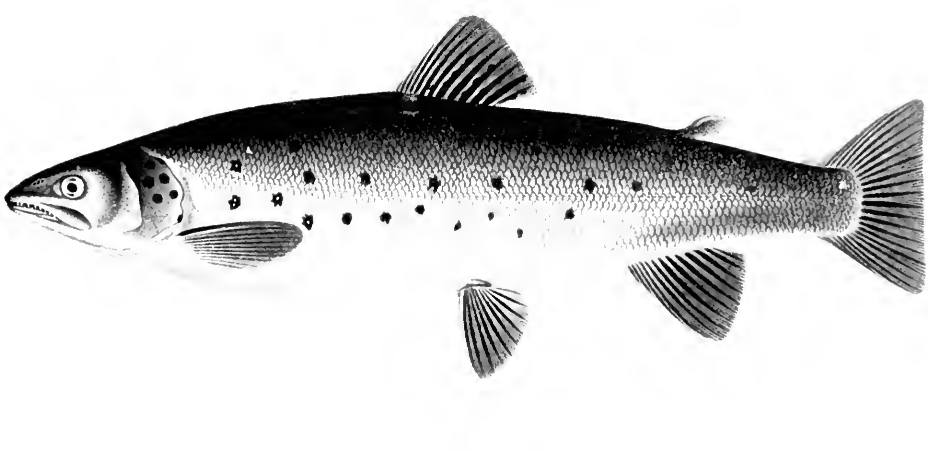


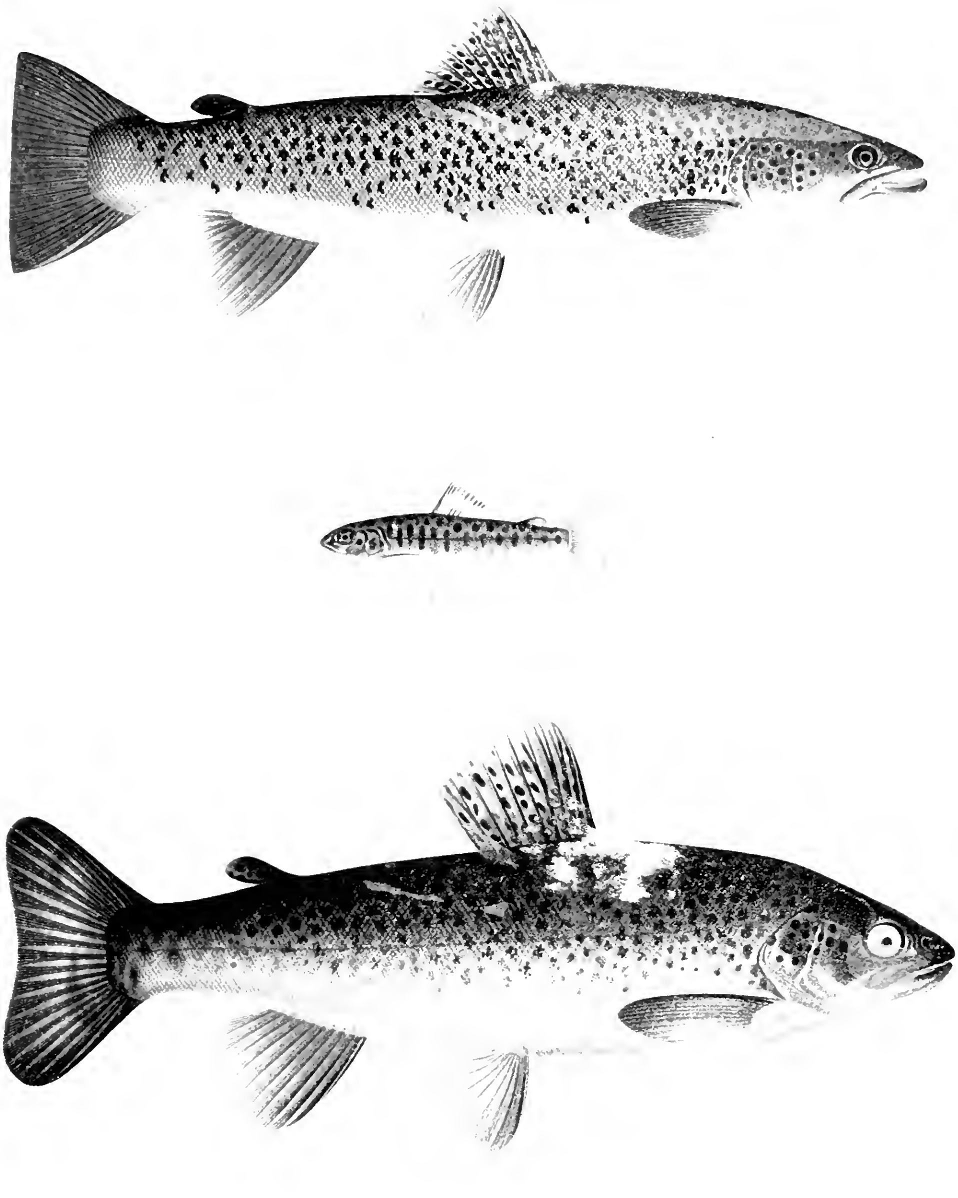
1 et 2 Salmo umbla (salvelinus) 1 2. 3 et 4 Salmo salar (nobilis 3 4.

