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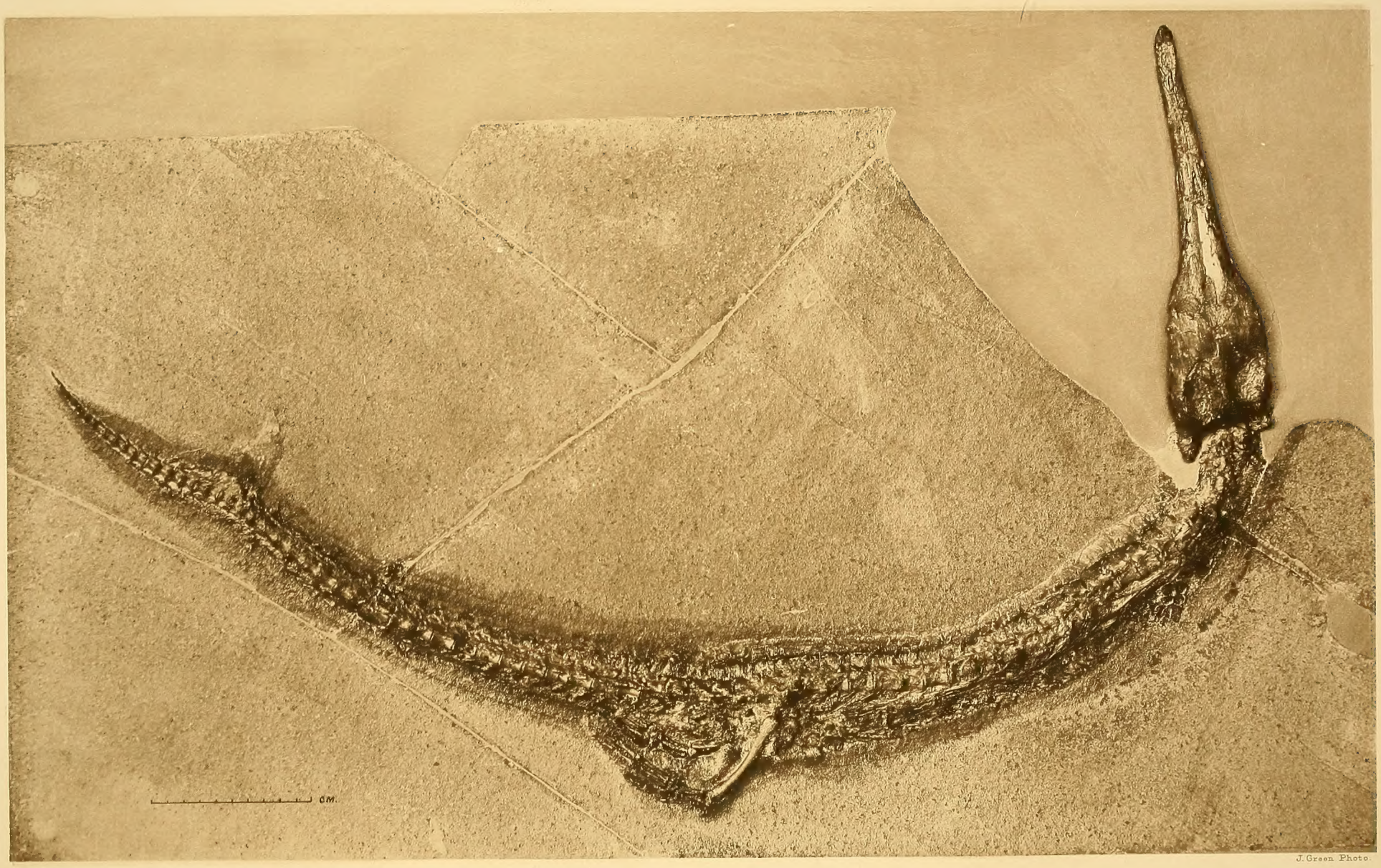

J. Green Photo.

GEOSAURUS GRACILIS.

A DESCRIPTIVE CATALOGUE

OF THE

MARINE REPTILES

OF

THE OXFORD CLAY.

BASED ON THE LEEDS COLLECTION IN
THE BRITISH MUSEUM (NATURAL HISTORY), LONDON.

PART II.

BY
CHARLES WILLIAM ANDREWS, D.Sc., F.R.S.

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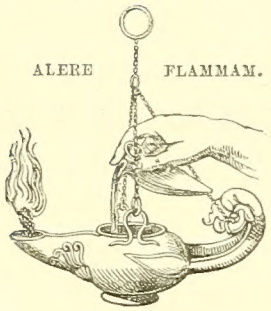

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PREFACE.

THE second and concluding part of the 'Catalogue of the Marine Reptiles of the Oxford Clay' begins with an account of the Pliosauridæ, which were known only by scattered fragments until the discoveries of Mr. Alfred N. Leeds. They are now exactly defined and described, and the gigantic species, *Pliosaurus ferox*, proves to be especially interesting. Among other features it will be noticed that in this reptile the bones of the young are comparatively dense, while in old individuals they are as light and spongy in texture as those of the larger existing whales.

The marine crocodiles of the families Teleosauridæ and Geosauridæ, which are also described in a more exhaustive manner than has previously been possible, are represented by numerous skeletons and parts in an unusually good state of preservation. As the bones have been completely removed from the clay, they can be separately studied, and the collection thus adds in a remarkable degree to our knowledge of the Upper Jurassic genera hitherto depending mainly on the skeletons embedded in the hard Lithographic Stone of Germany and France. One of the finest of these skeletons, showing impressions of the skin, is preserved in the Museum and shown in the Frontispiece of the present volume.

The value of the Catalogue is much enhanced by the careful drawings and diagrammatic sketches, which have been prepared by Miss Gertrude M. Woodward.

A. SMITH WOODWARD.

DEPARTMENT OF GEOLOGY,
BRITISH MUSEUM (NATURAL HISTORY),
4th February, 1913.

INTRODUCTION.

In the present volume the account of the Plesiosauria in the Leeds Collection is completed by the description of the Pliosauridæ, represented by the genera *Pliosaurus*, *Simolestes*, and *Peloneustes*. The Crocodilia are also described and catalogued, this order being represented by several members of two families, the Teleosauridæ and the Geosauridæ. The Teleosauridæ include two genera, *Steneosaurus* and *Mycterosuchus*, the latter being now established for the reception of the species *Mycterosuchus nasutus*, which is in several respects less specialised for an aquatic life than the species of *Steneosaurus*. The Geosauridæ are all referred to the genus *Metriorhynchus*, the various species being, on the whole, closely similar to one another, and there being a fairly complete gradation of forms between the slender-snouted species like *Metriorhynchus læve* and the broad-skulled and short-snouted *M. durobrivense*, which was formerly made the type of the genus *Suchodus*. The family Geosauridæ, as here understood, agrees exactly with the group Thalattosuchia of E. Fraas.

The Pliosauridæ differ in several respects from the Elasmosauridæ, described in Part I., the differences resulting for the most part from their greater adaptation to a pelagic life. As pointed out in the Introduction to Part I. (p. xv), the Elasmosaurs, with their long neck and small head, probably paddled about on the surface of the water of no great depth, the elongation of the neck being ill-adapted for rapid motion beneath the surface, but of great advantage in procuring food. In the Pliosaurs, on the other hand, the cervical vertebræ are not only fewer in number but possess relatively shorter centra than are found in the Elasmosaurs. At the same time, their head was proportionately larger, and in *Pliosaurus* and *Peloneustes* at least had a long

pointed snout. Both the shortening of the neck and the elongation of the head seem to show that these reptiles could not merely paddle on the surface of the water, but swim through its depths at considerable speed. The means of propulsion, also, in the Pliosaurs differs somewhat from that of the Elasmosaurs, in which the fore paddle was the largest and most important organ of progression. In the Pliosaurs, on the other hand, the fore paddle, though still large, is the smaller, and the shoulder-girdle is comparatively weak, while the pelvis and hind limb are enlarged and clearly played the chief part in swimming: there is no evidence that the tail bore any fin or took any part in the propulsion of the body in the members of this group.

Although, from the contents of the stomach of *Peloneustes* (see Introduction to Part I. p. xvi), it is certain that these animals fed largely on Cephalopods, nevertheless the great size and strength of the teeth in the Pliosaurs generally seem to indicate that probably larger and more powerful animals were caught and killed by them. It is also likely that many of the deeply scored grooves often seen on bones from this horizon, were caused by the teeth of these animals while feeding on the carcases, and this use of the teeth may account for the considerable degree of wear often exhibited by the tooth-crowns, *e. g.*, in the teeth of *Peloneustes evansi*, shown in text-fig. 28 (p. 73 of the present volume). Of course, in many cases the tooth-marks may have been caused by some of the numerous Crocodiles.

All the members of the Sauropterygia described in this Catalogue are too highly specialised for an aquatic life to supply any valuable information as to the early history and relationships of the order, but in the Trias there occur several genera which are of considerable importance from this point of view. The earliest remains are from the Lower Trias, but it is in the Middle Trias (Muschelkalk) that they become abundant and sufficiently well-preserved to establish any conclusions. The best-known genus is *Nothosaurus*, of which the osteology of several species has been fairly completely worked out; some traces of a terrestrial ancestry are shown, *e. g.*, in the comparative elongation of the propodial bones, but this animal had already attained a large size and was mainly, if not entirely, aquatic in its habits, so that it is of less importance from a phylogenetic point of view than the smaller forms, such as *Lariosaurus* and *Neustico-saurus*. These are small lizard-like reptiles, which were probably amphibious, but certainly were capable of progression on land. A nearly complete skeleton of

Lariosaurus balsami has been described by Boulenger *; this shows that the limbs were not paddle-like, the propodial bones being relatively long, and the manus and pes not having undergone any increase in the number of phalanges. In the shoulder-girdle the clavicular arch is strongly developed, but the scapulæ have no well-developed ventral ramus, and the coracoid is not expanded as in the later Plesiosauria. No ossified precoracoid has been found in any of the primitive Sauropterygians, but, as Seeley has shown †, it is probable that a precoracoidal cartilage existed: the disappearance of this element is probably due to the great development of the clavicular arch, which is itself replaced functionally in many of the later Plesiosaurs by the ventral rami of the scapulæ.

The pelvis in the Triassic Sauropterygia differs considerably from that of the later forms. Thus the ilium, ischium, and pubes meet in the acetabulum in a triradiate suture in the normal way (see Part I. text-fig. 64, p. 114), there is a pubic notch or foramen, and the pubes and ischia are not greatly expanded; the enormous plate-like pubes and ischia of forms like *Pliosaurus* have been secondarily acquired in correlation with the entirely aquatic mode of life—the enlarged pubes being mainly for the support and protection of the abdominal viscera, the ischia for the attachment of swimming-muscles.

Concerning the relationships and origin of the Sauropterygia many different opinions have been expressed. Many writers (*e.g.*, Baur ‡ and Fürbringer §) have considered that there is close relationship with the Chelonia, but the many objections to this view which have been summed up by Williston ‖ and Hay ¶ render it untenable. Broom ** considers that the group sprang from a land ancestor somewhat resembling *Sphenodon*, but with the supratemporal fossa alone developed; Jaekel ††, on the other

* Trans. Zool. Soc. vol. xiv. (1896) p. 1.

† Proc. Roy. Soc. vol. 54 (1893–4), p. 157.

‡ "The Phylogenetic Arrangement of the Sauropsida," Journ. Morph. vol. i. (1887) p. 97.

§ "Zur vergleichenden Anatomie des Brustschulterapparates und der Schultermuskeln," Jenaische Zeitschr. vol. xxxiv. (1900) p. 335.

‖ "The Skull of *Brachauchenius*, with Observations on the Relationships of the Plesiosaurs," Proc. U.S. Nat. Mus. vol. xxxii. (1907) pp. 486–9.

¶ 'The Fossil Turtles of North America' (1908), p. 30.

** "Observations on the Structure of *Mesosaurus*," Trans. S. African Phil. Soc. vol. xv. (1904), p. 103.

†† "Ueber das System der Reptilien," Zool. Anzeig., Jahrg. xxxv. (1910) p. 324.

hand, considers that both fossæ were developed, but that the lower temporal bar had been lost. The present writer * also, chiefly on account of the structure of the palate, once regarded the Sauropterygia as descended from a primitive Rhynchocephalian reptile. Boulenger † considers, as Seeley ‡ did, that *Mesosaurus* is closely related to the Sauropterygia; but the skull in *Mesosaurus* is too imperfectly known to be certain of its relationships either to the Sauropterygia or any other order, though it has been referred by Osborn § to the Diaptosauria, a group including the primitive Rhynchosaurian types.

A. S. Woodward and Williston, especially the last-named author, consider the group as nearly related to the Theriodontia, a view which is here adopted, the arguments against the relationship of the two groups having been to some extent weakened by recent discoveries among the South African Therapsids.

The primitive Sauropterygian may be regarded as probably possessing the following characters :—

Skull with a single temporal fossa, the zygomatic bar being formed by the squamosal meeting the jugal or postorbital or both; large pineal foramen; fixed quadrate; palate with vomers (prevomers) separating the internal nares and meeting the anterior ends of the pterygoids behind; a transpalatine and epipterygoid present; a well-developed parasphenoid (vomer) uniting posteriorly with the basisphenoid; postfrontal present and, in some cases, excluded from the temporal fossa; prefrontal and lachrymal present, at least in some, and a septo-maxillary (postnasal of Jaekel) occurring at least in *Simosaurus* and *Nothosaurus*. Teeth on the edge of jaws thecodont; small teeth on pterygoids (in *Lariosaurus*).

The shoulder-girdle with strongly developed clavicular arch; probably a separate cartilaginous precoracoid; coracoid not greatly expanded, and scapula without largely developed ventral ramus. The pubes and ischia not greatly expanded, and joining the ilium in the acetabulum in a triradiate suture; there may be a pubic foramen or notch. The limbs ambulatory, not modified to form paddles, there being no

* "On the Structure of the Plesiosaurian Skull," Quart. Journ. Geol. Soc. vol. lii. (1896) p. 246.

† "On a Nothosaurian Reptile from the Trias of Lombardy, apparently referable to *Lariosaurus*," Trans. Zool. Soc. vol. xiv. (1896) p. 1.

‡ "The Mesosauria of S. Africa," Quart. Journ. Geol. Soc. vol. xlviii. (1892) p. 586.

§ "The Reptilian Classes Diapsida and Synapsida, and the Early History of the Diaptosauria," Mem. Amer. Mus. Nat. Hist. vol. i. (1903) p. 451.

hyperphalangy. Plastron consisting of ventral ribs arranged in rows, each consisting of a median element and two or more lateral pairs.

The primitive Therapsids seem to possess many of the above characters. Thus in the skull of the Therocephalia we find a single temporal fossa (the zygomatic arch being formed by the postorbital and squamosal), a large pineal foramen, a fixed quadrate; a postfrontal excluded from the temporal fossa, a prefrontal, a lachrymal, and a septo-maxillary. The palate also is very similarly constituted, and there is a parasphenoid (vomer) which in the later Theriodonts becomes large. The teeth in the premaxillæ and maxillæ are thecodont, but are here differentiated into incisors, canines, and cheek-teeth, a character which shows that this group is too highly specialised to be the actual ancestor of the Sauropterygia. In some forms there are small teeth on the pterygoids. In the shoulder-girdle the precoracoid is ossified, but the reduction of this element to cartilage in the early Sauropterygia is probably due to their beginning to be adapted to an aquatic life, and to the development of their clavicular arch. The pubes and ischia, though plate-like in the Therocephalia, become modified in the Cynodonts, and a similar modification leading to the development of a large obturator foramen might have given rise to the form seen in *Nothosaurus*. The large plate-like pubes and ischia in the later Sauropterygia are, no doubt, as already noted, secondarily acquired. The phalangeal formula in *Lariosaurus* (2, 3, 4, 4, 3 in the manus, 2, 3, 4, 5, 4 in the pes) might easily be derived from the Therocephalian 2, 3, 4, 5, 3 and 2, 3, 4, 5, 4.

The great development of the ventral ribs in the Sauropterygia might be regarded a difficulty in the way of regarding them as related to the Therocephalian stock, but this is discounted by the fact that in the Dromasauria (*Galepus* and *Galechirus*) ventral ribs occur. This group, though in many ways specialised, is clearly closely related to the primitive stock of the Therocephalians, in which, no doubt, ventral ribs and an undifferentiated dentition existed. It is from some such early type as this, rather than from any of the known Therocephalia, that the Sauropterygia may have arisen.

The Crocodilia of the Oxford Clay were probably all aquatic to a much greater degree than the modern representatives of the order, but the various groups differ considerably among themselves as to the extent to which the skeleton has become modified for pelagic life. The Teleosauridæ, represented by the genera *Steneosaurus* and

Mycterosuchus, are much less specialised in this direction than the Geosauridæ, especially in the following points:—(1) the premaxillary region of the snout is expanded, not pointed as in *Metriorhynchus*, and the prefrontals do not overhang the orbits; (2) the neck is relatively rather longer; (3) the fore limbs, though reduced in size, are not paddle-like; (4) the end of the tail is not deflected to form the support of a large terminal caudal fin, although there probably was a narrow dorsal fin, at least on the terminal portion of the tail; (5) the dorsal and ventral armour is retained. Of the Teleosauridæ, *Mycterosuchus* is somewhat less specialised than *Steneosaurus*, the fore limb being considerably larger in proportion to the hind limb. Probably these reptiles were capable of dragging themselves out of the water on to mud-banks, but it seems impossible that they can ever have moved any distance from the water, as sometimes happens in the case of the modern Crocodiles.

The Geosauridæ, represented in the Oxford Clay by various species of *Metriorhynchus*, have undergone extreme modification for a purely aquatic life. Thus the head has a pointed snout, the prefrontals form a protective projection above the orbits, the neck is shortened, the fore limb is paddle-like and very small compared with the large hind limb, the terminal section of the tail is deflected and carried a large vertical fin which, no doubt, was the chief means of propulsion. The dermal armour has disappeared, but there is a well-developed sclerotic ring on the eye. Some of the more slender forms (e.g., *M. læve*) show a complete loss of the cranial sculpture, probably an advantage to an animal rapidly moving through the water. E. Fraas *, Abel †, Arthaber ‡, and Auer § have described and discussed at great length the various modifications undergone by the skeleton in this family, which Fraas separated from the rest of the Crocodilia as a distinct group, the Thalattosuchia. He, for the most part, drew his descriptions and conclusions from *Geosaurus*,

* "Die Meer-Crocodilier (Thalattosuchia) des Oberen Jura," Palæontographica, vol. xlix. (1902) p. 1; "Reptilien und Säugethiere in ihren Anpassungserscheinungen an das marine Leben," Württemberg. Naturwiss. Jahreshefte, vol. lxi. (1905) p. 347.

† "Der Anpassungstypus von *Metriorhynchus*," Centralbl. f. Min. etc. 1907, p. 225. See also this author's volume 'Palæobiologie' (1912), p. 105 *et seq.*

‡ "Beiträge zur Kenntnis der Organisation und der Anpassungserscheinungen des Genus *Metriorhynchus*," Beiträge Paläont. Oester.-Ungarns, vol. xix. (1906) p. 287; also "Ueber den Anpassungstypus von *Metriorhynchus*," Centralbl. f. Min. 1907, p. 385.

§ "Die Extremitäten von *Metriorhynchus*," Centralbl. f. Min. 1907, p. 536; "Weitere Beiträge zur Kenntnis des Genus *Metriorhynchus*," *tom. cit.* p. 353.

while Abel, Auer, and Arthaber discussed more or less imperfect skeletons of *Metriorhynchus*, sometimes incorrectly restored, from the Oxford Clay of Peterborough.

A beautiful skeleton of a young individual of *Geosaurus gracilis* from the Kimmeridgian Lithographic Limestone of Eichstätt has lately been acquired by the British Museum. This specimen, which has been described by Dr. L. v. Ammon *, is figured in the Frontispiece and gives a good idea of the general appearance of these sea-crocodiles. It is especially remarkable, because, to some extent, it shows the outline of the body, and the form of the caudal fin (text-fig. A, p. xii) is beautifully shown. Dr. Ammon believes that portions of the muscles are preserved in phosphate, but it seems possible that these are fragments of wrinkled skin. The skull, which in the original block was thrust back over the cervical vertebræ and tilted up, has been freed from the matrix and placed in its natural position.

The skeleton lies in a curved position on the left side, the dorsal surface being turned to the concave side of the curve: one result of this is that the downwardly flexed part of the tail is partly straightened out, so that the exact form of the caudal fin is somewhat distorted. The total length of the skeleton along the curve is about 114 cm. (3 ft. 8½ in.), of which the skull occupies about 21 cm., the tail 51 cm.

The skull and mandible are in close contact in their natural position. The former is in the shape of an elongated triangle, the base of which is between a quarter and a fifth of its height (*i. e.*, length of skull to tip of snout). The skull-roof in the neighbourhood of the orbits is incomplete and consequently does not show the form characteristic of the group, the overhanging prefrontals being lost. The occipital and the antorbital regions of the skull are fairly well preserved. The palatal region is much crushed and its structure obscure. The snout is relatively longer and more slender than in any species of *Metriorhynchus* and none of the bones preserved show more than a trace of sculpture. The form of the supratemporal fossæ is doubtful, the openings, as shown in the figure, being probably too small. The external narial opening is elongated and without a median division. The teeth are small and numerous, but their exact form and number cannot be determined.

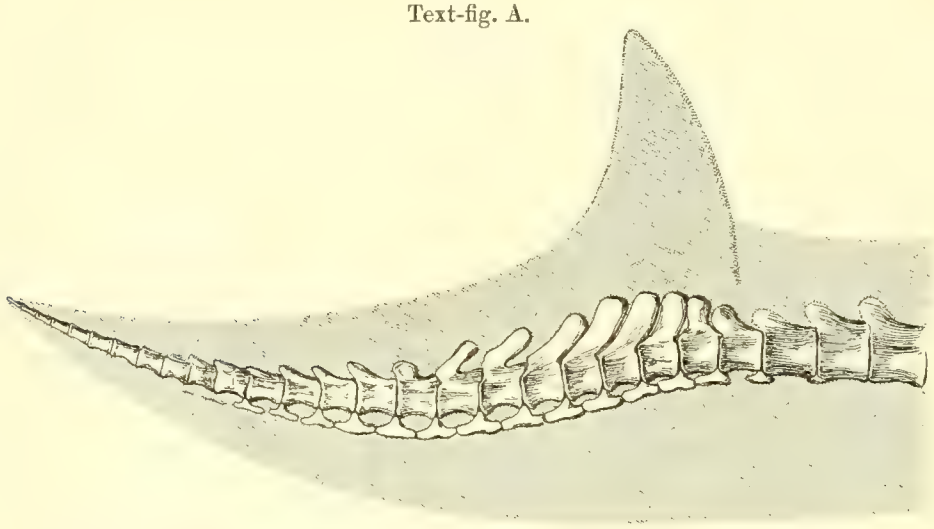
The anterior cervical vertebræ are incomplete, only three at the posterior end being preserved, though much crushed. Behind the last, the slab has been broken across

* "Ueber jurassische Krokodile aus Bayern," Geognostische Jahreshefte, Jahrg. xviii. (1905) p. 62.

and there is a space large enough for one centrum, probably the last cervical. The next vertebra has the parapophysis almost entirely on the arch and is here regarded as the first dorsal—if rightly so, there are nineteen dorsals altogether. In all, the transverse processes are broken away, but the neural spines, which are broad, low, and sloping a little backwards, are well preserved. The two sacrals are much obscured by the crushing that has taken place, the right ilium having apparently been forced down upon them and destroyed; the neural spines are similar to those of the dorsal region.

The caudal vertebræ (text-fig. A) are about fifty in number, and of these twenty-seven are in front of the downward flexure of the tail. E. Fraas states that in

Text-fig. A.



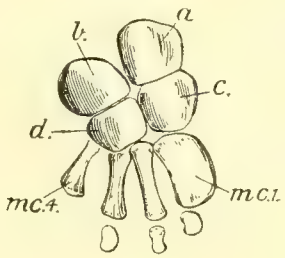
Terminal portion of tail of *Geosaurus gracilis*, showing the outline of the fin. (R. 3948, $\frac{2}{3}$ nat. size.)

Geosaurus suevicus there are forty-four caudals, but possibly some of the very small terminal centra, here preserved, may be wanting in his specimen. Caudal ribs seem to have been present on the first fourteen vertebræ, but on the last two of these they merely form slight prominences. The neural spines are not well preserved in the first few caudals, but further back it can be seen that they are composed of a larger backwardly sloping portion separated by a notch from a small anterior pointed process (the "Vorreiter" of Fraas). From the sixteenth to the twenty-fifth the neural spines are not well preserved, but on the twenty-sixth and twenty-seventh (the two immediately anterior to the downward bend) they are seen to slope sharply backwards and are

thickened at their upper end. The twenty-eighth vertebra (at the bend) has a high neural spine thickened at its upper end and upright or a little inclined forwards. The spines of the succeeding five vertebræ are inclined forwards and gradually become shorter. On the next the short spine slopes backwards, and the same is the case with the next two. Behind this to the end of the tail—that is, in about the last fifteen vertebræ—no spines can be seen, and probably in some of the terminal vertebræ no neural arch was present.

The chevrons begin on the second or third caudal vertebra; at first they are long Y-shaped bones, but from the fourteenth to the twenty-fifth vertebræ they are not clearly seen. Behind this they have very short pedicles and a much expanded median ventral portion, consisting of a smaller anterior and a longer posterior lobe. The ends of these lobes in the successive chevrons are in contact, forming a continuous chain

Text-fig. B.



Fore paddle of *Geosaurus gracilis*. (R. 3948, nat. size.)

a., radius; *b.*, ulna; *c.*, radiale; *d.*, ulnare; *mc.*1, first metacarpal; *mc.*4, fourth metacarpal.

as far back as the thirty-seventh vertebra: this arrangement probably greatly strengthened the basal portion of the tail-fin.