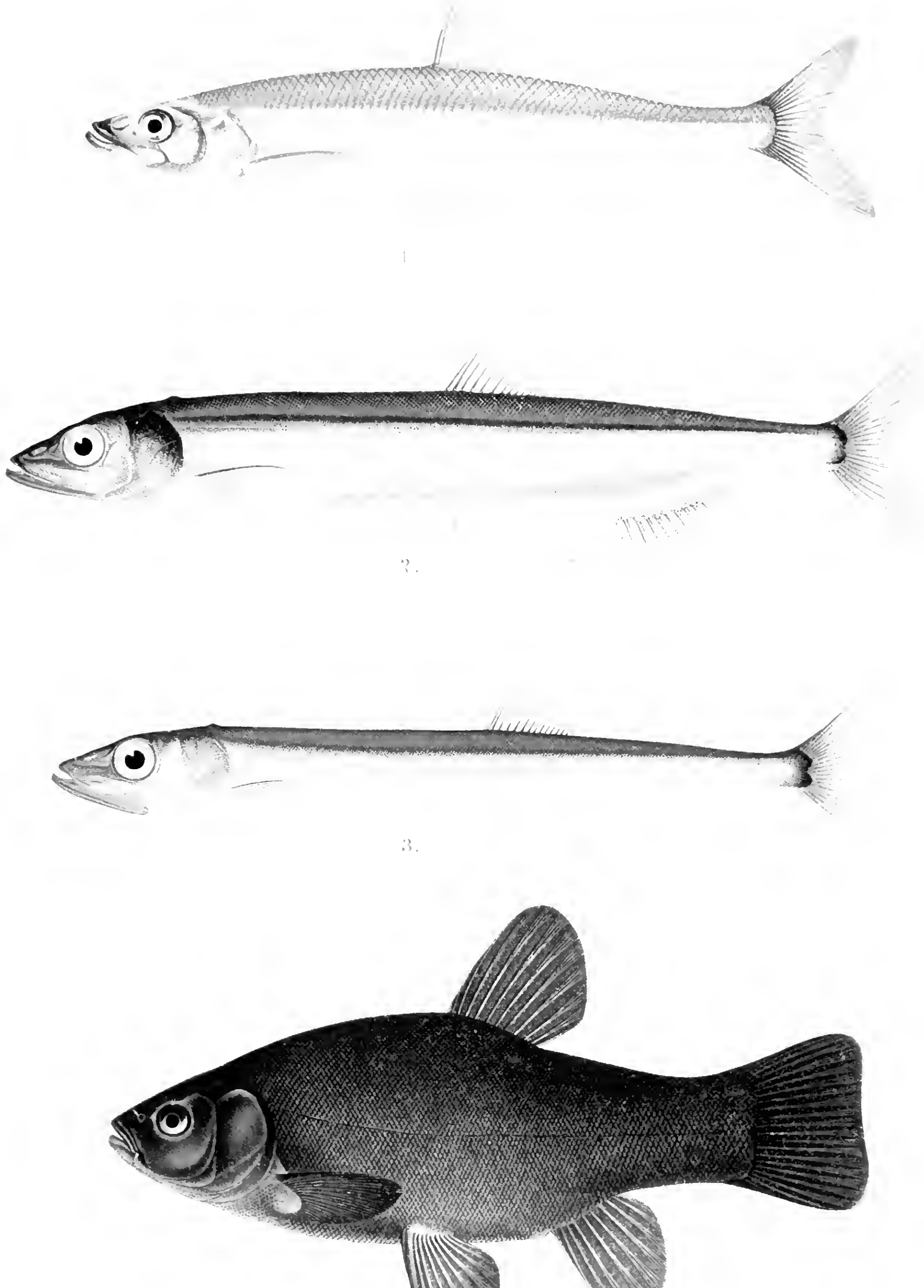




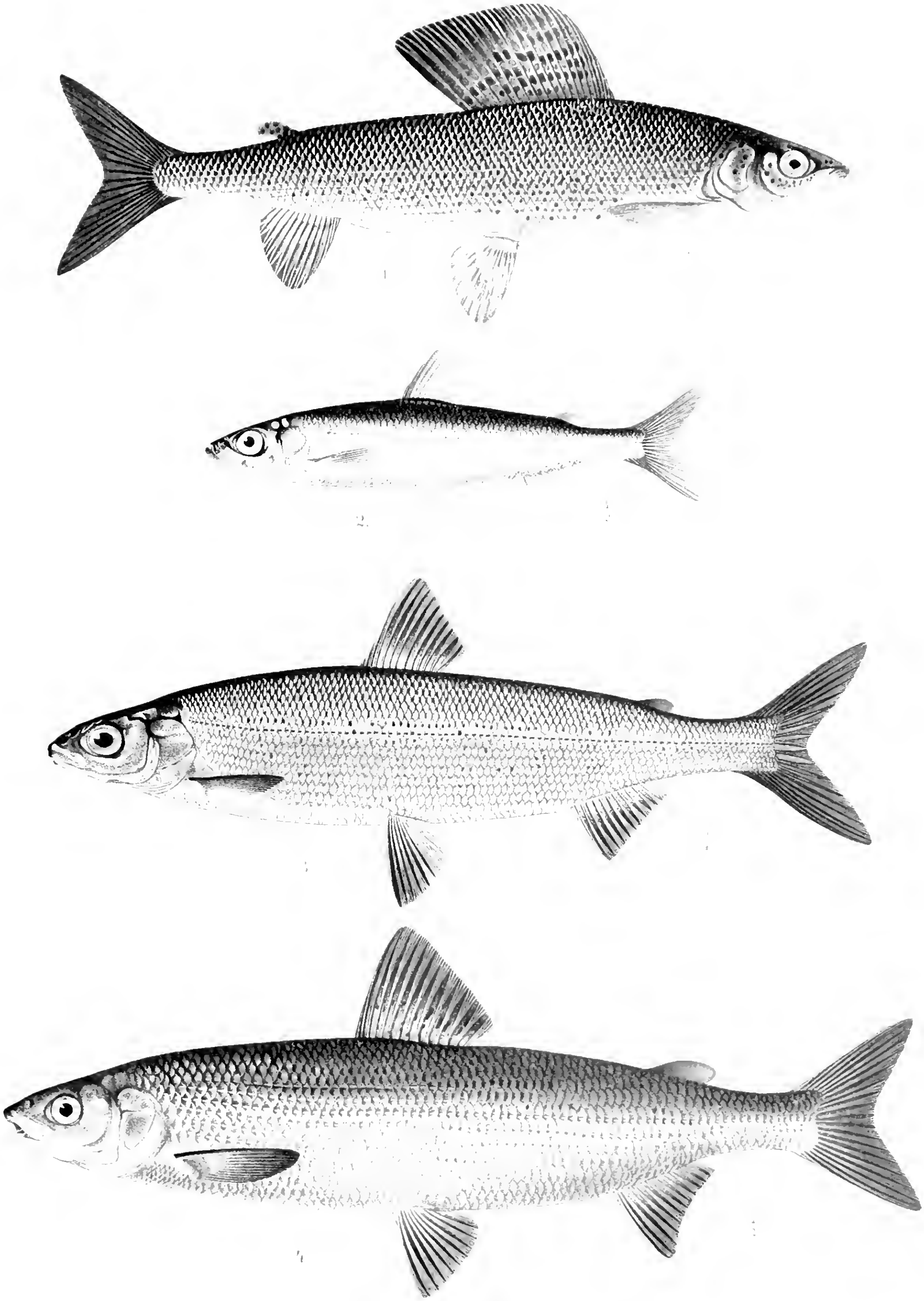






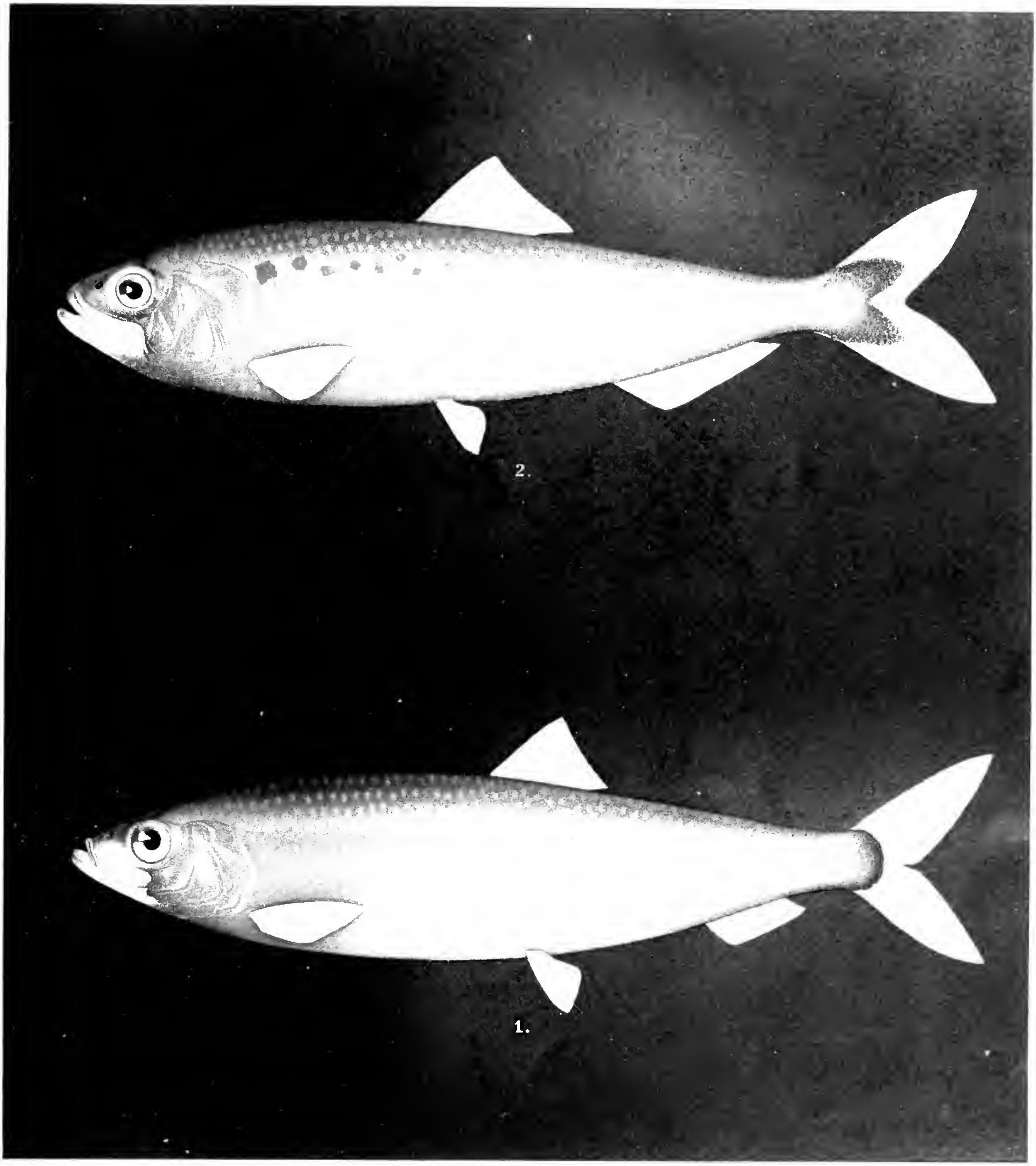


1. Osmerus eperlanus. 2 & 3. Mallotus villosus. 4. Tinca vulgaris.