The structure of the shoulder-girdle and fore limb can, to a great extent, be made out from their impressions on the matrix. The fan-shaped upper end of a coracoid with a coracoid foramen is well shown, and there is a mass of bone crushed beneath the vertebral column, which may be the lower part of a scapula, but the state of preservation is such that this is uncertain. The humerus is wanting, but the form of the paddle-like distal part of the limb is well shown; this is figured above (text-fig. B). It will be seen that it consists proximally of two pairs of subequal disc-like bones, the nature of which is not quite clear. Ammon, in his description, regards the proximal pair (*a.*, *b.*) as the radius and ulna, the distal (*c.*, *d.*) as the radiale and ulnare.

Fraas, in his account of the fore limb of *Geosaurus suevicus*, adopts this interpretation: in that species the preaxial bone of the distal row is large and quadrate, the postaxial very much smaller and roughly triangular (see 'Palæontographica,' vol. xlix. (1902) pl. viii. fig. 3). If Fraas and Ammon are right, as they probably are, then the distal row of carpals has entirely disappeared and the metacarpals articulate directly with the radiale and ulnare. It is not, however, possible to be quite certain that the four bones figured may not represent the two rows of carpals, the radius and ulna being lost. Even in the specimen upon which Fraas' figure is founded, the displacement of the bones is considerable and does not appear entirely to exclude this interpretation. Of the metacarpals the first is large and plate-like, with a convex anterior and slightly concave posterior border. The second, third, and fourth metacarpals are much more slender, probably flattened, rods of bone, somewhat constricted in the middle; the second is the longest and most slender. Ammon figures a fragment of the fifth metacarpal, but this I cannot see. The first phalanges of the first, second, and third digits are preserved; they are small and seem to have been much flattened. The whole limb must have formed a paddle-like organ, the digits being separated at their tips only, if at all. Though so much altered from the form of the fore limb of ordinary Crocodiles, the paddle is not very greatly reduced in proportion to the size of the body, its apparent smallness being partly the result of contrast with the enlarged hind limb; probably it was not used for propulsion, but rather in maintaining the balance of the body.

The pelvis is for the most part destroyed, but portions of the ilium and ischium, together with an impression of the rather slightly expanded distal end of the pubis, can be made out; unfortunately, the upper end of this bone is not sufficiently well preserved to show its relations to the ilium and ischium. The hind limbs are very well preserved, that on the right side being almost completely shown, though the tibia and astragalus are represented by impressions only. The tarsus in the left foot is complete and is very closely similar to that of *Metriorhynchus læve*, shown on Pl. X. fig. 3 of the present volume. In fact, the whole limb is very similar in the two species, the only notable difference being, that while in *Metriorhynchus læve* the tibia is more than a third of the length of the femur, in the present specimen it is less. The numbers of the phalanges preserved in the digits are 2, 2, 4, 4, but the terminal one is probably wanting in the second; the phalanges are much flattened.

The ventral ribs seem to have been strongly developed and a number of widely open **V**-shaped elements of the middle row can be seen; they are fairly stout and well ossified. There was probably at least one pair of lateral elements in the form of short rods.

The outline of the soft parts of the body seems to be indicated by a yellow stain, best seen in the caudal region. The terminal caudal fin, however, is not only outlined in this way, but also stands in slight relief as a natural cast, the anterior border being especially clear (see text-fig. A, p. xii). The exact form of this region is, however, somewhat obscured by the circumstance that the downwardly flexed portion of the vertebral column has been somewhat straightened out into line with the anterior part of the tail, in consequence of the curved position in which the animal is lying.

In a few places on the ventral side the surface is covered by some patches of a thin layer of a peculiar fibrous-looking substance. This has been examined in detail by v. Ammon, who regards it as phosphatized muscle. The possibility that muscle may be preserved in this way has been demonstrated by Reis * in several papers, but at the same time the uniform thinness of the substance rather suggests that it may be fossilized remnants of the skin which had fallen more or less into longitudinal wrinkles. So long ago as 1860 von Meyer † noticed the presence of what he considered to be skin in a specimen of the present species, also from the Solenhofen Lithographic Limestone.

On the question of the origin of the Crocodilia, the Oxford Clay specimens throw no light. The Steneosaurs are no doubt derived from the various species of *Mystriosaurus* found in the Lias, but beyond that their descent cannot be traced. In the case of the Geosauridæ the early history is still more obscure. The only form anterior to the Oxford Clay which appears to be nearly related is *Teleidosaurus*, of which Deslongchamps ‡ has described two species (*T. calvadosi* and *T. joberti*) and Collot §

* See especially: "Untersuchungen über die Petrificirung der Muskulatur," Archiv f. Mikros. Anatomie, vol. xli. (1893) p. 492; and "Neues über petrificirte Muskulatur etc." *op. cit.* vol. lii. (1898) p. 262. E. Fraas has also written on the subject: see "Ueber die Finne von *Ichthyosaurus*," Jahreshefte Ver. Vaterländ. Naturkunde in Württemberg, vol. xliv. (1888) p. 293; and "Die Hautbedeckung von *Ichthyosaurus*," *op. cit.* vol. l. (1894) p. 493.

† "Fauna der Vorwelt," Rept. Lith. Schiefer, p. 96, pl. xv.

‡ 'Notes Paléontologiques,' p. 274.

§ "Reptile Jurassique (*Teleidosaurus gaudryi*) trouvé à Sainte-Seine l'Abbaye (Côte-d'Or)," Mém. Académie Dijon, [4] vol. x. (1906) p. 41.

one (*T. gaudryi*), from about the horizon of the Fuller's Earth (L. Bathonian) in Northern France. In this Crocodile the prefrontals form slight projections over the orbits, apparently the commencement of the large overhanging prominences seen in *Metriorhynchus*. The snout is pointed and the surface sculpture, particularly of the frontal, is not unlike that of some species of *Metriorhynchus*. Deslongchamps regards this genus as transitional between the Steneosaurs and Metriorhynchs; but the structure of the base of the skull and palate is not well known, so that it is uncertain whether or not there was a large vomer (parasphenoid) as in the latter group. In fact, the presence of this structure in the Geosauridæ suggests that they have probably been derived from a stock widely different from that of the Steneosaurs, in which, so far as is known, it is absent; and if *Teleidosaurus* should be found to possess this character, it is the earliest-known member of the family of which the origin and relationships to the other Crocodiles are quite uncertain.

CHARLES W. ANDREWS.

Department of Geology,
December 1912.

LIST OF PUBLICATIONS

REFERRING TO THE

MARINE REPTILES

OF THE

OXFORD CLAY OF PETERBOROUGH,

COLLECTED BY

MESSRS. CHARLES EDWARD AND ALFRED NICHOLSON LEEDS.

1. ABEL, O. Der Anpassungstypus von *Metriorhynchus*. Centralbl. f. Min. etc. (1907) p. 225.
2. ANDREWS, C. W. On the Development of the Shoulder-Girdle of a Plesiosaur (*Cryptoclidus oxoniensis*, Phillips, sp.) from the Oxford Clay. Ann. Mag. Nat. Hist. [6] vol. xv. (1895) p. 333.
3. ——. On the Structure of the Skull in *Peloneustes philarchus*, a Pliosaur from the Oxford Clay. Ann. Mag. Nat. Hist. [6] vol. xvi. (1895) p. 242.
4. ——. The Pectoral and Pelvic Girdles of *Murænosaurus plicatus*. Ann. Mag. Nat. Hist. [6] vol. xvi. (1895) p. 429.
5. ——. Note on the Skeleton of a Young Plesiosaur from the Oxford Clay of Peterborough. Geol. Mag. [4] vol. ii. (1895) p. 241.
6. ——. Note on the Pelvis of *Cryptoclidus oxoniensis* (Phillips). Geol. Mag. [4] vol. iii. (1896) p. 145.
7. ——. On the Structure of the Skull of a Pliosaur. Quart. Journ. Geol. Soc. vol. liii. (1897) p. 177.
8. ——. Notes on the Osteology of *Ophthalmosaurus icenicus*, Seeley, an Ichthyosaurian Reptile from the Oxford Clay of Peterborough. Geol. Mag. [5] vol. iv. (1907) p. 202.
9. ——. On some new Steneosaurs from the Oxford Clay of Peterborough. Ann. Mag. Nat. Hist. [8] vol. iii. (1909) p. 299, pls. viii. & ix.
10. ——. On some New Plesiosauria from the Oxford Clay of Peterborough. Ann. Mag. Nat. Hist. [8] vol. iv. (1909) p. 418.
11. ——. On the Mounted Skeleton of a small Pliosaur (*Peloneustes philarchus*, Seeley, sp.). Geol. Mag. [5] vol. vii. (1910) p. 110, pl. xii.
12. ——. On the Structure of the Roof of the Skull and of the Mandible of *Peloneustes*, with some Remarks on the Plesiosaurian Mandible generally. Geol. Mag. [5] vol. viii. (1911) p. 160.

13. Arthaber, Gustav von. Beiträge zur Kenntnis der Organisation und der Anpassungserscheinungen des Genus *Metriorhynchus*. Beiträge Paläont. Oester.-Ungarns, vol. xix. (1906) p. 287.

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15. ——. Ueber die Hinterextremität von *Metriorhynchus*. Centralbl. f. Min. etc. (1907) p. 502.

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17. ——. Die Extremitäten von *Metriorhynchus*. Centralbl. f. Min. etc. (1907) p. 536.

18. ——. Ueber einige Krokodile der Juraformation. Palæontographica, vol. lv. (1909) p. 217, pls. xxii–xxvi.

19. Bauer, Fr. Osteologische Notizen über Ichthyosaurier. Anat. Anzeig. vol. xviii. (1900) p. 574.

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38. ——. Note on some of the Generic Modifications of the Plesiosaurian Pectoral Arch. Quart. Journ. Geol. Soc. vol. xxx. (1874) p. 436.

39. ——. On the Pectoral Arch and Fore Limb of *Ophthalmosaurus*, a new Ichthyosaurian Genus from the Oxford Clay. Quart. Journ. Geol. Soc. vol. xxx. (1874) p. 696.

40. ——. The Nature of the Shoulder-Girdle and Clavicular Arch in Sauropterygia. Proc. Roy. Soc. vol. li. (1892) p. 119.

41. ——. Further Observations on the Shoulder-Girdle and Clavicular Arch in the Ichthyosauria and Sauropterygia. Proc. Roy. Soc. vol. liv. (1893–4) p. 149.

42. ——. On the Extremity of the Tail in Ichthyosauria. Ann. Mag. Nat. Hist. [8] vol. i. (1908) p. 436.

43. ——. On the Interlocking of the Neural Arches in Ichthyosauria. Ann. Mag. Nat. Hist. [8] vol. i. (1908) p. 441.

SYSTEMATIC INDEX.

FRONTISPIECE.

THE photograph represents a nearly complete skeleton (**R. 3948**) of *Geosaurus gracilis*, v. Meyer, sp., in which the outline of the soft parts, especially of the caudal fin, is preserved. The fore and hind paddles are well shown, but the skull, which was imperfect, has been restored. The total length of the skeleton along the curve is about 3 ft. $8\frac{1}{2}$ ins. (114 cm.).

This specimen was described and figured by Dr. L. v. Ammon in 'Geognostische Jahreshefte,' vol. xviii. (1905) p. 62. A brief description, with figures of the fore paddle and tail, is also given in the Introduction to this volume (p. xi). From the Lithographic Stone (Lower Kimmeridgian) of Eichstädt, Bavaria.

LIST OF ILLUSTRATIONS IN THE TEXT.

A DESCRIPTIVE CATALOGUE

OF THE

MARINE REPTILES

OF

THE OXFORD CLAY.

PART II.

Order SAUROPTERYGIA (*continued*).

Suborder PLESIOSAURIA (*continued*).

Family PLIOSAURIDÆ.

Head relatively large, neck short; cervical ribs for the most part with double heads. Scapulæ not forming an extensive median ventral symphysis; clavicular arch not well known, but including, in some genera at least, a triangular interclavicle interposed between the inner ends of the ventral rami of the scapulæ. Fore paddles smaller than the hind paddles; pelvis very large.

Range: Lower Jurassic to Upper Cretaceous of Europe.

If, as seems probable, the large *Rhomaleosaurus* (? *Thaumatosaurus*) *cramptoni* is referable to this family, then its range in time was from the Upper Lias to the Chalk, where it is represented by *Polyptychodon*. The family seems to have flourished especially during the period of the deposition of the Oxford and Kimmeridge Clays. In the Oxford Clay of Peterborough it is represented by three genera: *Pliosaurus*, *Simolestes*, and *Peloneustes*. The genus *Thaumatosaurus* is very imperfectly known, but if the species *Thaumatosaurus victor*, recently described by Fraas *, from the Upper Lias of Holzmaden, actually belongs to that genus, it is probably very nearly

* Palæontographica, vol. lvii. (1910) p. 123.

allied to the other members of this family, but is excluded from it by the possession of single-headed cervical ribs.

Williston * has attempted a definition of this family on the assumption that the genus *Brachauchenius* from the Cretaceous of Kansas is closely allied to *Pliosaurus*. His definition is:—" Skull depressed, no parietal crest; palatines broadly contiguous on the middle line; pterygoids with a prominent ridge and abutting mandibular process. Neck short, cervical ribs single- or double-headed, all vertebræ without infracentral vascular foramina." Such a definition would exclude the type genus from the family. Probably the North-American reptiles corresponding to the Pliosaurs of Europe will be found to constitute a distinct family, in which the characteristics common to the two groups are the consequence of parallel modifications.

Genus **PLIOSAURUS**, Owen.

[Odontography, pt. ii. (1841) p. 282.]

1873. *Liopleurodon*, Sauvage, Bull. Soc. Géol. France, [3] vol. i. p. 377.

Skull relatively large, with an elongated rostrum; mandibular symphysis moderately long, extending back to about the level of the seventh tooth. Teeth sharp-pointed, with numerous longitudinal ridges of enamel of varying length, usually absent or only slightly developed on the outer side, which in the later (Kimmeridgian) forms may be flattened, so that the crown is roughly trihedral in section. Neck short, consisting of twenty-two or twenty-three vertebræ, with short centra and high neural spines. Cervical ribs with double heads, except, perhaps, the last. Dorsal and sacral vertebræ at least twenty-four in number; caudals at least fifteen, the posterior three or four diminishing in size very rapidly.

Skull (Pl. I.; text-fig. 1).—The skull in this genus has already been described in some detail in the Quarterly Journal of the Geological Society, 1897, p. 177, and although other specimens have been obtained since that description was written, none are better preserved or add much to our knowledge of this important part of the skeleton. The specimen (R. 2680) there described and figured is, therefore, now taken as the basis for a somewhat more detailed account, and is figured on Pl. I. It is unfortunate that this skull was not associated with the mandible or any other part of the skeleton. A second and more imperfect skull (R. 3536) is also referred to—this specimen being of especial importance, because it is associated not only with the mandible, but also with a considerable portion of the rest of the skeleton.

In its general outline the skull is a greatly elongated triangle, its length being about $2\frac{1}{2}$ times its width at the quadrates. The temporal fossæ are very large and are separated by a narrow and high sagittal crest. The orbits seem to have been rather

* Science, n. s. vol. xvii. (1903) p. 980.

smaller than in some other members of the group. The premaxillary region of the snout is very slightly expanded.

The *basioccipital* (*b.oc.*) is a very large and massive bone, bearing the whole of the large occipital condyle; this is almost hemispherical, its transverse diameter being a little longer than the vertical. In the middle of the condyle there is a slight flattening with a dimple-like depression, probably marking the former position of the notochord. Laterally and superiorly the surface of the condyle passes without interruption into the sides and top of the bone, but ventrally it is marked off by a deep groove which forms a sort of short neck to the condyle in this region. In the middle ventral line there is a rounded ridge which, beyond the region of the neck of the condyle, turns sharply down at right angles and terminates in the ventral face of the bone which is completely overlapped by the pterygoids. The lateral (pterygoid) processes are very short and stout; they arise about one centimetre in front of the rim of the condyle; their outer ends are deeply concave and seem to have been covered by the pterygoids in the uncrushed skull. The surfaces for union with the exoccipital-opisthotics are very large and separated by a narrow interval only. The *exoccipital-opisthotics* themselves are much crushed, especially at the upper end. It can be seen that, as usual, they are almost columnar bones forming the sides of the foramen magnum. The opisthotic bears a long paroccipital process (*par.p.*), the outer end of which is expanded and fits against the hinder face of the posterior (quadrate) ramus of the pterygoid and perhaps in part against the quadrate itself.

The *supraoccipital* (*soc.*) cannot be clearly seen, owing to the crushing down upon it of the parietals. The same is the case with the *prootic*.

The *basisphenoid* is concealed by the underlying pterygoids, with the exception of a small part of the anterior end; this, as usual, is underlain by the adherent *parasphenoid*. This bone (*pas.*) seems to have extended back between the basisphenoid and the pterygoids; certainly the pterygoids cannot have met between the parasphenoid and the basisphenoid in the manner described by Williston in the case of *Trinacromerum* *. The free portion of the parasphenoid in front of the basisphenoid is much broken, but it can be seen to have narrowed rapidly between the posterior interpterygoid vacuities †. Anteriorly where it passes between the pterygoids it widens again suddenly and then narrows gradually to a point, giving it the appearance of a very narrow spear-head; the ventral face is overlapped to some extent by the edges of the pterygoids, so that a greater area is exposed on the upper than on the palatal surface: this latter is flat or slightly convex from side to side. The anterior end of the bone is situated about 8·5 cm. in front of the anterior end of the posterior interpterygoid vacuities.

* Journal of Geology, vol. xvi. (1908) p. 715.

† It is proposed to use this term instead of "posterior palatine vacuity," to which some objections have been pointed out by Williston and others.

The *pterygoids* (*pt.*) are large bones forming a great part of the palatal surface of the skull. They are of the triradiate structure usual in the group. The anterior rami are very large and their front portion much thickened: externally they unite with the palatines in a nearly straight suture. Anteriorly they seem to have united with the vomers in a complex suture, excluding the palatines from the middle line. In the middle line they meet in front in symphysis for a short distance, then are separated by a narrow anterior interpterygoid vacuity (*a.p.v.*), behind which they again meet for a short distance (about 4 cm.), but behind they are separated by the anterior part of the parasphenoid, which is thrust in between them for about 8·5 cm.; behind this the inner edges of the pterygoids curve away from the parasphenoid to enclose the posterior interpterygoid vacuities (*p.p.v.*), which are about 10–11 cm. long. Behind these openings the pterygoids again meet in median symphysis, beneath the basisphenoid and basioccipital, which, as noted above, they largely conceal; they also cover, and in the uncrushed condition probably united with, the lower ends of the lateral (pterygoid) processes of the basioccipital. The length of the suture between the pterygoids beneath the basis cranii is about 9 cm.; the posterior third of this distance bears a strong and prominent ridge, which anteriorly bifurcates, the two branches forming prominent crests which curve outwards through about a quarter of a circle and become continuous externally with the postero-inferior edge of the lateral rami of the bones; towards their outer ends these crests become thickened with strong tuberosities directed downwards and outwards; these prominences fit closely against similar projections of the transpalatines (*t.p.*) in front, forming the downwardly directed processes of the palate seen in *Sphenodon* and many other reptiles, the outer edge abutting against the inner face of the mandible when the jaws are closed. The anterior border of the lateral ramus is situated a little in front of the level of the anterior ends of the posterior interpterygoid vacuities (*p.p.v.*); it runs out nearly at right angles to the long axis of the skull, and unites in an irregular suture with the posterior end of the palatine. Externally the lateral ramus is overlapped by the *transpalatine* (*t.p.*). The outer border of the posterior ramus is greatly thickened and rounded from above downwards; this part of the bone is prolonged backwards in a long stout process towards the quadrate, with which it unites closely; this union may be brought about by the overlapping of the posterior pterygoid process on a corresponding process of the quadrate, or may have been directly with the inner edge of that bone; the arrangement is obscured by crushing, but the former seems the more probable interpretation. The expanded distal end of the paroccipital process (*par.p*), as above described, fits closely against the hinder surface of the pterygoid-quadrate bar, which bears a shallow groove for its reception; the surfaces of contact are smooth and it seems that a certain amount of movement between the bones was possible. The upper surface of the pterygoids near the outer border of the posterior ramus, immediately behind the point of origin of the lateral ramus, bears a long oval surface for the

columella cranii or *epipterygoid* (*col.*). This bone is stout and seems to have been oval in section, narrowing rapidly towards its summit, where it no doubt joined the lower edge of the parietal, though the crushing to which the skull has been subjected has caused much dislocation in this region.

The *palatines* (*pal.*) are large elongated bones; their inner borders unite in suture with the pterygoids; anteriorly they narrow considerably and they seem to join the vomers for a short distance and perhaps take a small share in the formation of the hinder border of the internal nares. Externally these bones unite in front for about half their length with the maxillæ, but behind this they are separated from those bones by a narrow elongated suborbital vacuity (*s.o.v.*) which is closed behind by the transpalatine. Each palatine is perforated by a foramen (*pal.f.*), about 1 cm. in diameter, situated on the left side about 4 cm. from the hinder border of the bone and 1 cm. from its inner edge; on the right side the part of the bone lying behind and internal to the opening is broken away, but it seems that the opening was a little further back than on the opposite side.

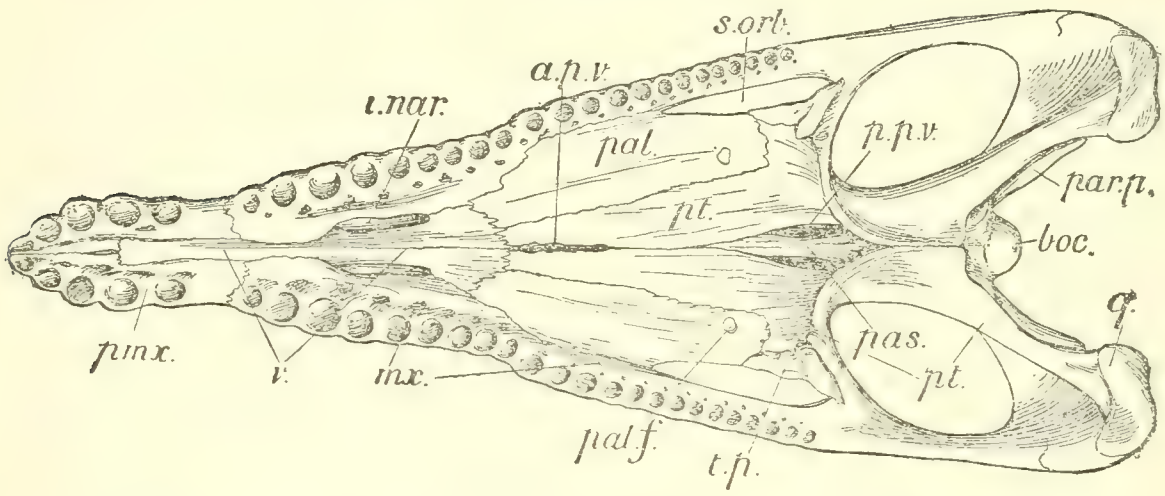
The *vomers* (*v.*) (prevomers of Broom) are large bones about 40 cm. long and for the anterior four-fifths of their length anchylosed together. Anteriorly they run forwards some distance between the premaxillæ, behind which they are in contact with the maxillæ, thus excluding the premaxillæ from any share in the enclosure of the internal nares. On their palatal surface the vomers are overlapped to a considerable extent by the palatal plates of the maxillæ and premaxillæ; between the second maxillary teeth the width of their exposed surface is reduced by this overlap to a narrow strip less than a centimetre wide. Between the internal narial openings the united vomers form a bar, convex from side to side; at about the middle of these openings the width of the bar is about 3 cm., but at the posterior end it widens to about 4·8 cm. Behind the narial openings the bones widen into a fan-shape and unite with the pterygoids in the middle line by an irregular suture; external to this they have a short union with the palatines, and external to this again they join the maxillæ. In no specimen, however, are the relationships of the bones in this region very clearly shown.

The *premaxillæ* (*pmx.*) consist of the massive dentigerous portion forming the anterior part of the snout, and the long slender facial processes which run back on the dorsal surface of the skull to a point some distance behind the external nares, where they unite in suture with the anterior ends of the frontals or perhaps the parietals (see below). The premaxillæ bear five teeth each; of these the first pair are small, directed forwards and nearly in contact with one another on the middle line. The second, third, and fourth increase in size, the two last being very large; the fifth is again small. Between the last premaxillary tooth and the first on the maxilla is a diastema about 6 cm. long, crossed at about the middle by the premaxillo-maxillary suture. On the palate this suture runs inwards and a little backwards to the vomer,

defining a short palatine process which, however, does not reach the internal narial opening. Immediately internal to the alveoli there is a deep groove, at the bottom of which the tips of the replacing teeth appear; the inner wall of the groove forms a prominent ridge which, joining that of the opposite side, forms an elongated raised triangular area at the middle of the anterior end of the palate. By the divergence of these ridges posteriorly, a short groove is formed which is closed behind by the prominent anterior end of the combined vomers.

The upper (facial) surface of the anterior region of the premaxillæ is gently convex from side to side, and is roughened and marked by a number of small foramina opening into short longitudinal grooves. The great facial processes at first narrow gradually, but at a point about 40 cm. from the tip of the snout their sides become parallel and

Text-fig. 1.



Restoration of the skull of *Pliosaurus ferox* from palatal surface. (R. 2680, about $\frac{1}{8}$ nat. size.)

a.p.v., anterior interpterygoid vacuity; *boc.*, basioccipital; *i.nar.*, internal nares; *mx.*, maxilla: *pal.*, palatine; *pal.f.*, foramen in the palatine; *par.p.*, paroccipital process; *pas.*, parasphenoid; *pmx.*, premaxilla; *p.p.v.*, posterior interpterygoid vacuities; *pt.*, pterygoid; *q.*, quadrate; *s.orb.*, suborbital vacuity; *t.p.*, transpalatine; *v.*, vomers.

continue so to their union with the frontals (or parietals). They are separated from the external nares by a band of bone, which seems to be composed anteriorly of a process of the maxilla, and behind by part of a bone here regarded as a nasal (see below).