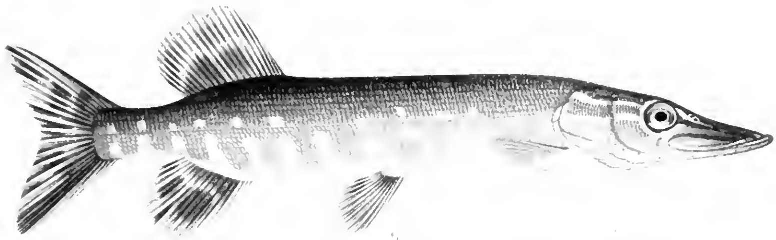


1. Thymallus vulgaris. 2. Coregonus albula. 3 et 4. Coregonus lavaretus.

W. v. Wright pinx.

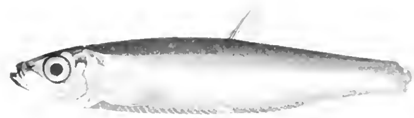


1 Clupea harengus 2 Clupea Alosa



4.

3.



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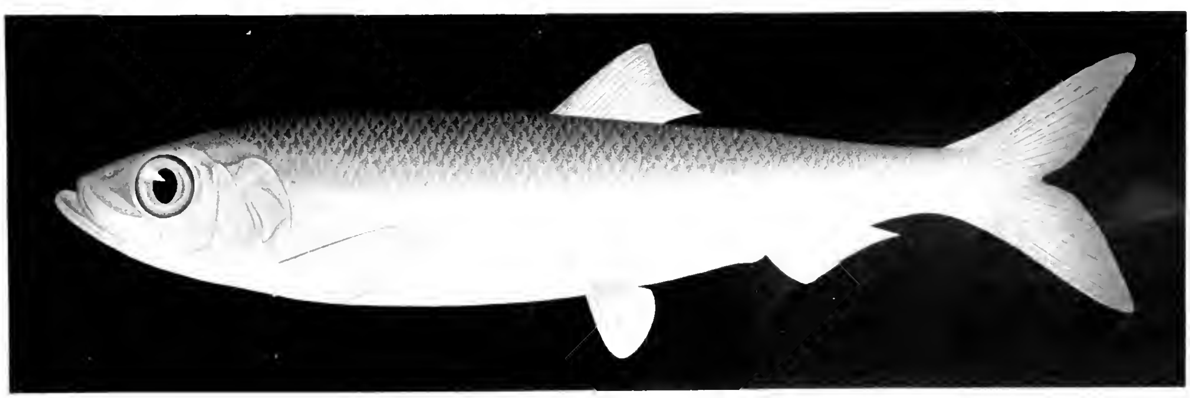
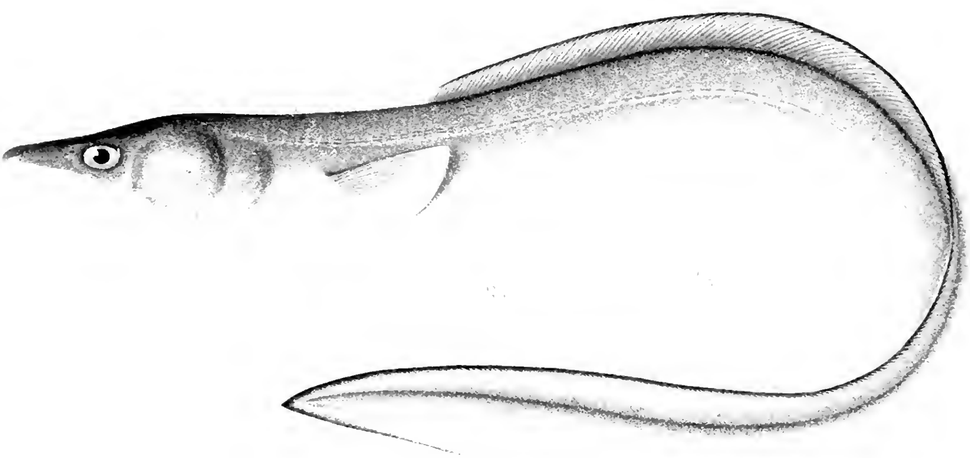
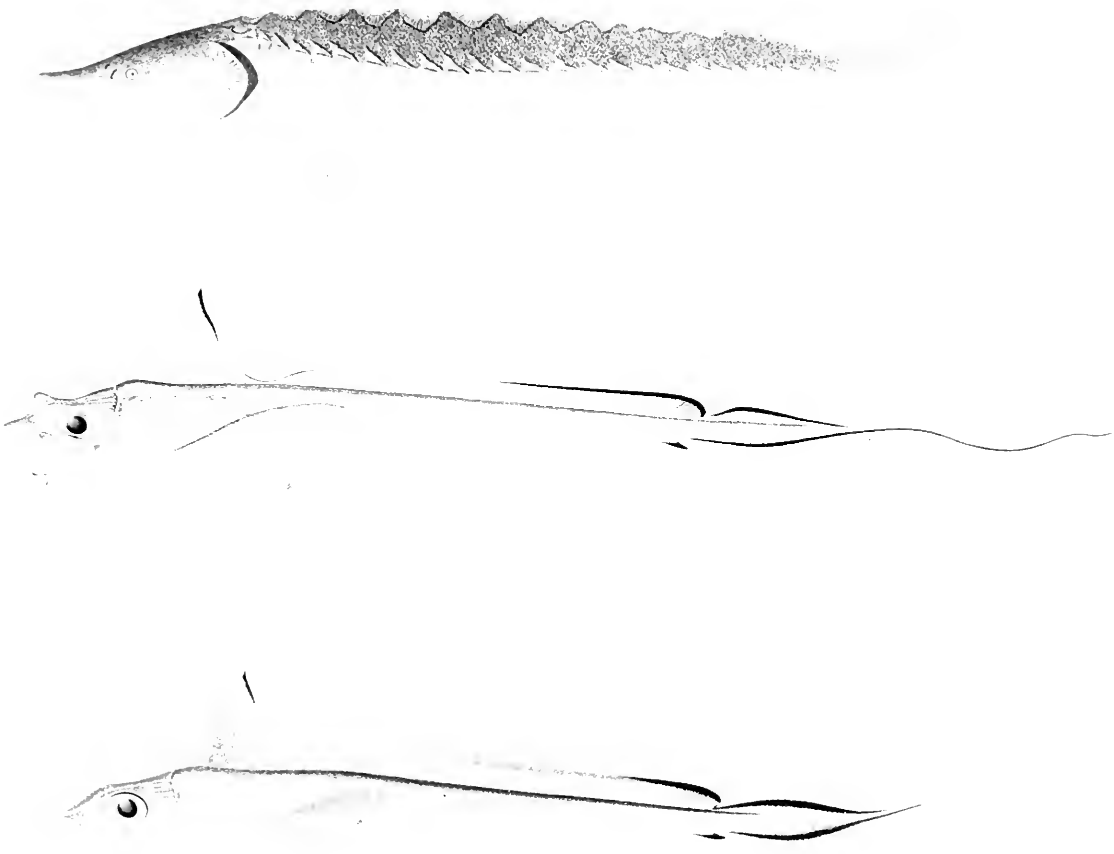


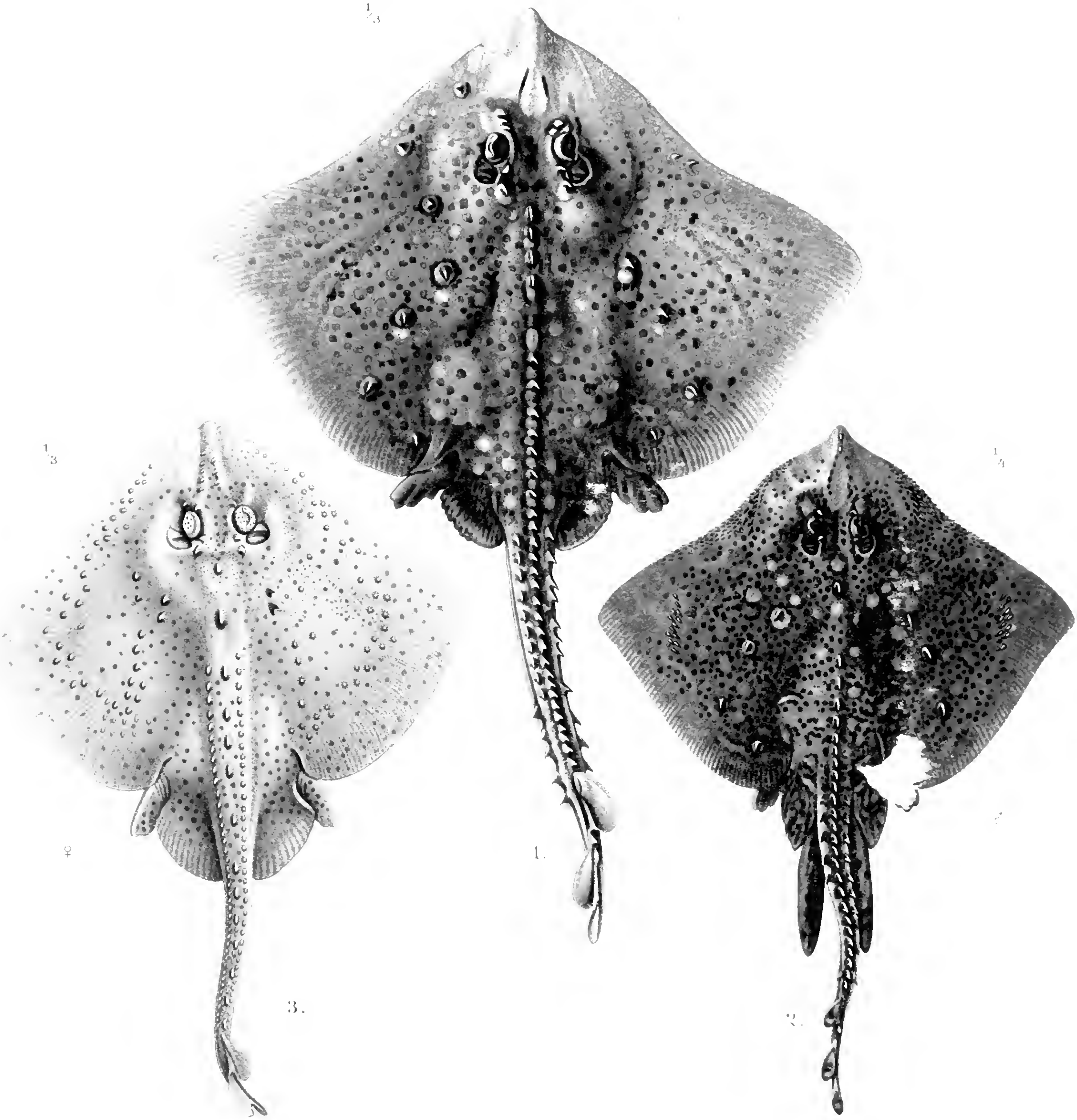
1.