The *maxillæ* (*mx.*) are very large bones, each bearing about twenty teeth; of these the first two are small, the third and fourth very large. Behind these there is a decrease in size to the ninth, but the tenth and eleventh are again large; behind these there is a gradual decrease to the end of the series, the hindmost teeth being very small. Seen from the side the margin of the jaw presents a sinuous outline, the first convexity being in the premaxilla, the next beneath the third and fourth maxillary

teeth, the last at the tenth and eleventh. As already mentioned, the palatine plate of the maxilla overlaps the vomer to a considerable degree in front. Opposite the internal nares it is raised into a high cristiform ridge which is perforated by a foramen and forms the outer wall of the narial opening. Behind this the maxilla unites with the palatine for some distance, but is then separated from it by the narrow suborbital vacuity (*s.orb.*) as above described; the transpalatine (*t.p.*) joins the maxilla to the pterygoid and closes this vacuity posteriorly. At its hinder extremity the maxilla sends a long process beneath the jugal, nearly as far as the anterior end of the zygomatic process of the squamosal. Within the alveolar margin as far back as the anterior end of the suborbital vacuity there is a deep groove, with a series of pits in which the tips of the crowns of the replacing teeth are seen. The facial surface of the maxilla is gently convex from above downwards. The maxillo-premaxillary suture has already been referred to; it seems to terminate opposite the middle point of the external narial aperture (*nar.*), where the process of the maxilla which forms the hinder part of its inner margin joins a corresponding process of the bone which may be the nasal (?*n.*). The maxilla also forms the outer border of the nares, from the posterior angle of which a suture runs back towards the orbit, separating the maxilla from the (?) nasal. Posteriorly it seems to be excluded from the orbit by an element which may be the lachrymal (*l.*).

The *jugal* (*j.*) is a small bone which at its hinder end joins the zygomatic process of the squamosal by a vertical suture. On the ventral border for the greater part of its length it joins the backward prolongation of the maxilla. Above, it unites posteriorly with the ventral end of the postorbital, and anteriorly it seems to have formed the postero-inferior part of the border and floor of the orbit. It probably also has a short contact with the transpalatine.

The *postorbital* (*p.orb.*) is a roughly triangular bone, the lower edge of which unites with the jugal, the anterior edge forms the lower part of the hinder border of the orbit, while the posterior border forms part of the edge of the temporal fossa. On its inner surface this bone bears a greatly thickened ridge which seems to separate the orbital region from that belonging to the temporal fossa: the relations of its upper end to the neighbouring bones are not known.

The *squamosal* (*sq.*) consists of a comparatively slender zygomatic bar, a stout dorsal branch, and a broad short ventral portion closely adherent to the quadrate. The dorsal ramus probably met its fellow on the middle line, the two forming the upper border of the occipital region of the skull to the exclusion of the parietals which they overlie. The quadrate portion is apparently fused with the quadrate; its ventral border is convex and forms a prominent rounded ridge a little distance above the articular surface of the quadrate: this ridge is most prominent on the inner side, where, between it and the quadrate condyle, there is a deep groove. The comparatively slender zygomatic process unites anteriorly with the jugal in a vertical suture.

The *quadrate* (*q.*) is a remarkably large and massively constructed bone. The body is concave from side to side anteriorly and convex posteriorly. The posterior surface is to a large extent concealed by the overlapping squamosal. The ventral end bears the very large articular condyle, the form of which will be best understood from the figure (Pl. I. fig. 1); it will be seen that the articular surface is divided by an oblique ridge into a smaller postero-internal and a larger antero-external region. From the inner border of the bone immediately above the condyle, it appears that a process arose, which was overlapped by the posterior limb of the pterygoid.

The *parietals* (*par.*) in their middle region form the high sagittal crest between the very large temporal fossæ; posteriorly they widen and project considerably behind the supraoccipital, with which they unite below. It is not quite clear to what extent they were overlapped by the dorsal rami of the squamosals, but probably, as stated above, these bones met in the middle line and formed the actual upper border of the posterior face of the skull.

Beneath the outer temporal crest the bones widen to form the roof of the cranial cavity, and a little behind the pineal foramen they unite by their lower borders with the upper ends of the columellæ cranii (epipterygoids). In front of this they widen and diverge to enclose the pineal foramen (*p.f.*), of which they seem to form the whole margin, at least on the outer face of the skull. The relation of the parietals to the frontals is obscure in the specimens examined: in the former description it was stated that the two bones were probably anchylosed, but that there seemed to be traces of a suture on the sides of the pineal foramen. Judging now from the better-preserved skulls of *Peloneustes* (see p. 40) it seems probable that, though the frontals may have extended back to the pineal opening on the inner side of the skull, on the outer surface they are overlapped by a pre-pineal extension of the parietals (*fr.* in Pl. I.) which meets the posterior ends of the facial processes of the premaxillæ, thus excluding the frontals from the middle line, at least on the outer surface of the skull. If this interpretation is correct, then the names of some of the other elements of the skull-roof will be different from those given in the earlier description and plate. At about the level of the pineal foramen the outer edge of the parietal unites with an element which must be the postfrontal (*po.f.*). In front of this is another element which helps to form the upper edge of the orbit; this was regarded as a prefrontal and is marked *pr.f.* in Pl. I., but probably it is the outer part of the frontal which, judging from the skull of *Peloneustes*, meets or nearly meets its fellow in the middle line beneath the parietals and extends back to the pineal foramen. The true prefrontal is probably the bone marked ? *s.orb.* and ? *n.* in Pl. I.; it extends forwards to meet the maxilla and is produced anteriorly into a narrow process, forming the inner border of the external narial opening: it is possible that a nasal element is represented by this part of the bone, but no suture is visible.

The anterior portion of the orbital border is formed by an element separated from

the maxilla by a curved suture, and in contact above for a short distance with the prefrontal; this element is probably the *lachrymal* (*l.*). It is produced inwards into a broad ridge, which forms the anterior wall of the orbit, and curving upwards and backwards becomes continuous with the rounded crest on the lower surface of the cranial bones which marks the inner limit of the orbit. The external nares (*nar.*) are oval apertures about 5 cm. long, situated about 57 cm. from the tip of the snout, that is to say some distance behind the internal nares. The distance between them is about 9·5 cm., probably exaggerated by the crushing the skull has undergone. As above described, the posterior outer and half the inner border are formed by the maxilla, the remainder being enclosed by the bone here regarded as the nasal.

In *Pliosaurus* a well-developed *sclerotic ring* seems to have been present, though so far it is only known from a few plates. Each plate consists of fibrous-looking bone; the outer and inner borders are concentric and the outer the longer, while the lateral edges are nearly straight and are grooved or tongued, as the case may be, for union with the adjacent plates. The outer and inner borders are thin and sharp and are irregularly serrated; the bone thickens regularly to a line a little nearer to the inner than to the outer border. These plates differ from those of *Ophthalmosaurus* in being only gently convex externally and concave internally, and not curving round on the back of the eye-ball.

Mandible (Pl. II. figs. 1, 1 *a*).—The mandible is distinguished from that of *Peloneustes* in having a somewhat shorter symphysis (*sym.*), which, at the same time, is longer than that found in *Simolestes*. The symphysial region extends back to the seventh tooth, and between the third and fifth teeth it widens considerably; it is formed almost entirely by the dentaries, the splenials only entering into it for a short distance on the ventral side. The upper surface of the symphysis between the rows of alveoli is raised into a prominent ridge, on either side of which is a series of depressions probably marking the places in which the replacing teeth developed; posteriorly the ridge divides, passing into the raised inner alveolar borders of the rami. These diverge from one another at a very acute angle; at first they are straight, then curve gently inwards to the articular surfaces for the quadrates. The anterior part of each ramus, as far back as the coronoid angle, is formed externally by the large dentary, the inner face of which is covered by the closely adherent coronoid (*spl.* in fig. 1) and splenial, the latter of which roofs in the dental canal.

The *coronoid* (*spl.* in Pl. II. fig. 1) is a very long thin strip of bone very closely adherent to the inner face of the dentary (*d.*). At its hinder end it forms the inner face of the coronoid angle, immediately beneath which it unites in complex suture with the surangular (*art. & surang.*). Its upper border is parallel with and close to the edge of the dentary, which forms the inner side of the groove within the line of alveoli; below it is overlapped by the splenial. Its anterior end extends to, or perhaps even enters, the symphysis.

The *splenial* (*spl.* in Pl. II. fig. 1 *a*) is a long thin strip of bone closely adherent to the inner face of the coronoid above, and of the dentary and anterior prolongation of the angular below. The posterior end cannot be made out in the specimens, though probably it was as in *Peloneustes* (see below, text-fig. 14). Anteriorly it enters the ventral side of the symphysis for a short distance. The post-coronoid portion of the mandible is composed of two pieces, (1) the fused *articular* and *surangular* (*art. & surang.*), (2) the angular (*ang.*). The former constitutes the upper part of the post-articular process (*p.a.p.*), bears the articular surface, in front of which its upper border, which is thickened and flattened above, slopes up to the coronoid angle; beneath this the bone unites with the coronoid on the inner, and the dentary on the outer side, ventrally it unites with the angular. The articulation for the quadrate is a concave kidney-shaped surface; its concave anterior rim is strengthened by a strong prominence situated rather to the inner side; the outer and posterior borders are also rather prominent. On the anterior side of the outer concavity there is a deep pit, probably for the attachment of a ligament. The *angular* is a large bone and constitutes the lower border of the jaw to within a short distance of the symphysis; posteriorly it unites with the surangular and articular above, and in front of the level of the articular surface, probably with the posterior prolongation of the splenial. In front of the coronoid angle it is prolonged forwards as a tapering process, uniting with the dentary on the outer side and the splenial on the inner side.

The *teeth* (Pl. II. figs. 2–4) in the lower jaw are about 28 in number on either side; of these seven are in the symphysial region. The anterior pair is small, close together, and directed nearly straight forwards; the next five pairs are large and about equal in size; they are directed forwards, outwards, and upwards, but the last tooth in the symphysis is smaller and does not seem to have been directed forwards. The teeth in the rest of the ramus are smaller than the large symphysial teeth, and remain about equal in size till the last four or five, which rapidly diminish. The structure of the individual teeth is the same in the upper and lower jaws. They have been described and figured by Lydekker in the Quart. Journ. Geol. Soc. vol. xlvi. (1890) p. 49, pl. v. fig. 1. Each tooth, as a whole, is curved and is nearly circular in section throughout its length. The root is very large, considerably larger than the enamel-clad crown, and its surface is quite smooth; the pulp-cavity is open below and is large, extending some distance up into the crown. The form of the crown varies somewhat in different parts of the jaw. In the smaller posterior teeth (Pl. II. figs. 4, 4 *a*) it is smaller in proportion to the root and more sharply curved than in the larger teeth. In all the crown, which terminates in a sharp point, is more or less curved; the outer convex face is covered with nearly smooth enamel (Pl. II. fig. 2 *a*), but on the remainder of the surface the enamel bears numerous sharp ridges, which start from the base of the crown and extend towards the apex to a varying extent: a few of the stronger ridges may actually reach the tip. Towards the base of the crown some

of the ridges may bifurcate and, in some of the largest teeth, the enamel is raised into vermiculate sculpture. In some cases the smooth outer face may show traces of the flattening which, in the later Kimmeridgian forms, is carried so far as to give the crown of the teeth a more or less trihedral section *. Near the base of the crown, on what is probably the posterior side, there is often a surface (Pl. II. figs. 2, 2 *b*, *w.s.*) from which the enamel has been completely worn away.

These teeth seem to be identical with those described by Sauvage (Bull. Soc. Géol. France, [3] vol. i. (1873) p. 378) under the name *Liopleurodon ferox*, from the Oxford Clay of Boulogne, and it was on this account that the name *Pliosaurus ferox* was adopted for the species to which the remains here described belong.

Vertebral Column (text-figs. 2–3).—No very well-preserved and complete vertebral column is available for description; that associated with the skull and mandible (R. 3536) above referred to is the most nearly complete, but the vertebræ, particularly in the dorsal and caudal regions, are much crushed and the neural arches are for the most part lost.

The *atlas* and *axis* have their centra closely fused together in the adult. The centrum of the atlas (odontoid) forms the middle portion and the neural border of the cup for the occipital condyle. The supero-lateral portions of the border of the cup were evidently formed by the ventral ends of the neural arch, but this is not preserved in any specimen. The ventral portion of the cup was formed by the anterior wedge-bone. The centrum of the axis is oval in section, the long diameter being transverse. Anteriorly it is closely united above with the odontoid, and below with the posterior face of the hinder wedge-bone, which is interposed between the centra of the atlas and axis ventrally. Judging from the structure of the atlas and axis in *Peloneustes* (see below, p. 47, figs. 15, 16), the bases of the pedicles of the neural arch were very large, forming the supero-lateral portions of the atlantal cup, as above noted, and extending down to unite by a broad surface with the upper angles of the anterior wedge-bone, thus excluding the odontoid from any share in the formation of the sides of the atlantal cup, such as is seen in *Murǣnosaurus* (see Part I. pp. 92–93, text-fig. 49) and *Cryptocleidus*. In this manner of forming the atlantal cup, *Pliosaurus* and *Peloneustes* resemble some Liassic Plesiosaurs † and also the North American Cretaceous genus *Trinacromerum* (*Dolichorhyncops*) described by Williston ‡. On the lateral surface the united atlas and axis bear a large facet for a rib, the greater part of which is on the axis, but apparently both the centrum of the atlas and the second ventral wedge-

* See Owen's figure of tooth (Brit. Mus. 37408) of *Pliosaurus macromerus*, Phillips (*P. grandis*, Owen), in "Reptilia of the Kimmeridge Clay" (Mon. Pal. Soc. 1863), pt. ii. pl. xii.

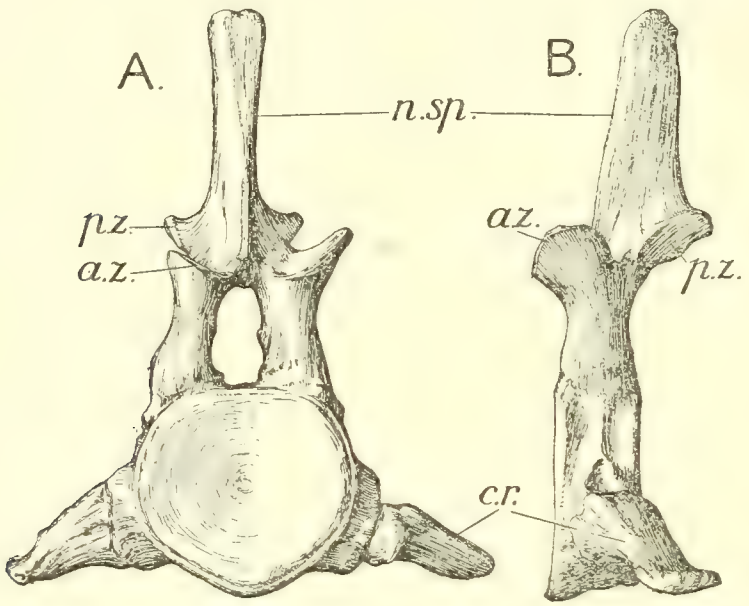
† Barrett, "On the Atlas and Axis of a Plesiosaur," Ann. & Mag. Nat. Hist. [3] vol. ii. (1858) p. 361, pl. xiii.

‡ "North American Plesiosaurs, Pt. I.," Field Columbian Museum, Geological Series, vol. ii. no. 1 (1903) p. 32, pl. xxii. fig. 5.

bone share in the formation of the antero-ventral portion of the facet, as is also the case in the atlas and axis of *Trinacromerum* (*Dolichorhyncops*) figured by Williston *. In *Peloneustes* the rib-facet is borne on the centrum of the axis alone, the second ventral wedge-bone being much smaller than in *Pliosaurus*. The posterior face of the centrum of the axis is evenly concave, with a well-marked pit in the middle.

The remaining cervical vertebræ (text-fig. 2) are about eighteen in number. Their centra are characterised by their shortness, the length in the mid-ventral line, where they are thickest, being less than half the vertical diameter of their articular faces.

Text-fig. 2.



Cervical vertebra of *Pliosaurus ferox*: A, from front; B, from left side. (R. 3536, ¼ nat. size.)
a.z., anterior zygapophysis; *c.r.*, cervical rib; *n.sp.*, neural spine; *p.z.*, posterior zygapophysis.

These are nearly circular in outline, the transverse diameter being a little longer than the vertical; beneath the neural canal the upper border is slightly concave; the surfaces are gently concave, with a median pit of such depth that the anterior and posterior pits can only be separated by a very thin layer of bone, but in no case have they been seen actually to communicate with one another. On the ventral side the articular faces have a well-defined rim or border, which in some cases may form a slight hypapophysial prominence, which looks as if it may be formed by a now completely fused intervertebral wedge-bone. The neural surface is slightly concave from side to side; the facets for union with the pedicles of the neural arch are diamond-

* *Op. cit.*

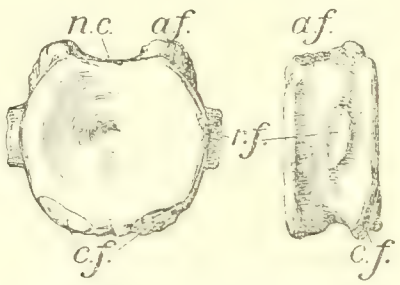
shaped and extend from one end of the centrum to the other. From the outer angle of these facets a slight ridge runs down the side of the centrum, becoming continuous below with the low prominence which bears the diapophysial and parapophysial surfaces for the articulation with the ribs. These surfaces taken together are pear-shaped, the rounded end being at the bottom, the pointed one at the top; they are in close apposition, being divided only by a slight groove which terminates at each end in a notch. The ventral surface of the centrum between the rib-facets is convex from side to side and slightly concave from before backwards. There is a pair of large nutritive foramina, the openings being about halfway between the mid-ventral line and the rib-facets.

The neural arch is high, the pedicles being relatively long; they widen out considerably at their lower end. The anterior and posterior zygapophyses (*a.z.* and *p.z.*) are large; their articular surfaces are oval and are slightly concave and convex, respectively, from side to side, and look forwards and backwards to a considerable extent. In this region the anterior and posterior zygapophyses are united by a ridge running upwards and backwards. The neural spine (*n.sp.*) is high and not very broad from before backwards; at the same time it is of considerable thickness from side to side, being much less compressed laterally than in the Elasmosauridæ. The anterior border of the lower part of the spine is thin and sharp-edged; it runs down to the anterior border of the arch between the anterior zygapophyses. Higher up the anterior border becomes thickened and rounded, and at the summit widens out and is roughened. The posterior face of the spine is flattened above and concave from side to side below, the concavity between the posterior zygapophyses being very deep and having deep pits for the attachment of ligaments.

The dorsal vertebræ are badly preserved in all specimens. It can be seen that the centra were much longer than in the cervical region, the longest being probably from about the middle of the back, where the articular faces are nearly circular in outline and very slightly concave; the sides of the centra are strongly concave in a longitudinal direction. The surfaces for union with the neural arch are very long, extending nearly the whole length of the centrum; the neural surface between these facets is very narrow. About two centimetres on either side of the middle line is a nutritive foramen, and there is another pair situated high up on the side. No good specimen of the neural arch in this region is available for description. It can, however, be seen that the pedicle of the arch was stout and that the transverse process was thick and bore a broad facet for the rib at its thickened extremity. The roof of the neural arch is broad and the stout neural spine is situated towards its hinder portion. The anterior border of the neural spine is continuous below with a deep groove which extends to the anterior border of the arch; its edges are raised and it encloses a roughened surface for the attachment of ligament. The lower end of the posterior border of the neural spine is also deeply hollowed.

The caudals (text-fig. 3), which are about 25–30 in number, have the centra rapidly shortening as the series is followed backwards, and the last four or five diminish in size very suddenly, the terminal centrum being a small irregularly-shaped nodule of bone, which, however, seems to have borne a rudimentary neural arch, but, so far as can be made out, neither caudal ribs nor chevrons. In the anterior caudals the articular surfaces of the centra are nearly circular in outline and are gently concave with a deep median pit. The neural surface (*n.c.*) is narrow, particularly in the middle where it is encroached upon by the deeply concave facets for the neural arch (*a.f.*). The sides of the centra are concave in a longitudinal direction; on either side they bear a short prominence (*r.f.*) with the summit of which the single-headed caudal rib articulated or fused: the nutritive foramina are situated just beneath these costal prominences. The ventral surface of the centrum is only slightly concave in a longitudinal direction; on its anterior and posterior edges are the semicircular chevron-facets (*c.f.*), the anterior looking downwards and forwards, the posterior, the larger of the two, downwards and backwards.

Text-fig. 3.



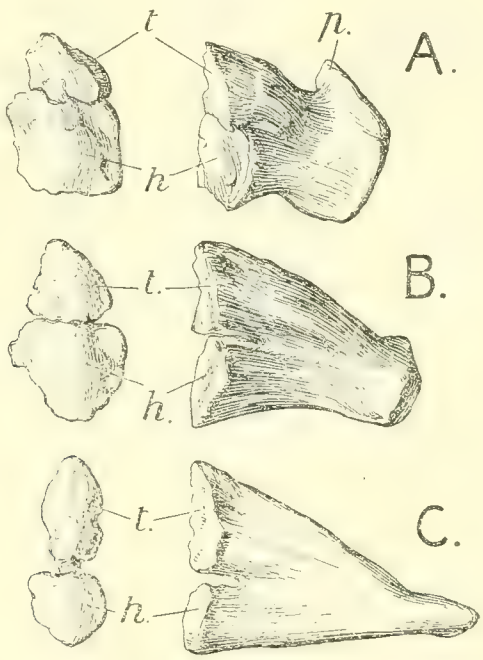
Centrum of a caudal vertebra of *Pliosaurus ferox*, from behind and from the left side. (R. 3536, ½ nat. size.) *a.f.*, facet for union with neural arch; *c.f.*, facets for chevrons; *n.c.*, floor of neural canal; *r.f.*, facet for rib.

Ribs (text-fig. 4).—So far as has been observed, there is no rib on the atlas; that on the axis is not well known, but seems to have been single-headed and to have articulated with a large facet borne mainly by the axis and partly by the second intervertebral wedge-bone and the odontoid. This facet shows no trace of division into an upper and a lower portion; in *Peloneustes* the rib of the axis is double-headed and borne by the centrum of the axis only. Behind the axis all the cervical ribs (text-fig. 4) are double-headed, with the possible exception of one or two posteriorly: the upper (diapophysial) head (*t.*) being separated from the lower (parapophysial) (*h.*) by a well-marked cleft which is continued on to the anterior and posterior face as a short deep groove. The distal end of the cervical rib is strongly compressed from above downwards and is produced backwards into a short angle (*p.*). The upper side of the proximal surface is roughened as if for the attachment of muscle, and from this point a ridge runs

down to the postero-external angle. The two or three hindmost cervical ribs are longer and more slender than those in front and form a transition to the dorsal type. Their articulation is single, or at least the separation between the head and tubercle is only very slightly marked and does not amount to a real division. Cervical ribs in this genus have been figured by Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. (1890) pl. v. fig. 2 (see also text-fig. 4).

The dorsal ribs are very strongly developed; they articulate by a single head, the concave surface of which is oval, the long axis being vertical. Immediately external to the head the rib narrows rather quickly for a short distance, then remains about the

Text-fig. 4.



Cervical ribs of left side of *Pliosaurus ferox*. The articular end and the anterior face of each are shown: A, from the anterior part of the neck; B and C, farther back. (R. 2446, ½ nat. size.)

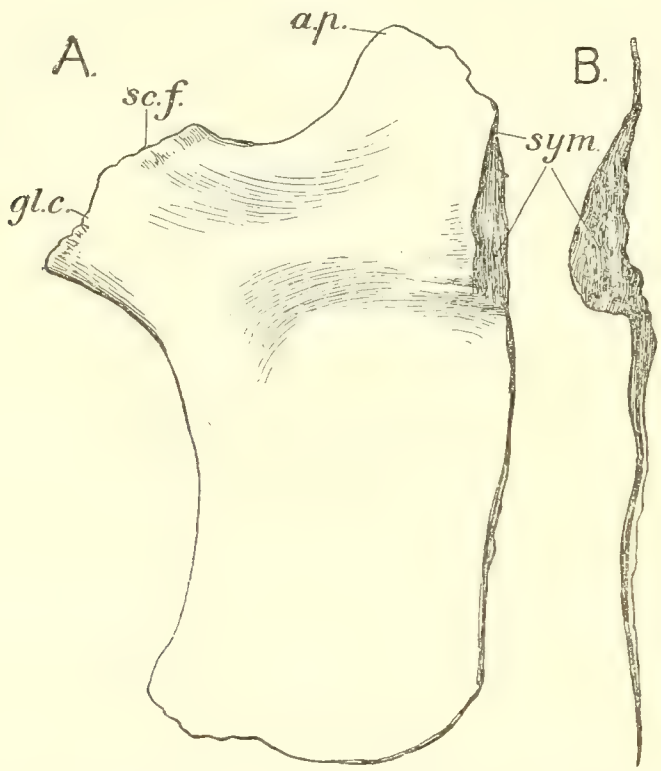
h., head of rib; *p.*, posterior angular process; *t.*, tubercle of rib.

same thickness to its lower end. It is somewhat compressed from before backwards and was probably grooved slightly along its posterior and perhaps its anterior surface, but owing to the crushing undergone by the specimens this is not certain. Some dorsal ribs of a very young individual (R. 3537) have been found in a quite uncrushed condition and present peculiar features. The articular head is small, its diameter being almost the same as that of the rib just outside it; its facet is flat and nearly circular with a slight ventral angle. External to the head, the rib runs first straight, then curves down, thickening gradually till near its distal end, when it again contracts and

terminates in a slightly concave surface, in which the bone appears to be made of a closely compressed bundle of individual bone-fibres. Evidently this was a sort of growing point, and immediately above it the surface is perforated by many vascular foramina which run upwards. Throughout nearly its whole length the rib is nearly circular in section, there being no trace of grooving: moreover, it appears to have been very heavy and solid in texture, somewhat like the rib of a Sirenian.