1. Clupea harengus 2. Clupea sprattus 3. Maurolicus Mülleri 4. Esox lucius



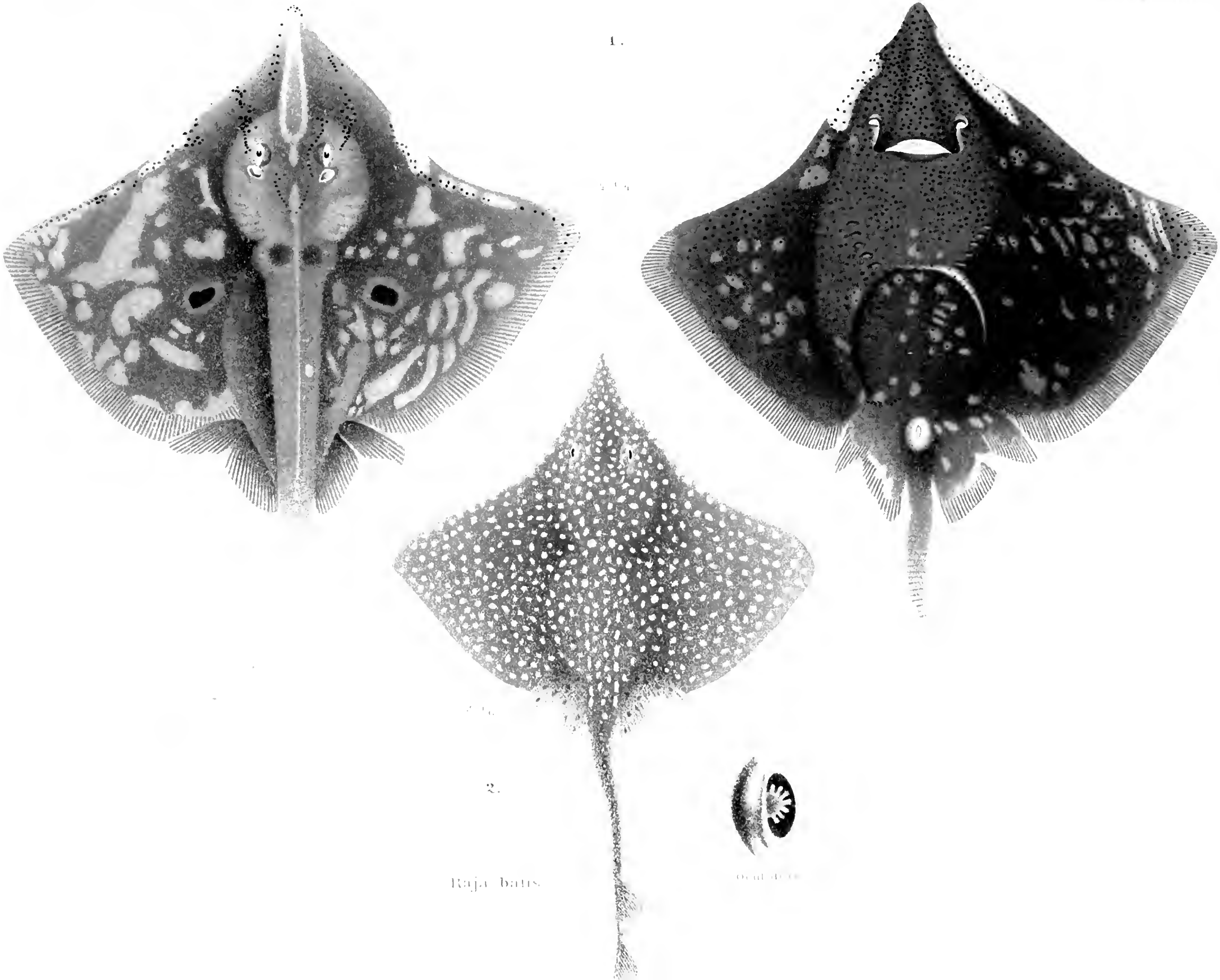
1. Anguilla vulgaris. 2. Conger niger.