The caudal ribs are not well known. They articulate with the centrum by a single head, the surface of which is nearly flat. The body of the bone is compressed from

Text-fig. 5.



Immature left coracoid of *Pliosaurus ferox*: A, from above; B, symphysial surface. (R. 2738, about $\frac{1}{8}$ nat. size.)

a.p., anterior prolongation; *gl.c.*, glenoid cavity; *sc.f.*, facet for scapula; *sym.*, symphysial surface.

above downwards and curves a little backwards; the anterior and posterior edges seem to have formed strong cristiform ridges.

Shoulder-girdle (text-fig. 5).—No complete specimen of the shoulder-girdle is known, but some isolated bones have been found and can be definitely determined as belonging to *Pliosaurus*, because they are similar in form, at least so far as can be made out, to the bones of the imperfect shoulder-girdle associated with the skeleton R. 3536, of which the skull is preserved.

The *scapula* is a triradiate bone. The posterior ramus, which unites with the coracoid and forms the anterior half of the glenoid cavity, is triangular in section, the inner angle being sharp, the outer more rounded, while the lower forms a tectiform ridge, becoming sharper as it is traced forwards to the anterior angle of the bone and dividing the ventral from the outer surface of the dorsal ramus. The articular end is much thickened and bears the surfaces for union with the coracoid and for the glenoid cavity: the former is triangular in outline and makes an angle of about 100° with the latter, which is longer and slightly concave. The dorsal ramus is broad and flat, but no specimen showing its exact form is known. The anterior (ventral) ramus is not known in any specimen belonging to this species, but probably it was very similar to that of the scapula of a Pliosaur from the Kimmeridge Clay (Brit. Mus. R. 287), which in other respects it resembles. In this it is greatly expanded at its inner end and is broadly rounded. The scapula is also similar to that of *Peloneustes*, except that the expansion of the ventral ramus is considerably greater. Probably the ventral rami did not quite meet in the middle line, but had an interclavicle wedged between them as in *Peloneustes*.

The *coracoid* (text-fig. 5) is here described from an isolated complete example about the same size as that belonging to the skeleton above noticed. The greater part of the bone is very thin, the thickened portion lying between the surfaces for the scapula and glenoid cavity on the outer side and the deepened portion of the median symphysis on the inner side. From before backwards the symphysial border is nearly straight. Anteriorly, as mentioned above, it is much deepened for a short distance, giving rise to a strong convexity on the visceral face and a slight concavity below (text-fig. 5, *sym.*). Anteriorly the middle portion of the bone is prolonged forwards (*a.p.*), the outer side of the prolongation being the thin anterior edge of the bone which extends to the facet for the scapula; there is no evidence that the anterior prolongation was in contact with the ventral ramus of the scapula; it was fringed with cartilage, at least on its anterior and inner sides. The outer border of the bone behind the glenoid cavity is concave, the hinder convex or irregular; there is no very well-marked postero-external process. The surface for union with the scapula is triangular and much roughened with ridges; the base of the triangle marks the line of union with the glenoid surface, which is very large and in the form of half an oval; it is gently concave, and its surface is smoother than that for the scapula. The angle between the glenoid and scapular surfaces is more obtuse than in *Cryptocleidus*, and measures about 150°. The posterior border of the coracoid is grooved and evidently was fringed with cartilage in life.

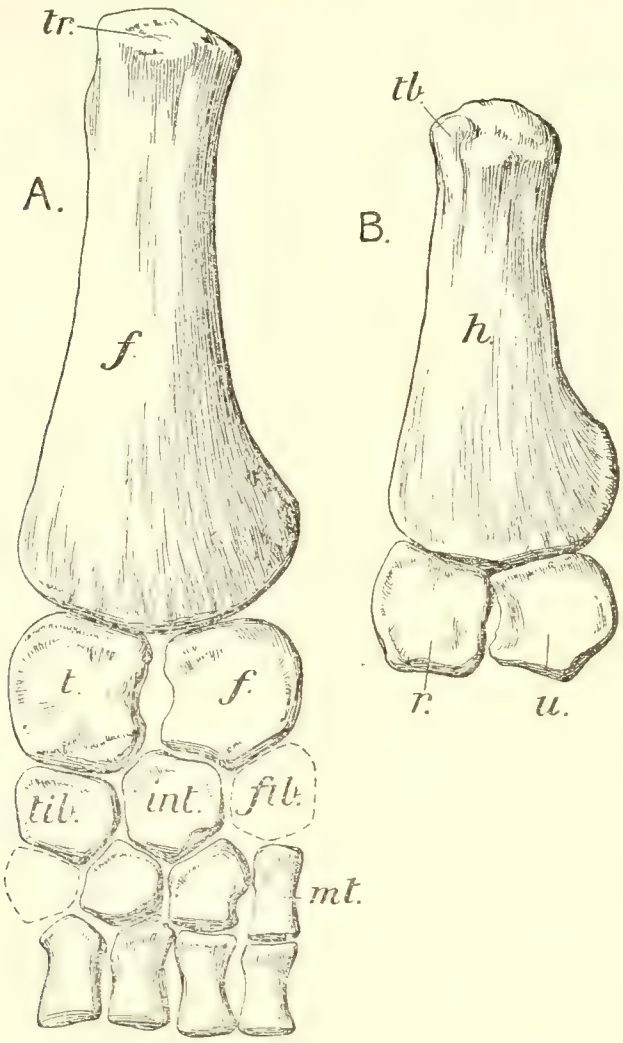
The clavicular arch is unknown in the genus: probably it was closely similar to that found in *Peloneustes* (p. 56).

Fore Limb (text-fig. 6, B).—Unfortunately no very complete specimen of the fore paddle is available for description, but since, so far as it is known, it is closely similar

to that of *Peloneustes*, of which good specimens are described and figured below, this is not of great importance.

The fore paddle is smaller than the hind, as is usual in this family. The *humerus* (*h.*) has a well-developed great tuberosity (*tb.*), beneath which it widens gradually to

Text-fig. 6.



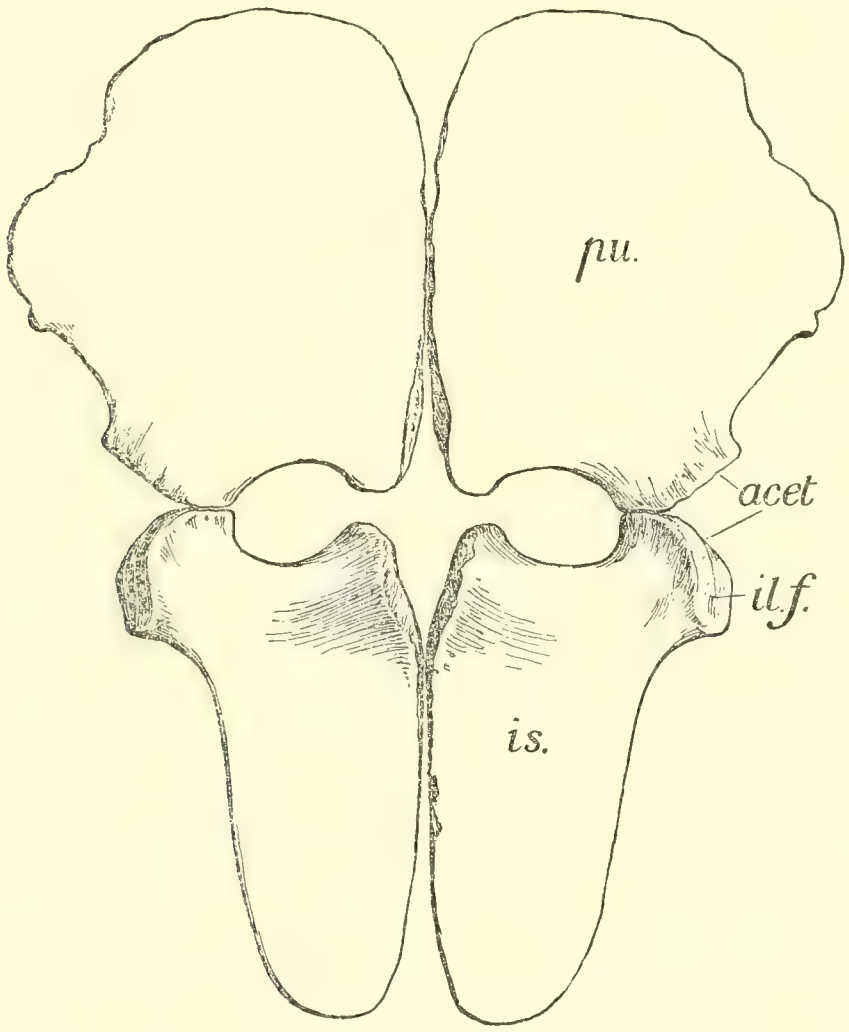
A, imperfect left hind paddle of *Pliosaurus ferox* (R. 2446); B, proximal portion of right fore paddle of same species or *Peloneustes evansi* (R. 2437). ($\frac{1}{4}$ nat. size.)

f., femur, fibula; *fib.*, fibulare; *h.*, humerus; *int.*, intermedium; *mt.*, metatarsal; *r.*, radius; *t.*, tibia; *tb.*, tuberosity of humerus; *tib.*, tibiale; *tr.*, trochanter of femur; *u.*, ulna.

the distal expansion, there being no narrowing in the shaft, such as is usual in the Elasmosaurs. The distal end is considerably expanded, more so relatively than it is in the femur. The *radius* (*r.*) and *ulna* (*u.*), which have been figured by Lydekker

(Quart. Journ. Geol. Soc. vol. xlvi. (1890) pl. v. fig. 4), are very similar in form to the tibia and fibula, but a little less elongated; they articulate with one another proximally and distally, but are separated in the middle by an oval vacuity. The radius is longer than wide; in the ulna the reverse is the case. Distally these two bones articulate

Text-fig. 7.



Pubes and ischia of *Pliosaurus ferox*. (R. 3536, $\frac{1}{12}$ nat. size.)
acet., acetabulum; *il.f.*, facet for ilium; *is.*, ischium; *pu.*, pubis.

with at least three elements, the *radiale*, *intermedium*, and *ulnare*, and probably there was also a postaxial accessory ossicle. There are three distal carpals and, as usual, the fifth metacarpal articulates with the ulnare. The metacarpals are much compressed on the plane of the paddle, the phalanges rather less so, so that they are

oval in section; they are much constricted in the middle. The number of phalanges in the several digits is unknown.

Pelvis (text-fig. 7).—An isolated specimen of the *ilium*, probably belonging to this genus, shows that it was very similar to that of *Peloneustes* described below (see p. 59). The *pubis* (*pu.*) is an immense plate of very thin bone; there is a thickened portion extending from the articular region to the posterior part of the median border, where the symphysial surface is somewhat thickened. When the bone was uncrushed the symphysial border must have been straight and extended nearly the whole length of the bone. The posterior edge is thin and sharp, and is concave; the postero-external angle is thickened and bears two surfaces—one, looking backwards, for union with the ischium, the other forming the anterior part of the acetabulum (*acet.*); these surfaces make a very obtuse angle with one another. In front of the articular surfaces the outer border of the bone is concave, then it passes by a strongly convex curve on to the anterior border, which is also convex and shows signs of having been fringed with cartilage in life.

The *ischium* (*is.*) is likewise a thin, greatly expanded bone, its ventral portion being much elongated. In the uncrushed bone there would be a long straight median symphysial surface for union with the opposite ischium; owing to the thickening of the bone opposite its neck, this symphysial surface is deepest in that region. The anterior border is concave and sharp, forming the posterior edge of the obturator foramen. The articular head is borne by a relatively narrow neck, in which the bone is thicker than in the expanded median portion; it bears three articular surfaces as usual—one, looking forwards, for union with the pubis; a second, looking outwards and a little forwards, forming the middle part of the acetabulum; and a third, the hindmost, looking upwards and backwards, for union with the ilium (*il.f.*). The pelvis seems to have been closely similar to that of *Peloneustes* described below (p. 59). In the specimen here figured both the pubes and ischium have been completely flattened by pressure: in their natural condition they must have been gently convex below and concave above.

Hind Limb (text-fig. 6, A).—The hind paddle is very similar to the fore, and is also much the same as the hind paddle of *Peloneustes* described and figured below (p. 59, text-fig. 23, B). It is, however, larger than the fore limb, and the femur is perhaps rather less expanded distally, while the tibia and fibula are rather more elongated than the radius and ulna, which they otherwise resemble. The proximal row of tarsals (tibiale, intermedium, and fibulare) are much like the corresponding bones in the fore paddle, and the same may be said of the rest of the tarsals, metatarsals, and phalanges.

Pliosaurus ferox, Sauvage, sp.

[Plates I. & II.; text-figs. 1–7.]

1873. *Liopleurodon ferox*, Sauvage, Bull. Soc. Géol. France, [3] vol. i. p. 378.
1880. *Polyptychodon ferox*, Sauvage, Bull. Soc. Géol. France, [3] vol. viii. p. 544.
1889. *Pliosaurus ferox*, Lydekker, Catal. Foss. Rept. Brit. Mus. pt. ii. p. 145.

Pliosaurus pachydirus, Seeley (Index to Aves, etc., in Woodwardian Museum, 1869, p. 118), and *Thaumatosaurus mosquensis*, Kiprijanoff (Mém. Acad. Imp. St. Pétersbourg, vol. xxxi. (1883) art. 6, p. 27), are perhaps synonyms.

Type Specimen.—A tooth from the Oxford Clay of Wast near Boulogne-sur-Mer.

The teeth in this species are circular in section, not trihedral as in the Kimmeridgian species. Lydekker regards this form as probably ancestral to *P. macromerus.*

All the following specimens from the Leeds Collection were obtained from the Oxford Clay in the neighbourhood of Peterborough.

R. 2630. Nearly complete skull with numerous isolated teeth. This specimen is figured on Pl. I. and was described and figured in Quart. Journ. Geol. Soc. vol. liii. (1897) p. 177, pl. xii. The whole has been somewhat crushed from above downwards, and the bones of the roof are thus somewhat difficult to determine.

The dimensions (in centimetres) of this specimen are :—

Length from tip of snout to occipital condyle	112·0
„ „ „ anterior angle of external nares	57·0
„ „ „ „ „ internal nares	36·0
Length from tip of snout to posterior end of the facial processes of the premaxilla	74·0
Length of the external nares	5·0
„ „ internal nares	6·5
„ posterior interpterygoid vacuities	11·0
Width of skull between the outer angles of the quadrates (perhaps exaggerated by crushing)	50·0
Width of skull at level of transpalatine bone	48·0
„ „ middle of internal nares	19·0
„ „ at diastema	11·3
„ „ at widest part of premaxillæ	12·0
Width of articular surface of quadrate	12·6
Greatest (transverse) diameter of occipital condyle	6·5

Teeth (Pl. II. figs. 2, 2 *a*, 2 *b*, 3, 4, 4 *a*):	Largest.	Smallest.
Length along outside of curve	23·5	6·2
Length of crown	8·5	2·0
Diameter at base of crown	2·8	1·1

R. 3536. A great part of the skeleton of a very large individual. The parts preserved are :— skull, mandible, many teeth, atlas and axis (fused), and twenty other cervical vertebræ (text-fig. 2) mostly wanting neural arches and ribs; twenty-three centra of dorsal vertebræ and fourteen caudals (text-fig. 3); numerous neural arches and cervical, dorsal, and caudal ribs; ventral ribs; portions of coracoid and scapula, humerus, radius, ulna, and numerous paddle-bones; pubes and ischium (text-fig. 7).

The skull in this specimen wants the roof between the external nares and the pineal foramen; the middle portion of the palate and the zygomatic arches are also wanting. The presence of sclerotic plates (see page 9) in this specimen is of interest. No teeth, except some of the uncut crowns of successional teeth, were found *in situ*. The cervical vertebræ are fairly well preserved, the neural arches and the cervical ribs in all cases separate; dorsals and caudals much crushed. The terminal caudals are present, showing the very rapid diminution in the size of the centra at the end of the tail.

The shoulder-girdle is badly preserved, but the proximal part of one fore paddle is in good condition. The humerus shows well that the distal expansion was a little more marked than in *Peloneustes*, and that the whole bone was more slender than in *Simolestes*. The enormous pubes and the ischium have been crushed out to nearly flat plates of bone.

The approximate dimensions (in centimetres) of this specimen are :—

Skull: length from quadrate to tip of snout	154·0
„ „ occipital condyle to tip of snout	126·5
transverse diameter of occipital condyle	8·0
width between outer ends of quadrates	72·0
width of quadrate	15·0
width of snout at constriction	13·7
„ „ „ widest part of anterior expansion	15·4
Mandible: extreme length	154·0
length of symphysis	30·5
width just behind symphysis	17·0
„ of articular surface	16·7
length of postarticular process	10·5

Teeth:			
Length along middle of curve	19·0	..	7·8
Height of crown	7·5	7·0	2·5
Greatest diameter of base of crown	3·0	2·7	1·5

Vertebræ	Atlas and axis.	4th (cervical).	15th (cervical).	17th (cervical).	23rd (pectoral).	Anterior caudals.	
Length of centrum on mid-ventral line	5·6	4·9	4·3	5·0	5·1	6·0	4·5
Width of posterior face of centrum	10·0	12·0	11·5	12·8	12·5	10·5	10·0
Height of posterior face of centrum	8·9	10·4	10·6	11·0	11·5	8·6	9·1
„ to top of neural spine	..	30·9	32·9	33·0			
„ of neural arch	..	..	22·2	21·7			
„ of neural spine	..	..	17·3	17·0			

Coracoid: width from outer angle of glenoid surface to symphysis	45·3
distance from anterior angle of surface for scapula to posterior angle of glenoid cavity	25·0
Scapula: width of articular end	14·7
„ neck	10·7
Humerus: length	53·8
width of upper end (crushed)	16·2
„ shaft at narrowest	12·3
„ lower end	26·3
Radius: length (anterior border)	11·7
width (proximal)	11·2
Ulna: length (approx. only)	10·1
width (proximal)	10·3
Pubis (approximate only):	
greatest length	78·0
„ width	68·0
width of articular region	21·3
length of symphysial border	73·0
Ischium (approximate only):	
greatest length of blade	83·0
width of blade in middle	32·0
„ neck	17·6
„ articular head	25·0

R. 2446 (Leeds Coll. 12). Portions of the skull and skeleton of a large individual. The parts preserved are:—exoccipital, anterior portion of premaxillæ, vomers, pterygoids, palatines, transverse bones, and numerous fragments of skull: symphysial and both articular portions of the mandible, also many fragments; numerous teeth (one figured by Lydekker in Quart. Journ. Geol. Soc. vol. xlvi. (1890) pl. v. fig. 1); centra of ten cervical vertebræ (one figured *loc. cit.* fig. 2), centra of two dorsal vertebræ and three caudals, neural arch of atlas and four others (*loc. cit.* fig. 3); second subvertebral wedge-bone; cervical ribs (text-fig. 4, also *loc. cit.* fig. 2); imperfect humeri, radius, and ulna (*loc. cit.* fig. 4), femora, tibiæ, and fibulæ (text-fig. 6, A), and numerous other paddle-bones.

In this specimen the skull is too much broken to supply any information of importance, the teeth are most perfectly preserved (see Lydekker's figure referred to above). The symphysial portion of the mandible shows very well the extent to which the splenial takes part in its formation. One of the median teeth remaining in the anterior portion of the premaxillæ shows that in this region the upper teeth bit against the lower and were greatly worn thereby; further back traces of wear are rarely seen, the upper and lower teeth interlocking, not biting against one another.

Some dimensions (in centimetres) of this specimen are :—

Mandible: width across symphysial region at narrowest point			13·4
Teeth:			
Length along curve	21·0	20·7	8·0
Height of crown	7·5	7·9	2·9
Diameter of base of crown	2·7	2·7	1·4
Greatest diameter of root	3·2	3·2	1·7

	Cervicals.			Caudals.	
Vertebræ	*a**.	*b*.	*c*.	*d*.	*e*.
Length in mid-ventral line	4·5	4·2	4·5	5·1	4·3
Height of articular surface of centrum.	9·2	9·0	9·7	9·1	6·1
Width of articular surface of centrum.	10·3	10·0	10·2	9·9	6·8

Neural arch of cervical vertebra: height from base of pedicle to top of neural spine	16 app.
height from top of arch to top of neural spine	10·3
Radius: length (outer side)	11·7
width, greatest	11·1
Ulna: length	10·2
width	11·6
Femur (crushed):	
length	60·9
width of upper end	?
„ middle shaft	14·1
„ lower end	25·3
Tibia: length	15·4
width	13·9
Fibula: length	14·1
greatest width	13·1
Intermedium: greatest length	8·7
„ width	8·5

R. 2447 (Leeds Coll. 11). Nearly complete mandible; there were about twenty-eight teeth on each side, seven of which were situated in the symphysial region, but all have been lost and are represented only by their alveoli. Figured on Pl. II. figs. 1, 1 *a*.

The dimensions (in centimetres) of this specimen are :—

Extreme length from posterior angle to tip of symphysis		109·0
Length of symphysis	(approx.)	23·0
Greatest width across symphysial region		11·0
Width of postsymphysial constriction		10·2
Depth of coronoid process	(approx.)	9·7
Width of articular surface		10·3
Length of postarticular process	(approx.)	7·4
Width between outer angles of the postarticular processes.		31·3

* Figured by Lydekker, *loc. cit.*

R. 3901. Three sclerotic plates.

R. 3537. Vertebral centra, neural arches, ribs, and an ischium of a very young individual.

R. 2738. Left coracoid, nearly complete (text-fig. 5), comparatively little crushed.

The dimensions (in centimetres) are :—

Extreme length	86·0
Width opposite posterior angle of glenoid cavity	52·4
Length of combined surfaces for scapula and glenoid cavity	24·1
Depth of glenoid surface	8·5
Greatest depth of thickened portion of glenoid surface	7·0
Length from anterior angle of scapular surface to postero-external angle	61·8
Width from postero-external angle to symphysial border	38·5

Genus **SIMOLESTES**, Andrews.

[Ann. Mag. Nat. Hist. [8] vol. iv. (1909) p. 424.]

Pliosaurs in which the head is short and broad; mandible with deep massive rami meeting in front in a short symphysis, extending back to the fifth or sixth tooth; about twenty-six closely crowded teeth on each side of the mandible: teeth circular in section, without carinæ, the enamel being raised into a series of fine longitudinal ridges, some extending to the tip of the crown; the ridges most numerous on the inner (concave) side of the crown. Neck short, consisting of about twenty vertebræ, the centra of which are about as wide as high, while their length is only about half as great. The shoulder-girdle and pelvis are much as in *Pliosaurus*, but the humerus and femur seem to have been more definitely expanded at their distal ends than in members of that genus. The humerus is the shorter of the two. Ventral ribs were present.

This genus is distinguished from *Pliosaurus* and *Peloneustes* by the shortness of the snout and of the mandibular symphysis.

Only one species is at present known, from the Oxfordian of England.

Simolestes vorax, Andrews.

[Plate III.; text-figs. 8–10.]

1909. *Simolestes vorax*, Andrews, Ann. Mag. Nat. Hist. [8] vol. iv. p. 427, text-figs. 4–7.

Type Specimen.—The greater part of a crushed skeleton (R. 3319), including the skull (Pl. III. figs. 1, 1 *a*), mandible (Pl. III. figs. 1, 1 *a*), vertebral column (Pl. III. fig. 4), pectoral girdle (text-fig. 8), except the clavicular arch; both humeri (text-fig. 9, A), right radius and ulna (text-fig. 9, A) and other paddle-bones, pelvis (text-fig. 10), both femora (text-fig. 9, B), left tibia and fibula and other paddle-bones.

Skull (Pl. III. figs. 1, 1 *a*).—The skull is unfortunately too much crushed and imperfect for it to be possible to give a complete account of its structure, since not only are portions wanting altogether, but the sutures in the parts preserved are very obscure.

The *basioccipital* (*boc.*) bears the whole of the very large, sessile, and nearly hemispherical occipital condyle. Beneath the condyle the body of the bone is covered and concealed by the underlying pterygoids (*pt.*), which meet beneath it in the middle line; large lateral (pterygoid) processes are present, the obliquely truncated ends of which united with the posterior rami of the pterygoids. The exoccipital and opisthotic seem to have been closely similar to the same elements in the other members of the family, e. g. *Peloneustes* (see p. 35).

The *quadrate* (*q.*) is a large and very stout bone, its articular surface for the mandible being very wide; in fact, the whole jaw-apparatus seems to have been exceptionally strong. The *squamosal* (*sq.*) is of the usual triradiate form; the inferior ramus unites with the quadrate, the upper runs up to the parietal, but owing to crushing the relations between the two bones are obscure; the anterior (zygomatic) ramus is comparatively slender.

The *parietals* (*par.*) form a high narrow sagittal crest between the temporal fossæ. They seem to surround the relatively small pineal foramen (*p.f.*), but their relations to the frontals cannot be made out. In the Plesiosaurs, the fronto-parietal suture is usually opposite the anterior end of the pineal foramen, so that the frontals take part in the formation of that opening, or just in front of it, so that they are excluded. Here it seems possible that the foramen is entirely enclosed by the parietals, which may extend some distance in front of it, meeting in front the hinder extremities of the long facial processes of the premaxillæ, as Williston describes in the skull of *Dolichorhyncops* *. If this is the true interpretation, then the *frontals* (*fr.*) are overlaid to a great extent by the parietals and only appear laterally on the outer surface of the skull; they unite anteriorly with the facial processes of the premaxillæ; external to the frontals there seems to be a separate bone, which is probably the *prefrontal.* The postorbital bar is missing on both sides, so that no trace of the postfrontal or postorbital can be seen.