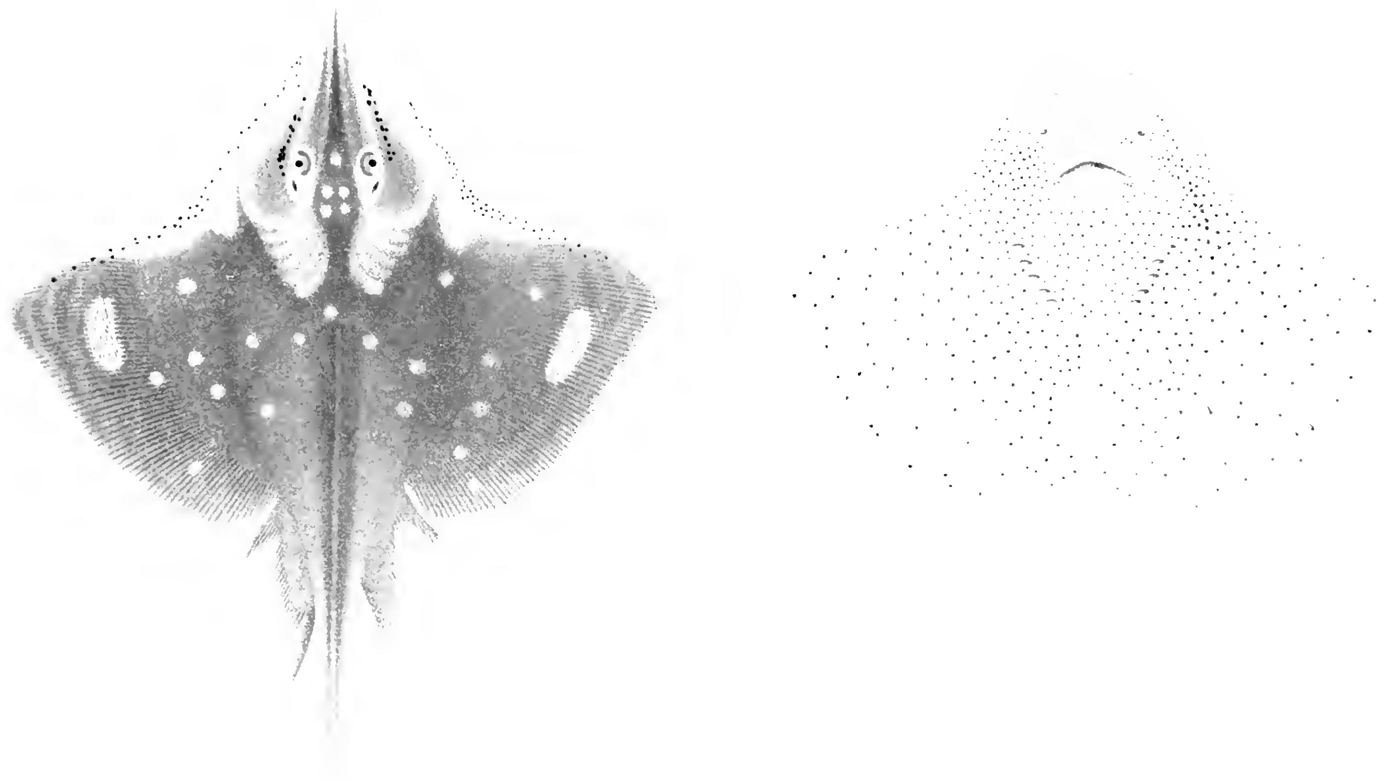


1 et 2: Raja clavata, 3. Raja radiata.

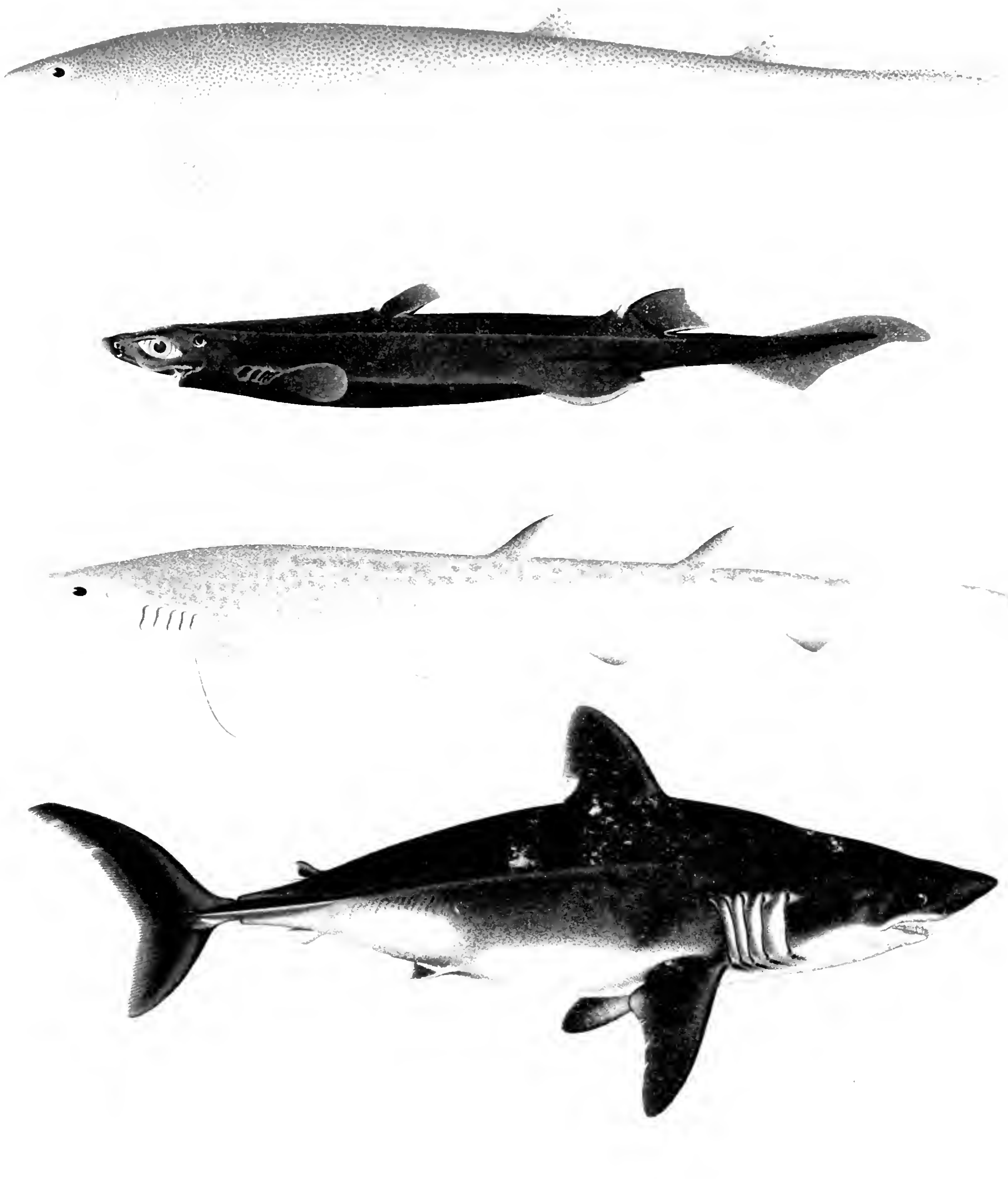
W. v. Wright pinx.