The anterior part of the snout is relatively shorter than in *Plesiosaurus* and *Peloneustes*; on their enlarged dentigerous portion, the *premaxillæ* (*pmx.*) each carry 5 or 6 teeth, the anterior pair being the smallest and in close apposition on the middle line. The facial processes are prolonged back as far as the level of the anterior border of the orbit, where they meet the parietals. The *maxillæ* (*mx.*) are very incomplete on both sides in the specimen described, and it is not known how many teeth they each bore. They extend back some distance along the facial processes of the premaxillæ

* "North American Plesiosaurs, Pt. I.," Field Columbian Museum, Geological Series, vol. ii. no. 1 (1903), p. 16, pl. iv. fig. 1.

and send a process between those bones and the external nares; the other bones bordering these openings cannot be determined.

The palate is fairly well preserved, but most of the sutures are obliterated. The *pterygoids* (*pt.*) are very large bones; posteriorly they run back in a strong vertically compressed process for union with the quadrate; beneath the basis cranii they meet in a median suture, which probably extends forwards beneath the hinder portion of the basisphenoid. The ventral edges of the quadrate processes are continued forwards on the ventral face of the pterygoids as strong crest-like ridges, which bifurcate anteriorly where the bones diverge from one another to form the outer border of the posterior interpterygoid vacuity (*p.p.v.*) in the posterior region: external to these ridges there is a deep concavity. As usual, the posterior interpterygoid vacuity is divided longitudinally by the *parasphenoid* (*pas.*), which is here narrow; anteriorly, no doubt, it was interposed for a short distance between the pterygoids, which in front of it unite in the median suture which seems to continue to their anterior extremities, the anterior interpterygoid fossa being absent. The lateral ramus of the pterygoid has its posterior border formed by the outer branch of the ventral ridge referred to above; at its outer end the ridge terminates in a knob, which, with a corresponding knob on the transpalatine (ectopterygoid), forms a strong projection downwards from the palate. The precise limits of the palatine portion of the pterygoids cannot be made out, the sutures between them and the palatines and vomers being invisible; no doubt they united in front with the *vomers*, which can be seen to form a strong convex bar of bone between the internal nares (*i.nar.*). The *palatines* (*pal.*) are perforated by a foramen which may approximately mark their line of union with the pterygoids: posteriorly they unite with the lateral rami of the pterygoids and the transpalatines; there may have been a small vacuity at the junction of the three bones.

Mandible (Pl. III. figs. 1, 1 *a*).—The mandible is stout and solidly constructed, the rami being deep. The symphysis (*sym.*) is deep but short, extending back to about the fifth or sixth tooth; it is considerably expanded from side to side and the teeth on it are enlarged, and indeed are the largest in the jaw. The anterior portion of the ventral face of the symphysis makes a well-marked angle of about 145° with the posterior portion, which is in the same line as the ventral borders of the rami. These are convex outwards, curving in towards the articulations for the quadrates. Their ventral borders are gently convex on the posterior half and concave in front, where they are continued into the symphysis as strong rounded ridges. The *splenial* enters the ventral part of the symphysis for a short distance; posteriorly it rises gently, overlapping the anterior end of the united articular-surangular. The *coronoid* seems to have been arranged much as in *Peloneustes* (see p. 45), extending on the inner face of the ramus from the coronoid angle, which it helps to form, to the symphysis. Its lower edge was probably overlapped by the splenial, while its upper border forms a ridge parallel to the alveolar border. The articular surface for the quadrate consists of two concavities separated by

a slight convexity: it is very wide. The postarticular process is relatively very small.

The five or six teeth (Pl. III. figs. 2 & 3) in the symphysial region are greatly enlarged; behind these are about twenty closely-crowded teeth, the first five or six small, then about ten of moderate size, and behind these a gradual decrease in size to the end of the series. The crowns are sharply pointed, curved and circular in section, and without marked carinæ, the enamel being marked by a series of fine longitudinal ridges, only a few of which extend to the tip; these ridges are most numerous on the inner (concave) side of the crown. The upper teeth are of a similar character.

Vertebral Column (Pl. III. fig. 4).—All the vertebræ in the type specimen are much crushed and no other skeleton in which they are preserved is at present known. The result of the crushing is that the vertebræ are distorted in various ways, so that little can be made out as to their exact form and proportions. The cervical region consists of about twenty vertebræ, including the atlas and axis, which are fused with one another. The atlantal cup can be seen to be completed below by a large wedge-bone in the usual manner. The succeeding cervicals (Pl. III. figs. 4, 4 *a*, 4 *b*) have short broad centra, the length of which in the mid-ventral line is about half the width; the height of the uncrushed centrum seems to be about the same as the width. The articular ends are gently concave. The double rib-facet (*r.f.*) is raised on a prominence projecting downwards and outwards; the upper and lower surfaces, which are deeply concave, are separated by a well-marked ridge. In the neural arch the pedicles are long and their bases unite with the whole length of the centrum; in the type specimen the neuro-central suture is still open. The zygapophyses (*a.z.*, *p.z.*) are very large and project very considerably both in advance of and behind the centrum; their articular facets are oval and nearly flat. The neural spines (*n.sp.*) seem to have been very short in the front of the neck, but increased in height posteriorly, though possibly those at the extreme hinder part of the neck were a little shorter than those anterior to them.

There appear to have been about thirty dorsals, but they are all so distorted that no description is possible; the same may be said of the caudals, the centra of which seem to have been rather deeply concave with a central pit.

Shoulder-girdle (text-fig. 8).—This, so far as known, is typically Pliosaurian. The *scapula* (*sc.*) is of the usual triradiate form, the ventral ramus (*v.sc.*) being much expanded and very thin; its inner end is broadly convex. A strong ridge separates the ventral surface from the outer face of the dorsal ramus (*d.sc.*).

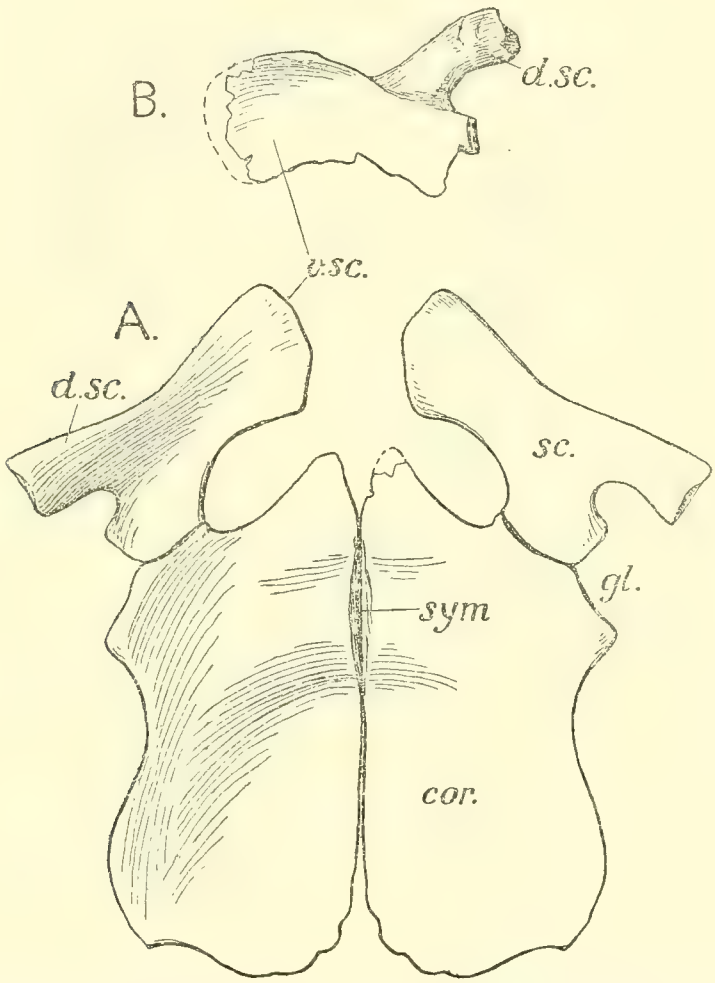
The *coracoid* (*cor.*) is a large plate of bone, very thin posteriorly but thickened at the level of the glenoid cavity, the thickening forming a convexity on the dorsal (visceral) surface which extends to the middle line, where it bears the deepened part of the symphysial surface (*sym.*) which is convex above and concave below (*cf.* text-fig. 21). In front of this thickened region the bone again becomes thin and is prolonged

forwards considerably in advance of the scapular surface; probably the median union of the coracoids was continued in the anterior region. It is doubtful whether the ventral ramus of the scapula met this anterior prolongation of the coracoids.

The clavicular arch is unknown.

Fore Limb (text-fig. 9, A).—The fore limb is considerably smaller than the hind, as usual in the family. The *humerus* (text-fig. 9, A) has its distal expansion more clearly

Text-fig. 8.



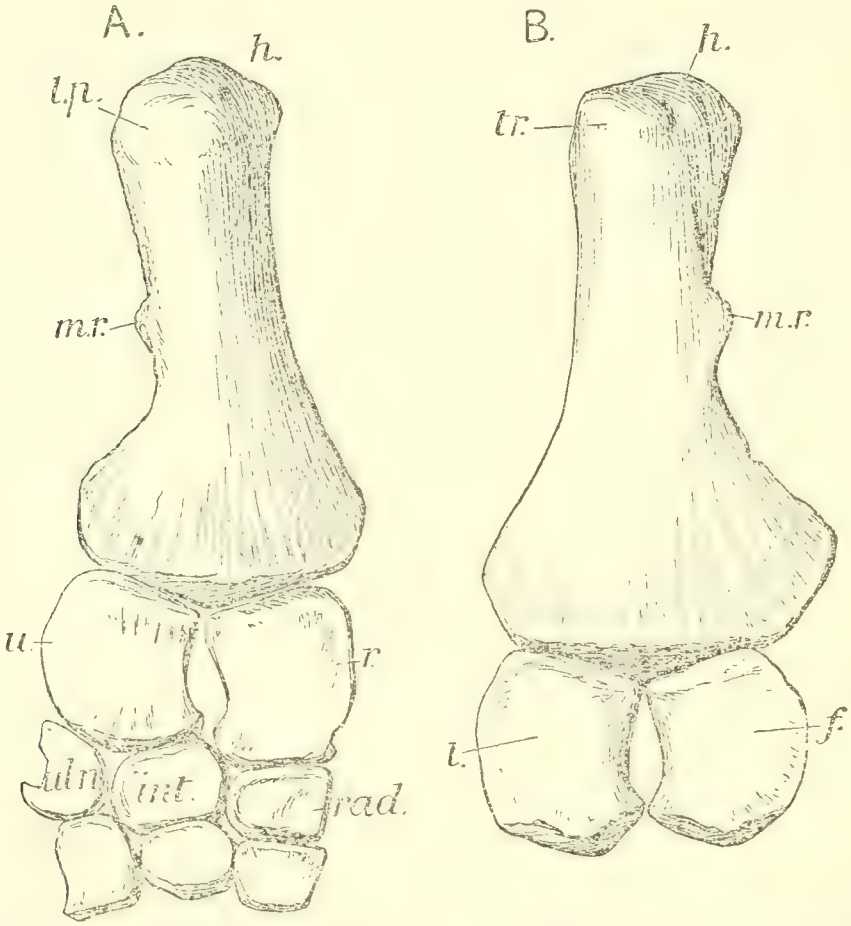
Shoulder-girdle of *Simolestes vorax*: A, from above; B, left scapula from below. (R. 3319, about $\frac{1}{10}$ nat. size.)

cor., coracoid; *d.sc.*, dorsal ramus of scapula; *gl.*, glenoid cavity; *sc.*, scapula; *sym.*, symphysial surface of coracoids; *v.sc.*, ventral ramus of scapula.

marked off from the shaft than is usual in the Pliosauria. In the type skeleton this bone is very completely ossified, the processes and rugosities for the attachment of muscles (*m.r.*) being strongly developed. The tuberosity (*l.p.*) ends proximally in a

flat, roughly quadrate surface, making an obtuse angle with the head (*h.*); it is situated towards the posterior edge of the upper surface. The posterior border of the shaft is concave, except for the presence of a strong pointed prominence for the attachment of a muscle (*m.r.*); the anterior border is less distinctly concave, the distal expansion being much more developed postaxially than preaxially. The distal surface bears two subequal facets, making a very obtuse angle with one another, for the radius and ulna. Externally to these facets the anterior and posterior borders of

Text-fig. 9.



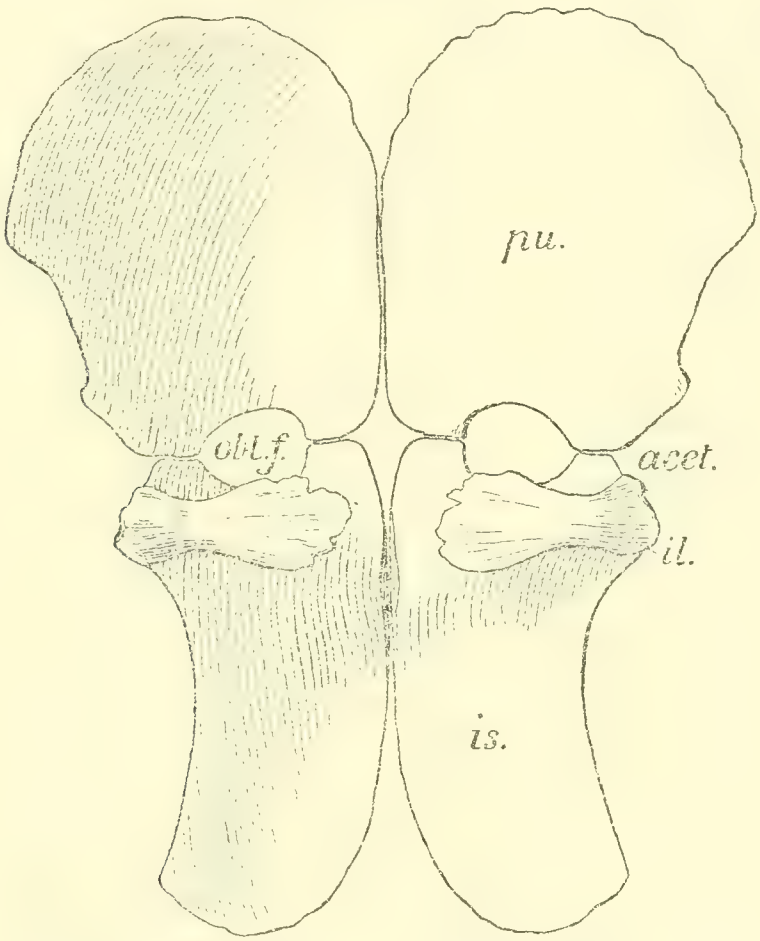
Imperfect fore and hind paddles of *Simolestes vorax*: A, portion of right fore paddle from above; B, portion of left hind paddle from above. (R. 3319, about $\frac{1}{6}$ nat. size.)

f., fibula; *h.*, head of humerus and femur; *int.*, intermedium; *l.p.*, tuberosity of humerus; *m.r.*, ridge for the attachment of muscles; *r.*, radius; *rad.*, radiale; *t.*, tibia; *tr.*, trochanter; *u.*, ulna; *uln.*, ulnare.

the distal expansion were probably fringed with cartilage. The *radius* and *ulna* (*r.* & *u.*), though much flattened, are less shortened than in the Elasmosaurs. The radius (*r.*) is a little the longer of the two; its proximal end bears a flat straight surface for union

with the humerus; its anterior (preaxial) border is thin and convex, while its inner (postaxial) side is concave and with the similarly concave preaxial border of the ulna encloses a considerable opening. Distally the bone bears a straight facet at right angles to its long axis for union with the radiale, and a very short surface for the intermedium, inclined to the last. The ulna (*u.*) is shorter than the radius; its proximal end bears a flat facet for the humerus. Its anterior border, as already noted,

Text-fig. 10.



Pelvis of *Simolestes vorax*, from above. (R. 3319, about $\frac{1}{10}$ nat. size.)
acet., acetabulum; *il.*, ilium; *is.*, ischium; *obt.f.*, obturator foramen; *pu.*, pubis.

is concave, the posterior is convex; distally it bears two facets inclined to one another, for the intermedium and ulnare. The usual three proximal carpals (*radiale*, *intermedium*, and *ulnare*) are present. Proximally the radiale and ulnare articulate only with the radius and ulna respectively; the intermedium unites with the radius by a short facet and with the ulna by a long one. The arrangement of the rest of the fore paddle-bones is not certain.

Pelvis (text-fig. 10).—This is chiefly remarkable for the large size and extreme thinness of the pubes and ischia and for the great elongation of the latter. The *pubis* (*pu.*) is a broad sheet of bone; its inner (symphysial) border is nearly straight and is a little thickened in its posterior third. The anterior edge is broadly convex and in life was fringed with cartilage. The outer border is sharp and concave. Postero-externally the bone is somewhat thickened and bears two surfaces, the anterior forming the front of the acetabulum, the posterior, making a very obtuse angle with it, uniting with the ischium, there being, as usual in the group, no union between the pubis and ilium. Internal to the surface for the ischium the posterior border is sharp and concave, forming the front of the obturator foramen, which seems to have been closed by a backward projection of the median portion of the pubis meeting a corresponding forward projection of the *ischium* (*is.*). This latter is, in the main, a greatly elongated plate of bone uniting with its fellow in the middle line in a straight suture; at its anterior end it is somewhat thickened, so that the symphysial surface is there deepened. Posteriorly the bones diverge a little from one another, but in life were probably united by cartilage for some distance behind the true symphysis. The posterior end of the bone is rounded, the outer border concave. The prominent thickened antero-external region is separated from the main body of the bone by a neck; it bears, as usual, three facets, the anterior for union with the pubis, looking directly forwards, the middle one forming the middle part of the acetabulum (*acet.*), and the posterior looking somewhat upwards and outwards for articulation with the ilium. Internal to the pubic facet the anterior border of the bone is sharp and concave, forming the hinder border of the obturator foramen. Internal to this, again, is the median prominence for union with the pubis, the pubic-ischial symphysis being, as above noted, continuous from end to end of the pelvis.

The *ilium* (*il.*) is greatly crushed, particularly at its upper end, which seems to have been somewhat expanded; at the distal end there are the usual two facets, one for union with the ischium, the other forming the posterior portion of the acetabulum (*acet.*).

Hind Limb (text-fig. 9, B).—The *femur* is considerably longer than the humerus, but is very similar in form. The trochanter (*tr.*) is well developed and is defined posteriorly by a shallow groove, which extends some distance down the posterior face of the shaft, the outer border of the lower end of the groove bearing a strong angular prominence (*m.r.*) with rugose surfaces for the attachment of muscles; beneath this point the shaft is oval in section, though the antero-posterior diameter is not much greater than the vertical one. The distal expansion is similar to that of the humerus. It bears two facets for union with the tibia and fibula, and for the rest seems to have been fringed with cartilage. The *tibia* (*t.*) and *fibula* (*f.*) are almost exactly similar in form to the radius and ulna, though perhaps a little longer in proportion to their width. Their relation to the proximal row of tarsals is the same as that existing between the radius and ulna and the proximal row of carpals.

R. 3319. An imperfect and much crushed specimen. The parts preserved are :—Skull and mandible (Pl. III. figs. 1, 1 *a*) ; twenty cervical vertebræ, some with neural arches (Pl. III. figs. 4, 4 *a*, 4 *b*) ; thirty dorsals and nineteen caudals, all distorted and for the most part wanting arches and ribs ; scapulæ and coracoids (text-fig. 8), humeri (text-fig. 9, A), right radius and ulna (text-fig. 9, A), pelvis (text-fig. 10), femora (text-fig. 9, B), left tibia and fibula (text-fig. 9, B), and a number of other paddle-bones. Type specimen described and figured in Ann. Mag. Nat. Hist. [8] vol. iv. (1909) pp. 424–429, text-figs. 4–7.

The approximate dimensions (in centimetres) of this specimen are :—

Skull (Pl. III. figs. 1, 1 *a*) :	
Length from occipital condyle to tip of snout	73·0
Width between the outer angles of the quadrates	51·0
Diameter of occipital condyle	5·5
Width of the articular end of the quadrate	10·3
Mandible (Pl. III. figs. 1, 1 *a*) :	
Greatest length	97·0
Length of symphysis	17·3
Width at posterior end of symphysis	13·3
Middle cervical vertebra (Pl. III. figs. 4, 4 *a*, 4 *b*) :	
Length in mid-ventral line	3·2
Width of centrum	7·9
Height	7·9
„ to top of neural spine	21·5
Scapula (text-fig. 8) :	
Greatest length	36·0
Length from anterior angle to top of dorsal ramus in a straight line	39·5
Width of neck	11·4
Coracoid (text-fig. 8, A) :	
Length	71·0
Width at narrowest point	32·0
„ between the glenoid cavities of the two bones as mounted	65·0
Humerus (text-fig. 9, A) :	
Length	43·0
Width of shaft at narrowest	10·5
„ distal expansion	21·8
Pubis (text-fig. 10) :	
Greatest length	60·0
„ width	48·0
Ischium (text-fig. 10) :	
Greatest length	61·0
„ width opposite acetabulum	32·0
Width of neck	15·0

Ilium (text-fig. 10):	
Length	31·0
Width of distal end	10·2
Femur (text-fig. 9, B):	
Length	50·0
Greatest width at proximal end	15·0
Width of the shaft at narrowest	9·8
„ distal expansion	27·5

R. 3170. Portions of skull, nearly complete mandible, teeth, anterior wedge-bone of atlas, numerous much-crushed centra of vertebræ, including five cervicals and ten caudals; imperfect scapulæ, portions of coracoids; humeri, radius, ulna, ?ilium, femora, tibiæ, fibulæ, and numerous paddle-bones.

The dimensions (in centimetres) of this specimen are :—

Skull: width of articular end of quadrate	(approx.)	8·7
Mandible: length		84·5
length of symphysis	(approx.)	14·0
width of symphysis		14·5
„ behind symphysis		12·8
„ of articular surface	(approx.)	9·2
Scapula: width of articular head		9·4
„ middle of ascending ramus		4·9
Humerus: length		39·5
width of shaft at narrowest		8·8
„ distal expansion	(approx.)	22·0
Radius: length		13·3
width at upper end		9·7
Ulna: length		11·7
approx. width in middle		9·2
Femur: length	(approx.)	45·8
width of shaft at narrowest		9·0
„ distal expansion	(approx.)	22·7
Tibia: length		15·7
width at upper end		11·0
Fibula: length		14·1
width in middle		10·0

Genus **PELONEUSTES**, Lydekker.

[Quart. Journ. Geol. Soc. vol. xlv. (1889) p. 49.]

Pliosaurs which are smaller than the members of the typical genus *Pliosaurus*. Skull elongated, the premaxillæ very long, each bearing six teeth. Mandibular symphysis greatly elongated, bearing about 12–15 teeth on either side. Neck short;

the cervical vertebræ 21–22 in number, the centra much shorter than wide. The neural spines high and narrow. The limbs and limb-girdles generally similar to those of *Pliosaurus*.

This genus was established by Lydekker for the reception of two species of Pliosaurian reptiles—*Peloneustes æqualis*, Phillips, sp., from the Kimmeridge Clay, and *P. philarchus*, Seeley, sp., from the Oxford Clay. Subsequently (Catal. Foss. Rept. Brit. Mus. pt. iv. Supplement, p. 273) *Pliosaurus evansi* was also referred by him to this genus. This species is larger than the other two, and in some respects seems transitional between *Peloneustes* and *Pliosaurus*: a large mandible with an elongated symphysis is here referred to it, and possibly some of the skeletons assigned to *Pliosaurus* may also belong here.

Middle Jurassic; England, Russia *.

The following account of the structure of the skull and skeleton in this genus is founded mainly on two fairly complete skulls and mandibles (R. 2679 and R. 3803) of *P. philarchus*, and a nearly complete skeleton (R. 3318) of the same species, now mounted in the Gallery of Fossil Reptiles.

Skull (Pl. IV.; text-figs. 11–13).—The skull in this genus has already been described in some detail in the Annals and Magazine of Natural History, [6] vol. xvi. (1895) p. 242, and the following account is founded partly on the description there given and partly on the examination of several other well-preserved specimens, particularly R. 2679 and R. 3803.

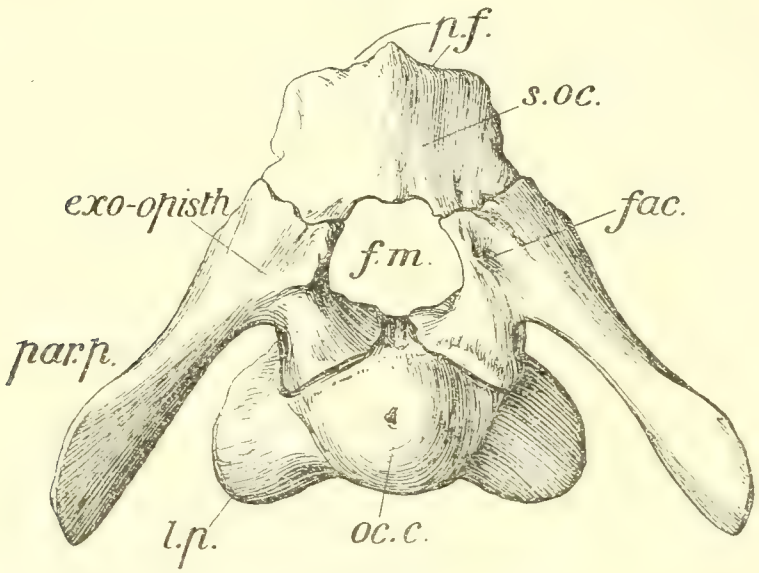
The general outline of the skull is that of an isosceles triangle, the apex of which is blunt and the height about two and a half times the length of the base, that is the width of the hinder end of the skull between the outer angles of the quadrates. The *basioccipital* (*b.oc.*; *oc.c.*, text-fig. 11) is a very massive bone; it bears the whole of the occipital condyle (*oc.c.*), with the exception of a very small portion of the supero-lateral border borne by the exoccipitals. The condyle is oval in outline, the long axis being transverse. The lateral regions of the bone are produced outwards and downwards into a pair of very stout processes (*l.p.*), the truncated outer ends of which look outwards and downwards and are much roughened; they may have served in part for muscle-attachments, but the anterior part at least was probably overlapped by the pterygoids. The upper surface of the basioccipital bears two roughly quadrate surfaces for union with the exoccipitals. These surfaces are concave and much roughened; they are separated in the middle line by a narrow ridge of bone, the basioccipital having taken a very small share in the formation of the border of the *foramen magnum*.

The *exoccipital* (*exo-opisth.*, text-figs. 11 & 12, D & E) in all specimens examined

* A. Riabinin, "Zwei Plesiosaurier aus den Jura und Kreideablagerungen Russlands," Mémoires du Comité Géologique, n. s. livr. 43 (St. Petersburg, 1909).

is fused with the *opisthotic*, the line of division (text-fig. 12, D, *s.*) being quite distinct on the surfaces for union with the supraoccipital and basioccipital. The united bones (*exo-opisth.*) consist of a stout columnar portion forming the sides of the foramen magnum and enclosing part of the auditory organ, and a long paroccipital process (*par.p.*) projecting outwards and downwards and expanding somewhat at the end. The posterior border of the stout columnar portion is broadly rounded below and bears a backwardly directed facet above (text-fig. 11, *fac.*), looking like a zygapophysis; this may have articulated with a pro-atlas, or perhaps merely served for the attachment of ligament. The lower end of the combined bones widens out and bears a broad

Text-fig. 11.



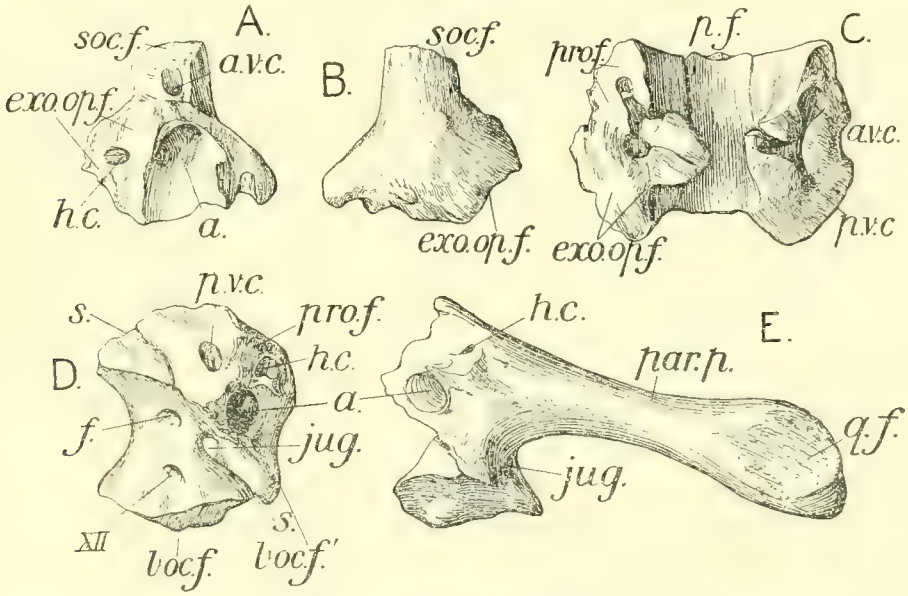
Occipital region of skull of *Peloneustes philarchus*, from behind. (R. 3803, $\frac{2}{3}$ nat. size.)

exo-opisth., exoccipital-opisthotic; *fac.*, facet like a zygapophysis; *f.m.*, foramen magnum; *l.p.*, lateral (pterygoid) process of basioccipital; *oc.c.*, occipital condyle; *par.p.*, paroccipital process; *p.f.*, facet for union with the parietals; *s.oc.*, supraoccipital.

surface, convex in the middle, for union with the basioccipital; the greater part of this surface is formed by the ventral end of the exoccipital (text-fig. 12, D, *boc.f.*), but the anterior angle, which is separated from the rest by a deep groove, is on the lower end of the opisthotic (*boc.f.'*). At their upper ends also the united bones widen out, here bearing two facets—a posterior, triangular one, looking inwards and upwards, for union with the supraoccipital (text-fig. 12, D), and a smaller anterior surface directed forwards, upwards, and inwards for the lower end of the prootic (*pro.f.*). Only a small portion of the posterior surface is formed by the exoccipital, the remainder of the hinder surface and the whole of the anterior being on the opisthotic. In the posterior portion of the opisthotic surface there is the oval opening of the passage which lodged the lower

part of the posterior vertical semicircular canal (*p.v.c.*); this passage communicates with the large rounded fossa (*a.*) situated on the antero-internal face of the opisthotic and lodging the ampulla of the canal; this same cavity also communicates with the channel of the horizontal semicircular canal (*h.c.*), the opening of which is in the middle of the facet for the prootic. The inner face of the exoccipital is concave from above downwards; it is perforated by two foramina, the upper (*f.*) perhaps for a blood-vessel, the lower for the hypoglossal nerve (XII.); this latter opens externally on the posterior wall of the outer opening of the jugular foramen (*jug.*). This foramen is

Text-fig. 12.



Bones of the auditory region of the skull of *Peloneustes philarchus* (R. 3803, $\frac{2}{3}$ nat. size): A, prootic, inner face; B, prootic, outer face; C, supraoccipital, anterior face; D, exoccipital-opisthotic, inner face; E, exoccipital-opisthotic, anterior face.

a., cavities for ampullæ; *a.v.c.*, channel for anterior vertical semicircular canal; *boc.f.*, facet for basioccipital borne by exoccipital; *boc.f.'*, facet for basioccipital borne by opisthotic; *exo.op.f.*, facet for exoccipital-opisthotic; *f.*, ? vascular foramen; *h.c.*, channel for horizontal semicircular canal; *jug.*, jugular foramen; *par.p.*, paroccipital process; *p.f.*, facet for parietals; *pro.f.*, facet for prootic; *p.v.c.*, channel for posterior vertical semicircular canal; *q.f.*, quadrate facet on paroccipital process; *s.*, remnants of suture between the exoccipital and opisthotic; *soc.f.*, facet for supraoccipital; XII, foramen for the hypoglossal nerve.

enclosed between the exoccipital behind and the opisthotic in front; it is a large oval opening which no doubt transmitted the vagus nerve together with other nerves and vessels; externally it opens beneath the base of the paroccipital process and, as mentioned above, receives the outer opening of the hypoglossal canal. On the inner face the posterior edge of the opisthotic forms a prominent oblique ridge, overhanging the

inner opening of the jugular foramen (*jug.*) and separating it from the opening of the ampulla (*a.*) above noticed. At its lower end the opisthotic is separated from the exoccipital by a deep groove (text-fig. 12, D, *s.*) both on the lower and inner sides of the bones, but externally complete fusion between them seems to have taken place. The paroccipital process (*par.p.*) is borne by the upper part of the opisthotic, it arises by a broad base and is oval in section. Towards its middle it contracts and becomes more compressed; distally it again widens out and is greatly compressed from before backwards; the posterior face of this expanded portion is gently convex from above downwards, the anterior somewhat concave and possessing a rugose surface (*q.f.*) apparently for union with another element, the quadrate or quadrate-process of the pterygoid; the actual distal end of the paroccipital is occupied by a surface that probably was capped by cartilage during life.

The *supraoccipital* (*s.oc.*, text-figs. 11, 12, C) is a broad band of bone curved from side to side, the inturned ends being enlarged and lodging a portion of the auditory organ; there is no evidence that these auditory portions of the bone are at any time separate epiotic elements. The upper edge of the bone is entirely occupied by a large surface (*p.f.*), which is nearly flat except on the middle line, where it is raised into a blunt angular projection; this surface is for union with the parietals. The posterior face of the bone is strongly convex from side to side, while the cranial surface is concave in the same direction. The middle portion of the ventral border, forming the upper border of the foramen magnum, is concave with a slight median projection; external to this are the broad oval surfaces, looking downwards and outwards, for union with the exoccipital-opisthotics; in the anterior part of this surface there is the opening of the passage lodging the upper portion of the posterior vertical semicircular canal (*p.v.c.*). In front of the surface for the exoccipital-opisthotic there is a large facet (*pro.f.*) for union with the prootic; this surface, which looks nearly directly forwards, is excavated by a large recess for the upper part of the posterior and anterior vertical semicircular canals, the latter (*a.v.c.*) opening on the upper part of the facet, the former (*p.v.c.*), as already noted, on the facet for the exoccipital-opisthotic. The auditory region of the supraoccipital is greatly thickened and seems to have projected considerably into the cranial cavity.

The *prootic* (text-fig. 12, A, B) is an irregularly triangular bone; the upper angle is truncated by a surface (*soc.f.*) for union with the supraoccipital, and bears the opening of the passage for the anterior vertical semicircular canal (*a.v.c.*). The posterior angle is truncated by the surface for union with the opisthotic (*exo.op.f.*); this facet is perforated by the opening of the horizontal semicircular canal (*h.c.*). The anterior angle is produced into a process which terminates in a facet, but the nature of this and the anterior facet-like anterior edge of the bone is uncertain; possibly the process may have reached a facet on the basisphenoid. The body of the bone is hollowed by a large ampullary cavity (*a.*) which communicates with the

anterior vertical and the horizontal semicircular canals. The outer surface is smooth and convex in all directions, except at the base of the anterior process.

From the account here given it will be seen that the arrangement of the bones containing the auditory apparatus is much as in other reptiles, and is especially closely comparable with that found in some Chelonians *.

The *basisphenoid* is not well preserved in any specimen; its ventral surface is concealed by the overlap of the pterygoids and parasphenoid. Posteriorly it united with the basioccipital by a flat and nearly vertical surface. The hinder half of the upper surface is nearly flat, while the anterior portion is occupied by the large and deep *sella turcica*, into the postero-external angles of which the internal carotids open. Posteriorly the fossa is bounded above by two stout processes projecting over it and also outwards; the upper edge of these outer projections bears a facet for union with some element, and although, owing to the displacement of the parts in all the specimens, it is not possible to be certain what that element is, it seems probable that it is the anterior process of the prootic. The sides of the basisphenoid beneath the *sella turcica* bear strong lateral processes for union with the pterygoids.

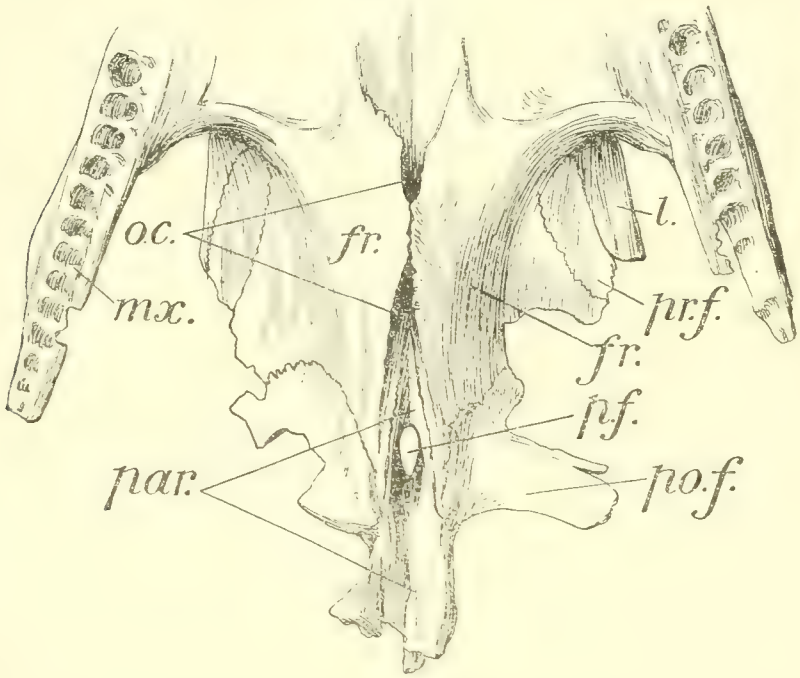
The *parasphenoid* (*pas.*, Pl. IV. fig. 1) is not well preserved in any of the specimens. It overlaps the basisphenoid posteriorly; in front of this it narrows so as to be nearly as deep as wide, and divides the posterior interpterygoid vacuity into two openings. Anteriorly it again becomes flattened and is thrust for some distance between the palatine plates of the pterygoids, which, however, a little in front of the vacuities, meet beneath it so that its full extent cannot be seen from the palatal surface. The upper surface of the parasphenoid in the neighbourhood of the vacuities and in front of them is marked by a longitudinal groove, of which the floor is roughened; this may indicate the presence of a vertical median plate of cartilage in this region.

The *parietals* (*par.*, Pl. IV. fig. 2; text-fig. 13) form a high crest between the temporal fossæ; they descend considerably on the side of the brain-case and their lower edge unites anteriorly with the upper edge of the epipterygoid (columella cranii, *col.*), which is very well developed (see below). Posteriorly they unite below with the facet on the upper border of the supraoccipital and send out lateral processes which unite with the upper (parietal) branches of the squamosals to form the post-temporal bars. What share each of the two bones takes in their formation cannot be determined, the sutures being obliterated, but it seems probable that the squamosals extend up along the upper edge of the parietals to within a short distance of the middle line. The temporal bars thus formed are curved, the convexity being directed upwards and forwards; their posterior face is convex from above downwards,

* Siebenrock, "Das Kopfskelet der Schildkröten," Sitzungsb. math.-naturwiss. Cl. k. Akad. Wiss. Wien, vol. cvi. pt. 1 (1897), p. 245, pl. iii.

the anterior concave. At their anterior end the parietals widen out and completely surround the pineal foramen (*p.f.*). Their relation to the *frontals* (*fr.*) is difficult to make out, owing to the complexity of the sutures between the two bones and the extent to which they overlap. In the earlier account of the skull of this species (Ann. Mag. Nat. Hist. [6] xvi. (1895) p. 252) the suture was described as passing just in front of the pineal foramen, as it certainly does in the Elasmosaurs, and the bones lying between the pineal foramen and the hinder ends of the facial processes of the premaxillæ were therefore regarded as frontals. Further examination of other specimens, particularly one which is broken across in several places, shows that in front of the pineal opening (*p.f.*) the parietals widen out on the outer surface of the skull and

Text-fig. 13.



Inner face of a portion of the skull-roof of *Peloneustes philarchus*. (R. 3803, ½ nat. size.)
fr., frontal; *l.*, lachrymal; *mx.*, maxilla; *o.c.*, olfactory canal; *par.*, parietals; *p.f.*, pineal foramen; *po.f.*, postfrontal; *pr.f.*, prefrontal.

overlap the frontals, extending forwards to meet the posterior ends of the premaxillæ. Although the frontals are thus in part concealed, they are exposed to a considerable extent on the upper surface of the skull to the outer side of the parietals. Posteriorly the frontals join the postfrontal (*po.f.*); in front of this they form the upper border of the orbit for a short distance, then they unite externally with the prefrontal (*pr.f.*) and on the inner side join the outer edge of the premaxillæ and appear to send forwards a process between those bones and the external narial openings (*nar.*), of which they form

the inner border. Looked at from the inner (ventral) side (text-fig. 13) the frontals are seen to extend back to a point behind the anterior end of the pineal foramen, but are completely excluded from it by the wedge-like prolongation of the parietals which extends between them for some distance in advance of the opening. In front of this ventral prolongation of the parietals, the frontals appear to meet in the middle line for some distance and extend considerably beneath the facial processes of the premaxillæ. On their ventral side near the outer edges they are produced downwards into thin laminæ, which curve inwards so as just to meet in the middle line, but without uniting with one another, thus partly enclosing a kind of median tunnel (*o.c.*) which probably lodged the olfactory nerves. Posteriorly this channel is continuous with the groove leading to the pineal foramen (*p.f.*); anteriorly the enclosing ridges gradually become lower and disappear at about the level of the front of the orbit; probably they are borne entirely on the frontals. The outer side of the wall of the tunnel just described forms the inner face of the upper part of the orbit, and from it a rounded ridge runs out on to the prefrontals and is continued down to the palatine, forming a partial division between the orbit and the olfactory cavity. Except that in *Peloneustes* the ridges forming the sides of the olfactory canal are much more strongly developed, the arrangement of the lower face of this part of the skull seems to be similar in a general way to that of *Hatteria* *. The extension of the parietals in front of the pineal foramen to the premaxillæ noticed above, has been described by Williston in *Brachauchenius* † and *Dolichorhyncops* ‡, two genera of Plesiosauria from the Cretaceous of North America. Possibly in these also it will be found that the frontals do extend back to the level of the pineal foramen and meet in the middle line for at least a short distance, though this union is concealed on the outer surface of the skull by the overlapping parietals. If this is so, the difference between the skulls described by Williston and those of the European Elasmosaurs is less marked than would appear from the descriptions.

The *postfrontal* (*po.f.*) unites mainly with the outer edge of the hinder end of the frontal, but it also has a short contact with the parietal opposite the middle of the pineal opening. Its inner end is broad and, looked at from above, is in part concealed in front by the overlapping of the frontals; at its outer end it narrows to a simple flat bar of bone, the lower end of which no doubt joined the postorbital to form the division between the temporal fossa and the orbit.

The *prefrontal* (*pr.f.*, text-fig. 13) is a large bone which unites on its inner side with the frontal in a long curved suture. At its posterior end it is separated from the

* Siebenrock, "Zur Osteologie des *Hatteria*-Kopfes," Sitzungsb. math.-naturwiss. Cl. k. Akad. Wiss. Wien, vol. cii. (1893) p. 250.

† Williston, "The Skull of *Brachauchenius*," Proc. U.S. Nat. Mus. vol. xxxii. (1907) p. 477.

‡ Williston, "North American Plesiosaurs, Pt. I."—Field Columbian Museum, Geological Series, vol. ii. no. 1 (1903), p. 14.

postfrontal by a short interval; its outer edge forms the border of the orbit for some distance, and on its lower face is part of the ridge which is mentioned above as to some extent separating the orbit from the nasal cavity. Its relations to the other bones at its anterior end are not clear; it seems, however, to have extended nearly, if not quite, to the narial opening. On its outer side in front it joins a small bone which seems to have formed the anterior lower rim of the orbit and is probably the lachrymal. Ventrally this element unites with the upper edge of the maxilla. The narial aperture (*nar.*), as already noted, has its inner border apparently formed by a prolongation of the frontal; its anterior margin forms a notch in the hinder edge of the maxilla. There is some indication that the posterior and outer borders are formed by a small distinct element, which, if actually present, must be regarded as a *nasal*.

The *premaxillæ* (*pmx.*, Pl. IV. figs. 1, 2) are separated from one another throughout their length by a distinct suture. Each consists of an enlarged anterior portion forming the anterior end of the snout, which bears teeth, and an elongated narrow facial process which extends back to the level of the anterior border of the orbits and joins the parietals on the outer surface of the skull and the frontals below. Each premaxilla bears six tooth-sockets, of which the first is the smallest and is directed downwards and forwards, the second is larger, and the third and fourth the largest of the series; the fifth and sixth decrease in size successively. Behind the last there is a short diastema crossed by the maxillo-premaxillary suture. On the palate the extension of the premaxilla is very small; the suture with the maxilla after crossing the alveolar border runs a little backwards (about 2 cm.), there forming the outer border of a short palatal process, the inner side of which unites with the vomers, which run forwards between the premaxillæ to a point opposite the interval between the fourth and fifth teeth. In front of this the premaxillæ meet in the middle line of the palate, which is here raised into a low platform separated from the alveoli by a deep groove. The upper surface of the anterior portion of the united premaxillæ is evenly convex from side to side, and the bone is marked by a number of small foramina; this region is widest at about the level of the fourth tooth, in front of which it narrows to the rounded tip of the snout, while posteriorly it also narrows slightly to the level of the diastema. The maxillo-premaxillary suture on the facial surface curves upwards and backwards till it is about 1·5 cm. from the middle line, then runs straight back parallel to the long axis of the skull, forming the outer edge of the facial processes, which remain of the same width till close to their hinder end. At the external nares or a little in front of them, the premaxillæ pass between the frontals and at their posterior extremity are just in contact with the overlapping parietals. Throughout their length the facial processes are strongly convex and together seem to have formed a rounded ridge along the middle of the preorbital region of the skull.

The *maxilla* (*mx.*, Pl. IV.) is a very large bone extending back to the level of the

posterior border of the orbit. Its alveolar region bears sockets for 28–30 teeth, of which the first and second are small, the next four much enlarged; behind these there is a gradual reduction in size to the posterior end of the series. Within the alveoli there is a line of pits marking the position of the points of the replacing teeth; in the anterior part of the bone these pits open at the bottom of a deep groove which separates the alveolar border from the narrow palatal region, the inner edge of which unites with the vomer both in front of and behind the internal nares, of which it forms the outer edge; behind the vomer the maxilla joins the palatine for some distance, but the length of this union cannot be made out, nor is it certain whether a suborbital vacuity was present or not. At its hinder end the maxilla unites internally with the transpalatine bone and sends back a tapering process closely united with the ventral face of the jugal, but not extending back to the squamosal. The *jugal* (*j.*) extends forwards above the maxilla, forming the lower border of the orbit and apparently uniting with the lachrymal in front. Posteriorly it has a union with the transpalatine (*t.p.*) on its inner side, while on its upper edge it joins the lower end of the postorbital. At its hinder end it joins the squamosal in an oblique suture. The *postorbital* (*p.orb.*) is a triangular bone, the base of the triangle joining the jugal in front and extending for a short distance on to the upper edge of the anterior end of the zygomatic bar of the squamosal; at its narrow upper end it no doubt united with the outer end of the postfrontal, thus completing the hinder border of the orbit.

The *squamosal* (*sq.*, Pl. IV.) consists of (1) a broad ventral ramus, which unites closely with the quadrate, overlapping its posterior face; (2) a laterally compressed zygomatic bar, which runs forwards to unite with the postorbital and jugal as already mentioned; (3) a dorsal ramus, which unites with the upper border of the lateral process of the parietal and probably nearly meets its fellow in the middle line at the vertex of the skull.

The *quadrate* (*q.*, Pl. IV.) is a massive bone which in its natural position seems to have been directed downwards, outwards, and backwards. On its inner side it is supported by the posterior prolongation of the pterygoid, uniting with it by suture; it is also very firmly united with the ventral ramus of the squamosal, which, as above noted, makes an extensive overlap on its hinder face; probably it was further supported by the paroccipital, which either unites directly with its upper end or with the portion of the pterygoid immediately adjoining; between the paroccipital process and the post-temporal bar formed by the squamosal and parietal, there must have been a post-temporal fossa of considerable size. The condyle for the mandible is transversely elongated and curved, with the concavity forwards. The articular surface is divided into two areas by a ridge which runs obliquely from the inner anterior angle to about the middle of the posterior border; the outer area is considerably the larger and is concave from side to side, but convex from before backwards; the inner area is gently convex in all directions.

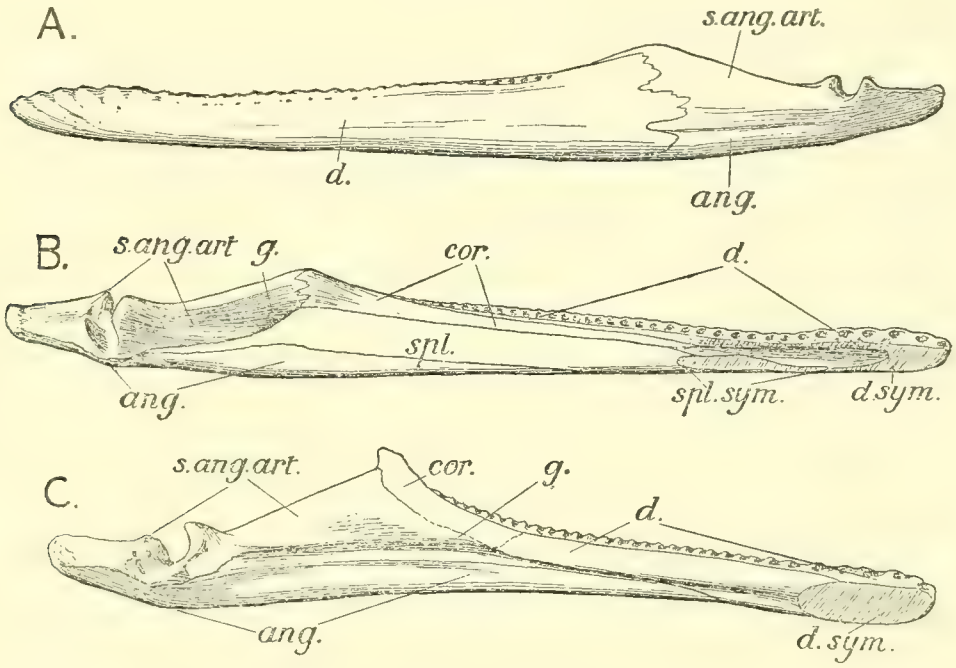
The palatal surface of the skull is formed mainly by the vomers (*v.*), palatines (*pal.*), pterygoids (*pt.*), and parasphenoid (*pas.*). The *vomers* (*v.*) are very large bones, extending nearly half the total length of the skull. Anteriorly they run in between the premaxillæ to about the level of the fourth premaxillary tooth, where they terminate in a point. From the premaxillæ to the anterior angle of the internal nares they unite externally with the maxillæ; at the internal nares, of which they form the inner edge, they are somewhat narrowed, but behind these openings they again widen out and terminate in a fan-shaped expansion; immediately behind the nares they probably unite externally for a short distance with the maxillæ, then with the anterior end of the palatines, and in the middle with the anterior ends of the pterygoids, which thus exclude the palatines from the middle line.