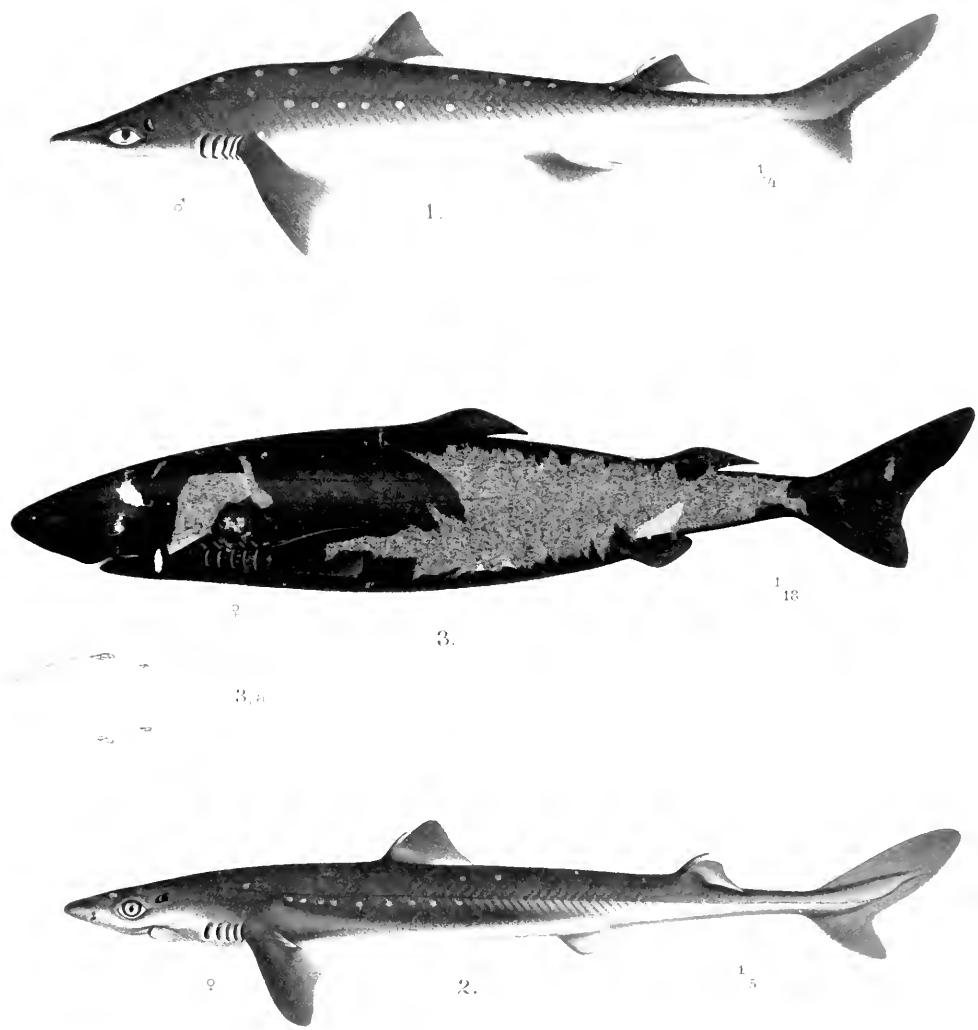


Raja batis



Raja oxyrhynchus.





1 et 2: Squalus acanthias; 3: Acanthorhinus carcharias.

Fig. 1 C. E[illegible] pinx
„ 2 et 3 W. v. Wright pinx