The form and relations of the *palatines* (*pal.*, Pl. IV. fig. 1) are not well shown in any specimen now available for examination. In my former paper on a skull of this species (Ann. Mag. Nat. Hist. [6] vol. xvi. (1895) p. 247) these bones were described as follows:—"The palatines are bounded externally by the maxillæ, internally by the internal nares, of which they form the postero-external margin, and, to the greatest extent, by the pterygoids. In no specimen is the whole of the posterior border preserved, but its inner portion unites with the anterior edge of the lateral wing of the pterygoid in a straight suture running nearly at right angles to the long axis of the skull, while the outer portion seems to have joined the transpalatine, there having been no suborbital vacuity in front of this bone, or, at any rate, only a small one." I am not now quite certain whether the palatines actually do form part of the border of the internal nares (*i.nar.*), or whether they are shut out from them by the union of the vomers and maxillæ, which would thus alone inclose the openings. These are elongated slits three or four centimetres long and about one centimetre wide. They are situated about opposite the seventh to the tenth maxillary teeth and are considerably further forwards than the external nares (*nar.*).

The *pterygoids* (*pt.*, Pl. IV. fig. 1), the largest bones in the palate, are very complex in form. They are triradiate, as usual in this group; the anterior ramus joins the vomer at its anterior end, where also, for some distance, it joins its fellow in the middle line; further back there is a narrow anterior interpterygoid vacuity (*a.p.v.*), which was not noted in my former description. Behind this opening the bones again meet in the middle line for a short distance and are then separated by the anterior end of the parasphenoid (*pas.*), which is thrust between them and to a considerable extent concealed by their overlap on to its palatal surface. The lateral wing of the pterygoid unites in front with the palatine in a transverse suture as above described; externally it joins the transpalatine (*t.p.*) in a V-shaped suture, the posterior limb of which passes through the prominent boss of bone which projects down from the palate and terminates in an oblique flattened and roughened surface; a similar and similarly constituted structure is found in many reptiles, e. g. *Hatteria*. The posterior border of

the lateral ramus curves inwards and backwards, crossing the posterior ramus as a high cristiform ridge, forming a prominent flange on its ventral face, and disappearing in the hinder part of the border of the posterior interpterygoid openings (*p.p.v.*). Behind these the pterygoids overlap the basioccipital and basisphenoid, and probably meet in the middle line; posteriorly they are produced back into strong processes, which seem to have overlapped and probably united with the lower ends of the lateral processes of the basioccipital. Behind these the posterior ramus becomes compressed vertically and runs back to join the inner border of the quadrate. On the upper surface of the pterygoid about opposite the middle of the posterior inter-

Text-fig. 14.



Mandibular ramus of *Peloneustes philarchus* (R. 3803, $\frac{1}{6}$ nat. size): A, from outer side; B, from inner side; C, mandibular ramus of *Murǣnosaurus* from inner side. (R. 2861, about $\frac{1}{3}$ nat. size.)

ang., angular; *cor.*, coronoid; *d.*, dentary; *d.sym.*, symphysis of dentaries; *g.*, dental groove; *s.ang.art.*, the united surangular and articular bones; *spl.*, splenial; *spl.sym.*, symphysis of the splenials.

pterygoid vacuity, is the surface of attachment for the *epipterygoid* (columella cranii, *col.*, Pl. IV. fig. 2), a rather large bone strongly compressed from side to side and uniting with the pterygoid below and the parietal above.

Mandible (text-fig. 14, A, B).—The Leeds Collection contains some nearly complete specimens of the mandible of *Peloneustes*, and an examination of these shows that they closely resemble the mandible of *Pliosaurus* and differ widely in structure from those of the Elasmosaurs. In the first part of this Catalogue (p. 89) the description of the mandible in these latter is in several respects inaccurate, and a correction of the

errors has already been published (Geol. Mag. [5] vol. viii. (1911) p. 160), but it, nevertheless, seems advisable to repeat the correction in the present volume, and this will be done below.

In *Peloneustes* the mandible (text-fig. 14, A, B) is composed of the following elements: (1) the united surangular and articular; (2) the angular; (3) the dentary; (4) the coronoid; (5) the splenial. Of these, as usual, the *dentary* (*d.*) is much the largest; this bone unites in front with its fellow of the opposite side in a long symphysis, in the posterior part of which, however, the two are separated ventrally by the splenials, which there unite with one another; it appears also that the dental canals are prolonged for some distance into the symphysis; the anterior ends of the coronoids (*cor.*, text-fig. 14) also extend just into the hinder portion of the upper part of the symphysis, though they do not seem to have actually united with one another. The upper surface of the dentary symphysis (*d.sym.*) is raised in the middle line into a strong ridge, which is separated from the alveoli on each side by a deep groove, at the bottom of which the tips of the replacing teeth appear. The symphysis, as a whole, is a little expanded, being widest opposite the fifth and sixth teeth, which are enlarged; towards its hinder end the teeth become smaller and the symphysis narrows considerably. In *Peloneustes philarchus* there are 14–16 teeth in the symphysis, while in *P. evansi* the number is only twelve. The outer surface of the dentaries is gently convex from above downwards, and is marked by a number of short grooves terminating in vascular foramina, at least in the upper half. On the inner face there is a deep longitudinal dental groove, which, as above mentioned, extends into the symphysial region. Behind this the channel is closed on the inner side by the coronoid (*cor.*) above and the splenial (*spl.*) below; at its posterior end it opens just behind the level of the coronoid process, the aperture (*g.*) being bounded by the surangular (*s.ang.art.*) externally and the splenial (*spl.*) on the inner side. The floor of the groove in its posterior portion is formed by the forward prolongation of the angular (*ang.*), which extends beneath the splenial and dentary and forms the lower border of the mandibular ramus to within a few centimetres of the symphysis. At its posterior end the dentary rises to the coronoid angle and overlaps the outer face of the surangular above and of the angular below. The alveolar border of the portion of the dentary behind the symphysis bears alveoli for about twenty-five teeth, the posterior ones being very small; on the inner side of the alveoli there is a groove, at the bottom of which the tips of the replacing teeth appear.

The *coronoid* (*cor.*) is in several respects remarkable; it is a large bone extending from the coronoid angle, which it helps to form, to just within the symphysis, where it is in contact with its fellow of the opposite side, but probably does not actually unite with it. At its hinder end it unites with the surangular in an almost vertical suture, and throughout its length it is closely applied to the inner face of the dentary, its upper edge being close to and nearly parallel with the alveolar border of that bone.

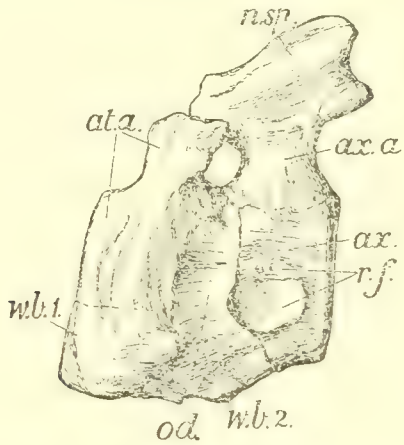
Its lower edge is overlapped by the splenial. The *splenial* (*spl.*) is a large plate of bone which completely roofs in the dental groove from the level of the coronoid angle to the symphysis, into the ventral side of which it extends for some distance (*spl.sym.*), uniting with its fellow of the opposite side. For a short distance behind this the splenial forms the lower border of the mandibular ramus; it then overlaps and unites by its lower edge with the angular, its union with that element extending to its posterior end, which is only a little in front of the articular surface for the quadrate. This posterior prolongation of the splenial behind the coronoid angle forms the lower border of the opening of the dental canal (*g.*, in text-fig. 14, B). The *surangular* and *articular* (*s.ang.art.*) are indistinguishably fused with one another. The articular surface for the quadrate is divided into an inner area deeply concave, especially from before backwards, and a smaller outer area, only slightly concave from side to side, but deeply so from before backwards. The anterior border of the articular surface forms a prominent lip, which added greatly to the strength of the joint. Just behind the outer portion of the articulation there is a deep pit, presumably for a ligament. Of the postarticular process the surangular and articular form the upper surface and also the rounded angle. In front of the articulation, and in a line with its outer portion, the upper edge of the surangular rises to the coronoid angle, and is much thickened and flattened at the top. In front it unites in overlapping sutures with the dentary externally and the coronoid internally; it actually extends some distance in front of the coronoid angle, but is concealed by these two bones. The lower border joins the *angular* (*ang.*). This bone forms the whole of the lower part of the posterior region of the jaw. In its posterior portion its upper surface is in close sutural union with the surangular and articular, in front of the articulation the bone deepens vertically as far as the level of the coronoid angle, and its upper surface bears a deep groove, the outer side of which receives the posterior prolongation of the splenial. Anteriorly the angular is prolonged forwards as a narrowing process to within a few centimetres of the symphysis; in this region it joins the dentary on the outer side of the jaw, the splenial on the inner, both these elements overlapping it.

Vertebral Column (text-figs. 15–20).—The cervical vertebræ, including the atlas and axis, are about 21 in number. All, with the exception of the atlas, bear ribs which are double-headed, except perhaps in the case of the posterior one or two of the series. The neural spines are high and narrow.

The *atlas* and *axis* (text-figs. 15, 16) are closely united in full-grown specimens, but the lines of division between the constituent parts usually remain more or less distinct. In a young specimen (R. 2439, text-fig. 16) all the constituent elements are separate, so that the structure of the atlas-axis complex can be clearly made out. The anterior surface of the body of the atlas (*od.*) forms the middle and upper portion of the cup for the basioccipital; it is concave, and in its centre is a slight pit. Below its lower third there is a deeply concave roughened surface for union with the anterior wedge-

bone (*w.b.* 1), the anterior face of which is concave and forms the lower part of the atlantal cup; its upper ends unite in straight sutures with the lower ends of the bases of the atlantal neural arch (*at.a.*), which unite with the centrum of the atlas in a large nearly triangular facet, which looks forwards, upwards, and outwards, and at its upper end extends the whole length of the centrum; the anterior faces of these basal portions of the arch are concave and complete the atlantal cup, forming the upper halves of its lateral borders. The neural surface of the atlas is nearly triangular, the anterior angle being truncated by the upper border of the atlantal cup. The posterior face is gently concave, with central dimple. It is wider than high and its upper (neural) border is nearly straight, while its ventral border is truncated by the large oblique facet for the second ventral wedge-bone (*w.b.* 2), which has a more extensive union with the atlas than with the axis. The lateral faces of the atlas are convex from above downwards, and gently concave from before backwards; there is no trace

Text-fig. 15.



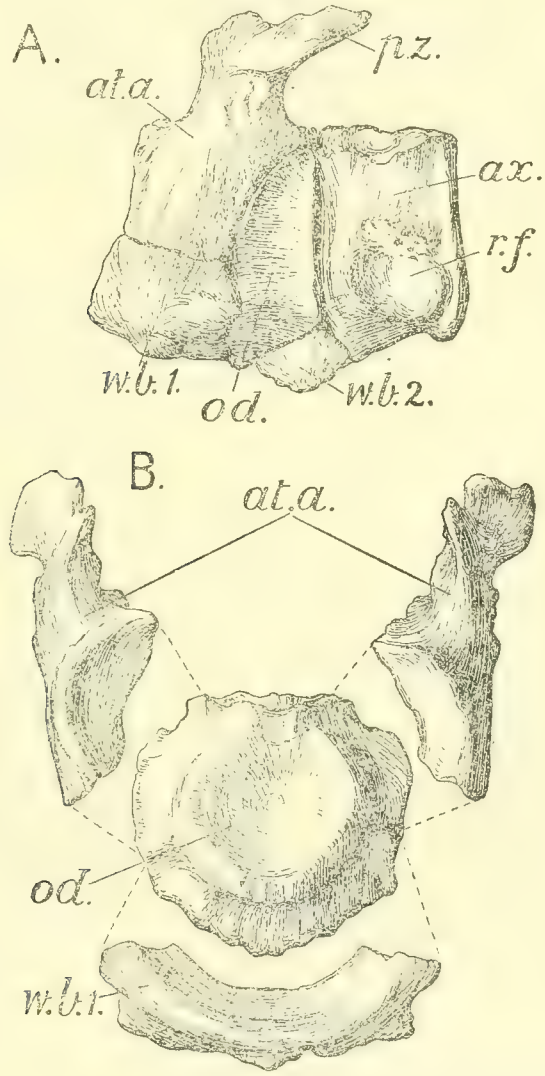
Atlas and axis of *Peloneustes philarchus*, from left side. (R. 2438, $\frac{2}{3}$ nat. size.)

at.a., neural arch of atlas; *ax.*, axis; *ax.a.*, neural arch of axis; *n.sp.*, neural spine; *od.*, odontoid (centrum of atlas); *r.f.*, rib-facets on axis; *w.b.* 1, *w.b.* 2, first and second subvertebral wedge-bones.

of any facet for an atlantal rib. The neural arch of the atlas (*at.a.*) consists of two separate halves, between the upper end of which there is a considerable interval. The enlarged ventral portion unites with the centrum as above described, and forms the upper lateral portion of the atlantal cup. The anterior border of the pedicle of the arch is situated a little distance from the anterior border of the body; on its outer face is a roughened surface, apparently for the attachment of muscle or ligament. Above, it expands into a smaller anterior lobe and a larger and more prominent posterior one, the latter bearing on its inner face a facet, the posterior zygapophysis (*p.z.*), which articulates with the pre-zygapophysis of the axis. The anterior lobe is roughened on its inner face, and may have been united by ligament with the peculiar facet on the

posterior surface of the exoccipital described above; or possibly a pro-atlas was present and rested against this anterior lobe of the arch and the facet of the exoccipital. The second subvertebral wedge-bone (*w.b.* 2) (hypapophysis) is small, and unites with the centra of the atlas and axis. The centrum of the axis (*ax.*) is very similar to that of

Text-fig. 16.



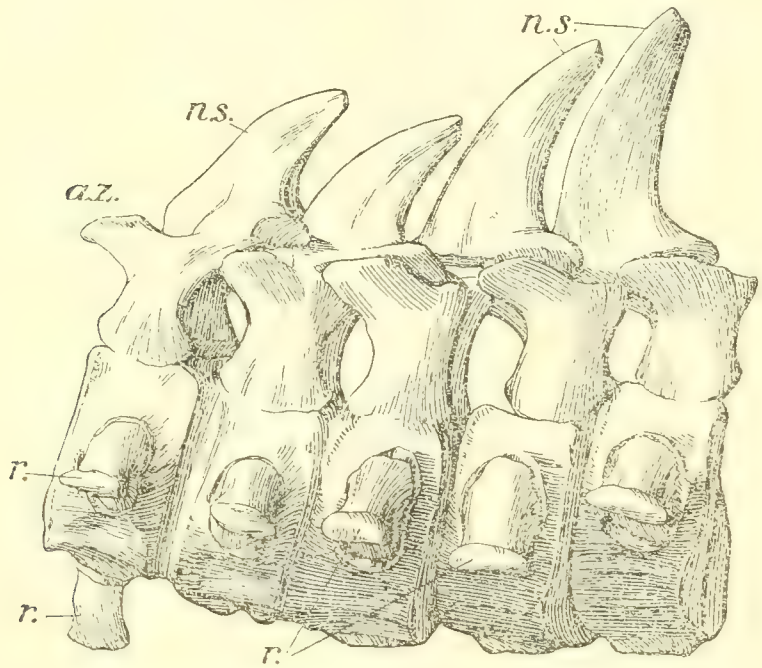
Atlas and axis of *Peloneustes philarchus*: A, from side; B, atlas from front, with the constituent elements separated. (R. 2439, $\frac{2}{3}$ nat. size.)

at.a., arch of atlas; *ax.*, axis; *od.*, odontoid; *p.z.*, posterior zygapophysis; *r.f.*, rib-facet; *w.b.* 1, *w.b.* 2, first and second subvertebral wedge-bones.

the succeeding cervicals, except for the small facet on its antero-ventral border for union with the wedge-bone. The articular surfaces of the centra are rather wider than high, and gently concave with a median pit. The length of the centrum is considerably less

than the height, and, owing to a slight forward projection of the antero-ventral region, the length on the mid-ventral is rather greater than that on the mid-dorsal line. The facets for union with the pedicles of the neural arch do not extend quite to the posterior end of the centrum, as they do in the vertebræ further back in the neck; the neural surface is wider behind than in front. The rib-facets (*r.f.*) are borne on a very short prominence, the upper end of which is deeply concave and obscurely divided by a groove into a smaller upper portion for the tubercle of the rib, and a larger lower portion for the head; the division between these surfaces is often indistinct, especially in the posterior cervicals; the rib-facets are a little nearer to the posterior than to the anterior edge of the centrum, and the ventral face between them is concave

Text-fig. 17.



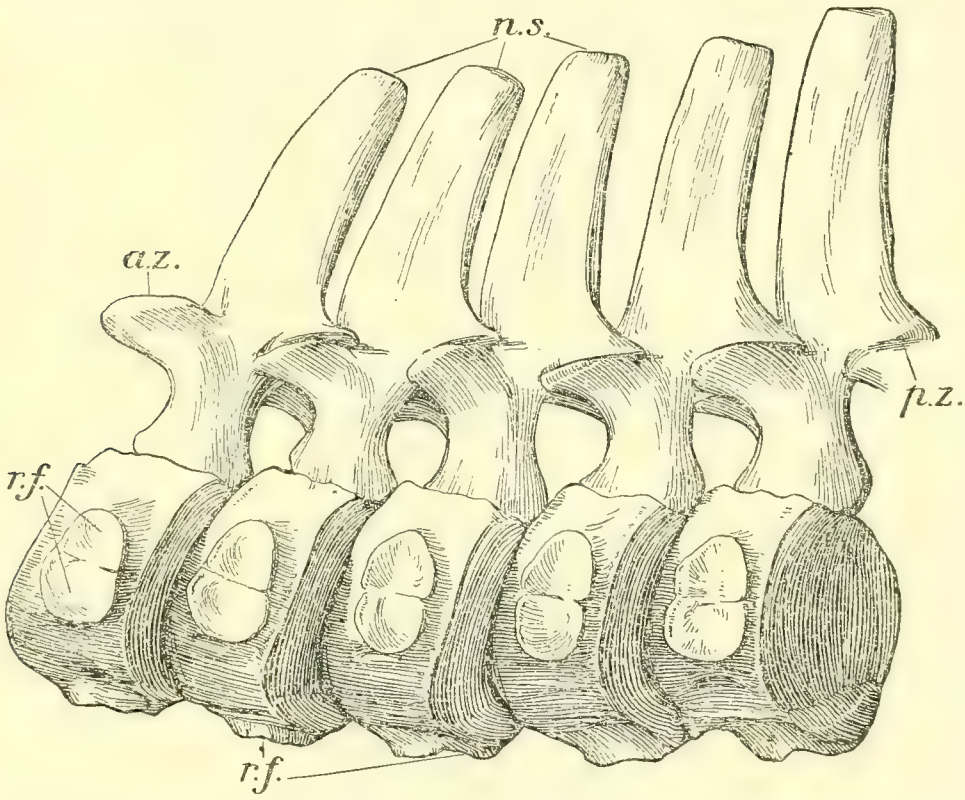
Anterior cervical vertebræ of *Peloneustes philarchus*, from left side. (R. 3318, $\frac{2}{3}$ nat. size.)
a.z., anterior zygapophysis; *n.s.*, neural spine; *r.*, ribs.

on either side of a low rounded hypapophysial ridge, which is more prominent at its anterior than at its posterior end; the nutritive foramina open into the concavities on each side of the ridge, but in the anterior cervicals they are sometimes obscure and perhaps altogether absent.

Speaking generally, the neural arch in the *cervical* series (text-figs. 17–19) is high, and the neural spine (*n.s.*) narrow. The neural arch of the axis described above is missing, but in another specimen (text-fig. 15, R. 2438) it is well preserved. The pedicle is broad, and it unites with the whole length of the centrum; above, the arch

widens out and projects forwards over the body of the atlas, bearing on its upper face the zygapophysial facets, with which the hinder ends of the two halves of the arch of the atlas articulate. From these surfaces a ridge runs upwards and backwards, and forms the outer edge of the posterior zygapophyses which project considerably behind the posterior surface of the centrum. The neural spine (*n.s.*) is low and stout, it slopes backwards, its anterior edge being convex, the posterior slightly concave; the upper end is considerably thickened. In the succeeding cervicals (text-fig. 17) the neural arch is similar, uniting with the whole length of the centrum and, in some cases, even forming a small portion of the upper edge of the articular surface. Both anterior and

Text-fig. 18.



Middle cervical vertebræ of *Peloneustes philarchus*, from left side. (R. 3318, $\frac{2}{3}$ nat. size.)

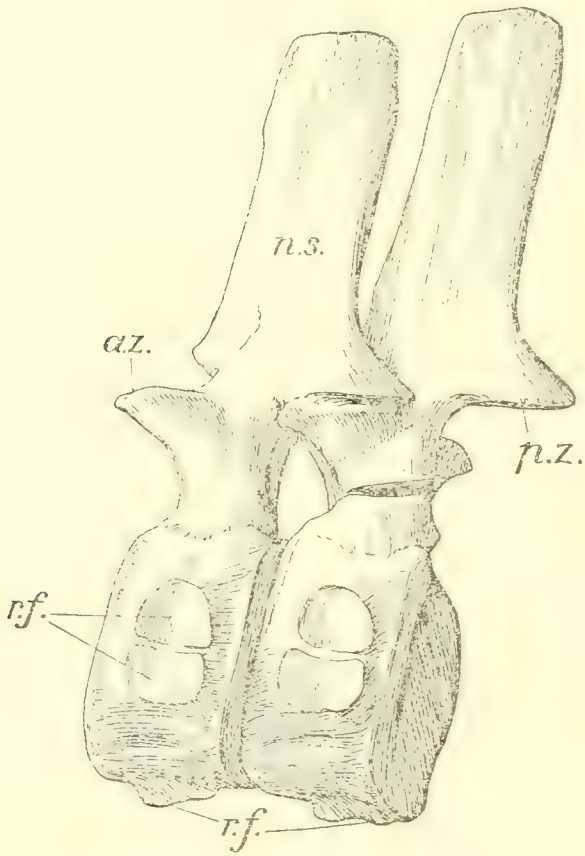
a.z., anterior zygapophysis; *n.s.*, neural spine; *p.z.*, posterior zygapophysis; *r.f.*, facets for ribs.

posterior zygapophyses are large, and their articular surfaces are flat and oval in outline; the anterior pair are directed somewhat upwards, the posterior downwards, and in each case they project considerably beyond the centrum. The base of the neural spine (*n.s.*) extends the whole length of the arch. The lower part of the anterior edge is sharp, but towards the top it thickens and becomes roughened; at the same time the width of the spine decreases. In the third vertebra, the spine (*n.s.*) is short and

curves sharply back, in the fourth and fifth there is an increase in length and they also curve backwards. Behind these to about the tenth (text-fig. 18) there is a gradual increase in height, the spines being nearly straight and sloping a little backwards. Behind this, again, the height of the spine remains about the same to the eighteenth, then in the posterior two or three members of the series (text-fig. 19) there is a decrease in height and increase of width, passing into the form found in the dorsal region.

In addition to the two or three vertebræ in which the rib-articulation is partly on the arch and partly on the centrum (*pectorals*), there are about twenty *dorsals*. The

Text-fig. 19.

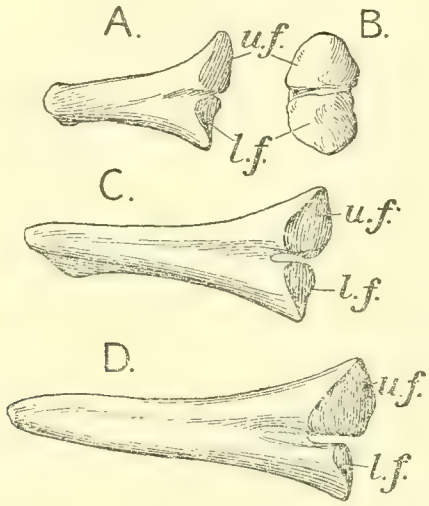


Posterior cervical vertebræ of *Peloneustes philarchus*, from left side. (R. 3318, $\frac{2}{3}$ nat. size.)
a.z., anterior zygapophysis ; *n.s.*, neural spine ; *p.z.*, posterior zygapophysis ; *r.f.*, facets for ribs.

centra of these are longer than in the cervicals, and their lateral and ventral faces are deeply concave from before backwards. The articular faces are higher than in the cervicals, the height in some cases exceeding the width ; the surface is very slightly concave and there is a central pit which, in some cases, is situated at the summit of a slight elevation. The neural arches are not well preserved in any specimen. The

neural spines seem to have been broader and lower than in the cervicals. The transverse processes are stout and slightly curved, the concavity being downwards; they enlarge a little at their outer end, which terminates in a nearly flat surface for union with the rib. In the posterior part of the back the centra seem to decrease in height, and in the *sacrals* they are considerably wider than high. The *caudal* centra are likewise wider than high, and at the same time are shorter than the dorsals. The caudal ribs articulate with deeply concave surfaces, the rims of which form well-marked projections on the sides of the centrum. Beneath the rib-facets the sides of the centrum are gently concave in all directions; they pass into the nearly flat ventral surface in rounded ventro-lateral angles, which are truncated both anteriorly and posteriorly by oblique chevron-facets. The last few caudal centra decrease in size very rapidly; in the last preserved, the neural arch was present and the chevron-facets

Text-fig. 20.



Cervical ribs of *Peloneustes philarchus*: A, B, anterior; C, middle; D, posterior ribs. (R. 3318, $\frac{2}{3}$ nat. size.)

l.f., lower (parapophysial) facet; *u.f.*, upper (diapophysial) facet.

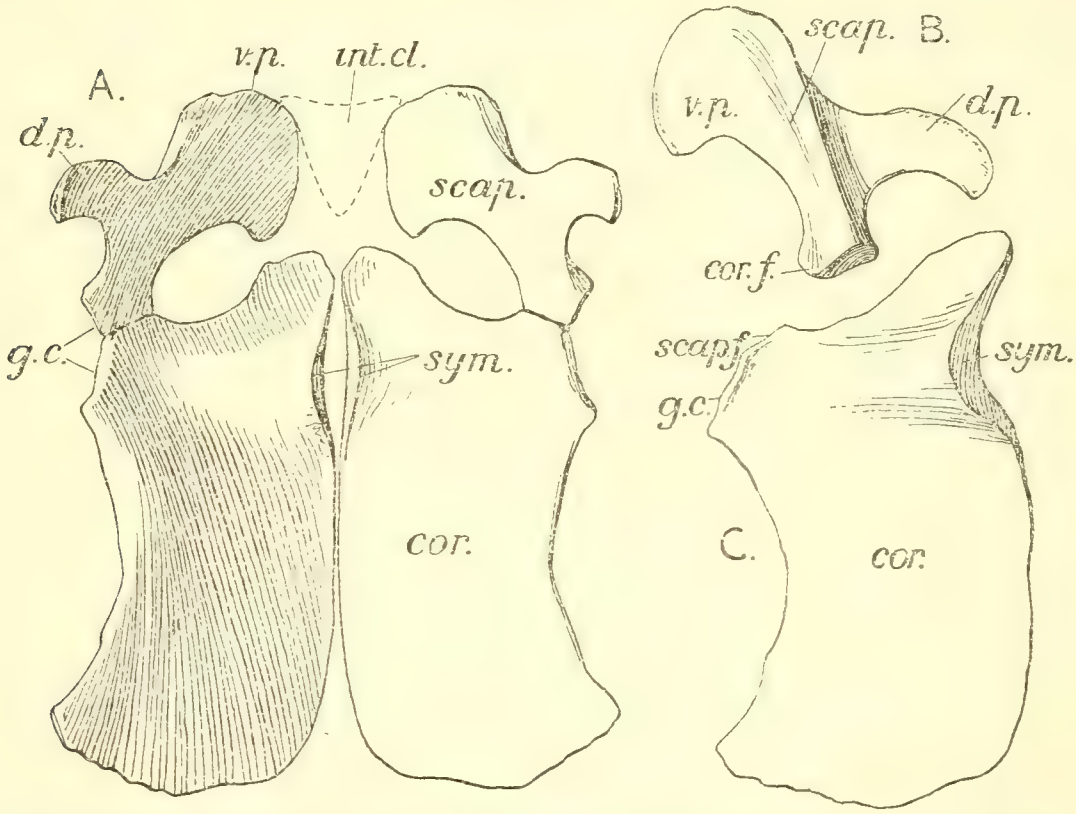
were relatively much larger than in the more anterior caudals; this may indicate that there was a small vertical fin-like expansion at the end of the tail. Unfortunately, no chevrons are preserved.

In the cervical region, as noted above, all the *ribs* (text-fig. 20), with the exception of one or two at the hinder end of the series, are double-headed; the upper (*u.f.*) and lower (*l.f.*) facets are separated by a notch or groove; towards their distal end, at least in the anterior part of neck, they are strongly compressed from above downwards, and widen out so that their outer end is produced a little forwards into a slight angle and backwards into a much more prominent one; in the posterior members

of the series this compression ceases and the length increases, so that there is a transition from the cervical to the dorsal type.

The dorsal ribs are usually greatly crushed, so that, as a rule, their true form cannot be made out; but in a few specimens this is not the case. Thus, in specimen no. R. 2439 it can be seen that the single articular head bears a very slightly concave articular surface for union with the transverse process; this facet is oval, the long axis being vertical. External to it the surface is rugose, especially on the face. Beyond these rugosities the bone is compressed and the upper border forms a sharp

Text-fig. 21.



Shoulder-girdle of *Peloneustes philarchus*: A, from above; B, left scapula from below; C, left coracoid from above. (R. 3318, $\frac{1}{6}$ nat. size.)

cor., coracoid; *cor.f.*, facet for coracoid; *d.p.*, dorsal ramus of scapula; *g.c.*, glenoid cavity; *int.cl.*, outline of interclavicle; *scap.*, scapula; *scap.f.*, facet for scapula; *sym.*, surface of symphysis; *v.p.*, ventral ramus of scapula.

crest, which terminates externally in a roughened prominence; beyond this, again, the shaft of the rib becomes oval in section, and probably continued so to its lower end, or in some cases became round. Owing to the presence of a central cavity or of soft tissue, the crushed specimens present the appearance of having been grooved on the

anterior or posterior surface, or on both. The sacral and caudal ribs are not certainly known in *P. philarchus*, but in *P. evansi* some bones referred to this position are described and figured (p. 74, text-fig. 29).

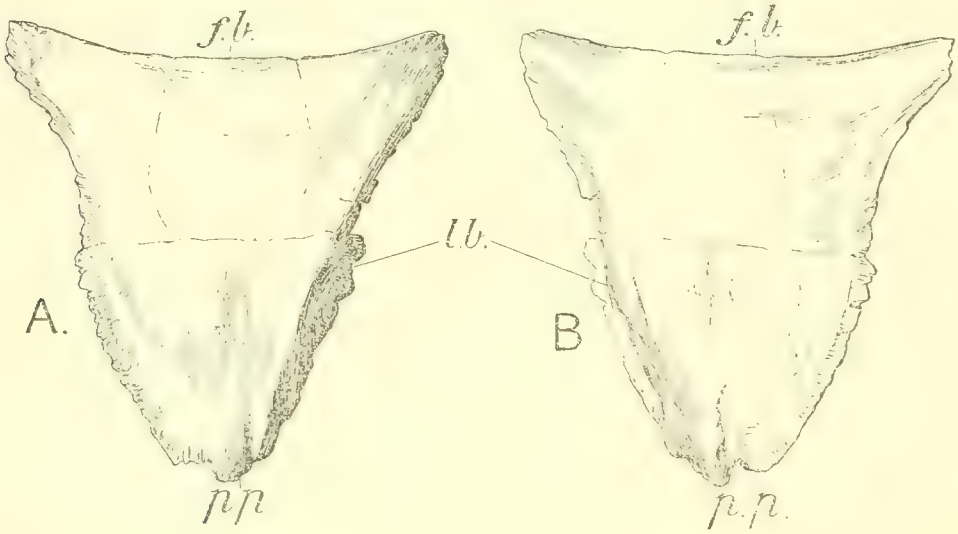
Shoulder-girdle (text-figs. 21, 22).—The shoulder-girdle of *Peloneustes*, like that of the other Pliosauridæ, differs widely from the Elasmosaurian type which has been described above (Part I. pp. 106–111). The constituent bones, though large, are relatively thinner and more lightly constructed, and the scapulæ, though their ventral ramus is much expanded, do not appear to have met in the middle line, though they may have touched the anterior prolongations of the coracoids. Of the clavicular arch, all that is known to have been present is a median triangular bone, the interclavicle (text-fig. 22), which seems to have been interposed between the inner ends of the scapulæ. The lightness and comparatively smaller degree of rigidity of the shoulder-girdle in this form, is no doubt connected with the fact, that the hind limb is here the larger and presumably the chief means of propulsion, the reverse being the case in the Elasmosauridæ.

The *coracoids* (text-fig. 21, *cor.*) are large thin plates of bone, the form of which will be best understood from the figure; the two meet in a long median symphysis (*sym.*), making an angle of about 90° with one another; the surface of union is very narrow except towards the front, where there is a crescent-shaped thickening, the convex surface of which is on the visceral side of the bone, while the concavity is on the outer (ventral) surface (see text-fig. 21, A, C, *sym.*); the thickening of the bone at this level is continued out to the articular surfaces (glenoid cavity, *g.c.*, and scapular facet, *scap.f.*). The antero-internal angle of the bone is produced forwards as a tongue-shaped process considerably in advance of the glenoid cavity; it is uncertain whether or not this anterior process was in contact with the ventral ramus of the scapula. The surface for the scapula (*scap.f.*) makes an angle of about 70° with that of the glenoid cavity. Behind the glenoid cavity the thin outer border of the bone is concave, while the posterior border is evenly convex; the postero-external angle is not produced into a strong process, as is the case in *Cryptocleidus*, except perhaps in advanced age.

The *scapula* (text-fig. 21, *scap.*) is, as usual in the group, a triradiate bone; the posterior ramus bearing the surfaces for union with the coracoid (*cor.f.*) and for the anterior part of the glenoid cavity (*g.c.*), is triangular in section. The ventral angle is continued forwards as the thin, sharp, outer edge of the ventral ramus (*v.p.*), while the inner angle is continued into its posterior border; the outer angle is continuous with the posterior angle of the dorsal ramus (*d.p.*). This is directed upwards and curves a little backwards; in its upper portion the anterior and posterior borders are nearly parallel; the anterior edge is continued forwards as a sharp ridge on the upper surface of the ventral ramus, reaching nearly to its anterior angle; the upper end of the dorsal ramus seems to have been tipped with cartilage. The broad ventral ramus is much expanded anteriorly, forming a thin plate of bone with a

strongly convex anterior and internal border; the thin posterior edge is concave and forms the anterior border of the coraco-scapular foramen, if that opening was really enclosed internally by the meeting of the scapula and coracoid. The ventral rami of the scapulæ, in any case, may have met each other in the middle line, but seem to have been separated by the triangular *interclavicle* (*int.cl.*). This bone (text-fig. 22) is gently convex below and concave above from side to side, and very slightly convex from before backwards on the ventral surface. The anterior border (*f.b.*), which has a thin smooth edge, is concave from side to side. The lateral border (*l.b.*) is at first a little concave, then posteriorly convex, the bone terminating posteriorly in a stout, blunt, asymmetrically placed process (*p.p.*). On the visceral surface the lateral borders are bevelled away and roughened, evidently for union with some other element, and this

Text-fig. 22.



Interclavicle of *Peloneustes philarchus*: A, dorsal (or visceral) surface; B, ventral surface. (R. 2442, ½ nat. size.)

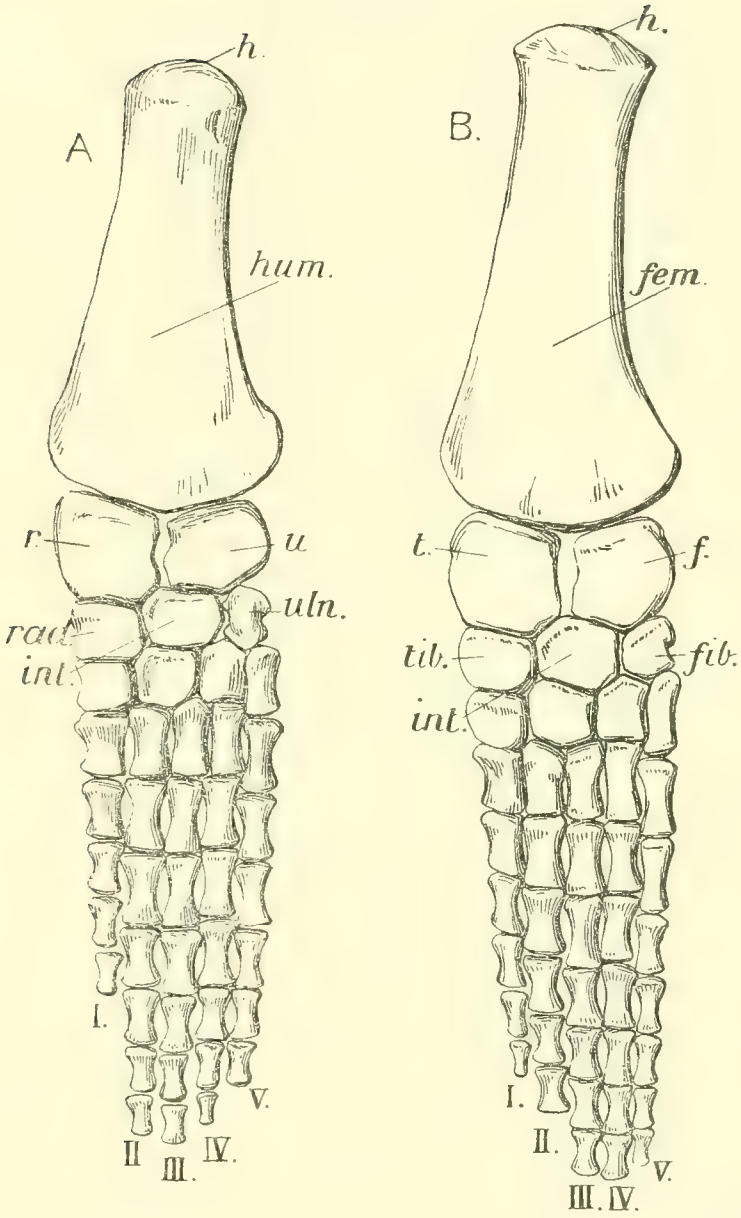
f.b., front border; *l.b.*, lateral border; *p.p.*, posterior process.

bevelled surface extends the whole length of the lateral border. The inner edge of the ventral ramus of the scapula cannot well have united with the whole border, and so it seems possible that some lateral elements (clavicles) were present, though they have never yet been found. In any case, there seems little doubt but that this triangular bone must be regarded as the interclavicle, and it has been so described and figured by Seeley *. Lydekker †, on the other hand, regarded it as an omosternum.

* Seeley, "Shoulder-girdle and Clavicular Arch in *Sauropterygia*," Proc. Roy. Soc. vol. li. (1892) p. 131, fig. 4.

† Catal. Foss. Rept. Brit. Mus. pt. ii. (1889) p. 151, fig. 44.

Text-fig. 23.



Fore and hind paddles of *Peloneustes philarchus* : A, fore paddle ; B, hind paddle.
(R. 2440, $\frac{1}{6}$ nat. size.)

f., fibula ; *fem.*, femur ; *fib.*, fibulare ; *h.*, head of humerus and femur ; *hum.*, humerus ; *int.*, intermedium ; *r.*, radius ; *rad.*, radiale ; *t.*, tibia ; *tib.*, tibiale ; *u.*, ulna ; *uln.*, ulnare ; I.–V., first to fifth digits.

Fore Limb (text-fig. 23, A).—The *humerus* (*hum.*) is shorter, and, in consequence, appears rather broader than the femur. The head (*h.*) is large and, when fully ossified, strongly convex ; on its postero-superior side it is continuous with the upper edge of

the strongly-developed tuberosity, the oblique proximal face of which is flat and roughened for cartilage. The shaft is oval in section, widening gradually towards the distal expansion; the anterior border is nearly straight, while the posterior is concave, the widening being mainly postaxial. The ventral and postaxial face of the upper part of the shaft is greatly roughened for muscle-attachments. Distally the bone is much flattened, and the expanded portion is rather more clearly marked off from the shaft than is the case in *Pliosaurus*. There are articular surfaces for the radius and ulna, but behind that for the latter bone there is a free border which in life was edged with cartilage and may have supported a postaxial accessory ossicle.

The *radius* (text-fig. 23, A, *r.*) is about as long as it is broad. It articulates with the humerus by a nearly straight facet. Its outer (anterior) border is convex, the inner (postaxial) is concave and appears to have enclosed with the ulna a small vacuity. Distally there is a long straight facet for the *radiale* (*rad.*) and a short oblique one for union with the *intermedium* (*int.*). The *ulna* (*u.*) is smaller than the radius, and is rather wider than long. Its proximal (humeral) border is slightly convex, its inner (preaxial) edge is concave, the outer strongly convex; distally it bears facets for union with the intermedium and ulnare. The form and arrangement of the carpals and the digits will be best understood from the figure. The fifth metacarpal, as usual, articulates proximally with the ulnare (*uln.*). The metacarpals are much flattened, as also are the proximal phalanges, while the distal phalanges become more rounded; all the phalanges are strongly constricted in the middle. The number of phalanges in each of the five digits is not known.

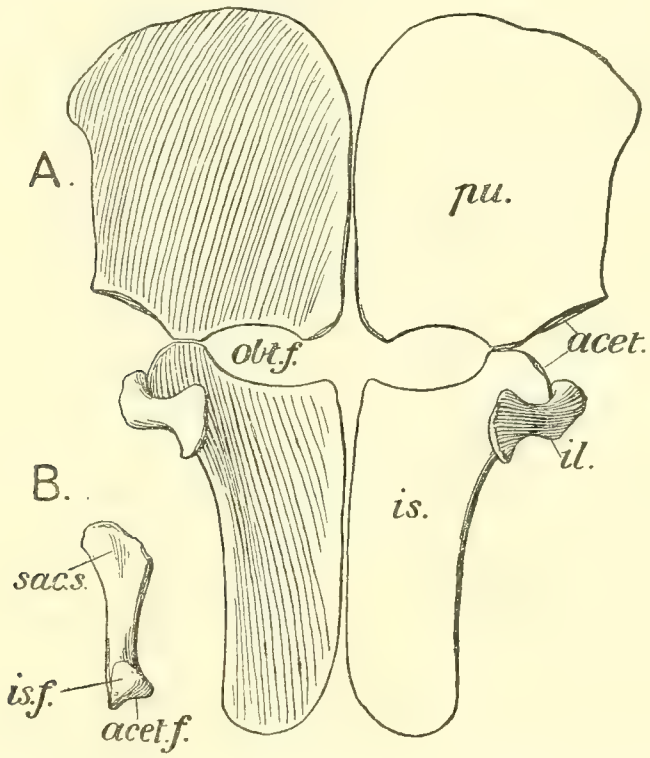
Pelvic Girdle (text-fig. 24).—The pelvis, as in the other Pliosaurs, is remarkable for the large size of the ischia and pubes. The *pubis* (*pu.*) is a large oblong plate of thin bone, uniting with its fellow on the middle line in a long symphysis, and with the ischium by a small facet. The inner edge is for the most part straight, but in front curves outwards, passing into the strongly convex anterior border, which is grooved and was fringed with cartilage in life. The outer edge is concave, but there is a slight antero-external prominence where it joins the anterior border. The acetabular surface (*acet.*) is large and gently concave, and is continuous internally with the ischial facet. The region of the bone bearing these facets is considerably thickened, the thickening extending across to the symphysial border. The posterior border is concave, forming the anterior edge of the obturator foramen (*obt.f.*), which was not closed by bone, but was probably completed internally by the bar of cartilage uniting the pubic with the ischial symphysis.

The *ischium* (*is.*) is remarkable for its great posterior prolongation. It consists of a head which bears three facets, one forming the middle portion of the acetabulum, the others for the pubis and ilium. Internal to this it narrows into a slight neck, then widening out into the great ventral plate, the form of which is shown in the figure. The two ischia unite in a very long median symphysis, diverging from one another

a little in front and behind, where probably cartilage was interposed between them. The anterior border is concave, and forms the posterior margin of the obturator foramen. The outer border is gently concave, while the posterior end is rounded. The line of the ischial symphysis in the sagittal plane makes a very obtuse angle with that of the pubic symphysis, so that the visceral aspect of the complete pelvic symphysis is convex dorsally in a longitudinal direction, while ventrally it is concave (text-fig. 26).

The *ilium* (text-figs. 24, 25) consists of a much-expanded upper portion, a constricted shaft, and a massive articular head. The expanded upper portion varies in form to a

Text-fig. 24.



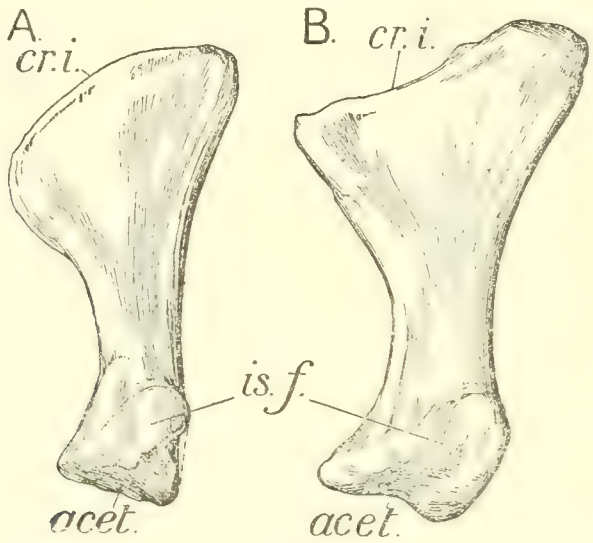
Pelvis of *Peloneustes philarchus*: A, pelvis from above; B, left ilium from inner side. (R. 3318, $\frac{1}{7}$ nat. size.)

acet., acetabulum; *acet.f.*, acetabular surface of ilium; *il.*, ilium; *is.*, ischium; *is.f.*, ischial facet of ilium; *obt.f.*, obturator foramen; *pu.*, pubis; *sac.s.*, surface of ilium for sacral ribs.

remarkable degree; probably this variation is the result of a varying degree of ossification of a cartilaginous upper border, but it is possible that when we know the skull of the animal to which the ilium shown in text-fig. 25, B, belongs, it may be found to be specifically different from *P. philarchus*. In undoubted specimens of this species (text-fig. 25, A) the upper end of the ilium is much more expanded than in any of the Elasmosauridæ. The upper border (*cr.i.*) is convex and passes into the

posterior border in an acute angle, the most posterior portion of the bone. Anteriorly it passes by a broadly rounded angle into the anterior border. The inner face of the expanded portion is somewhat roughened, but there is no clear evidence of contact with the sacral ribs. In the other form (text-fig. 25, B) the upper border is nearly straight and the anterior and posterior angles much more developed, particularly the anterior, which instead of being rounded off is a prominent angle of rather less than 90°. Just beneath it on the inner face of the anterior border there is a tuberosity which may indicate union with the anterior sacral rib. In both forms beneath the expanded blade the bone contracts into a shaft, roughly oval in section, the inner face being flattened and the posterior rather sharper than the anterior border. At its ventral end the bone is greatly thickened and bears two facets, one looking downwards, inwards,

Text-fig. 25.



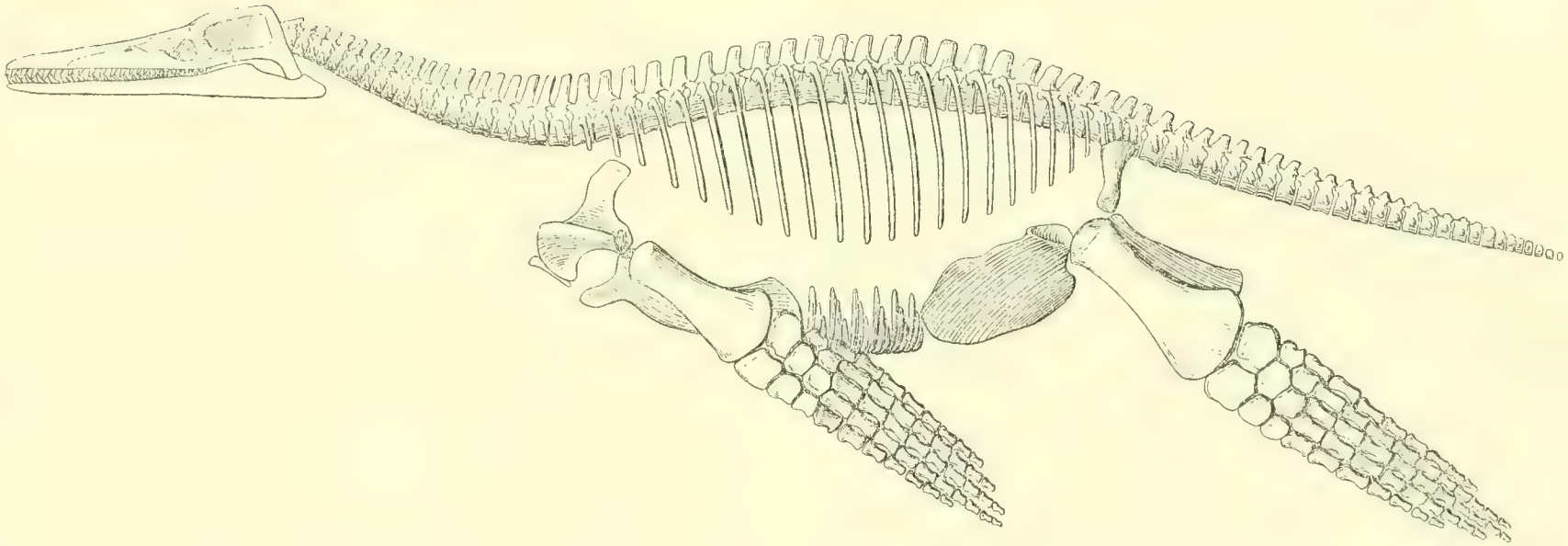
Two right ilia of *Peloneustes philarchus*, showing the variation in form: A, ilium of R. 2441; B, ilium of R. 2438. ($\frac{1}{3}$ nat. size.)

acet., acetabular surface; *is.f.*, facet for ischium; *cr.i.*, crista ilii.

and backwards for union with the ischium (*is.f.*), the other looking downwards and forwards and forming the posterior portion of the acetabulum (*acet.*); both are roughened and pitted as if for a covering of cartilage, and they make an angle of about 100° with one another.

Hind Limb (text-fig. 23, B).—The hind paddle, as usual in the family, is larger than the fore, the *femur* (*fem.*) especially being longer and relatively, perhaps, a little more slender than the humerus. The head (*h.*) is rounded, and on its outer side joins the trochanter, the upper face of which is flattened and rough, having been covered with cartilage in life. The shaft is oval in section; on the ventral face and posterior border

Text-fig. 26.



Restoration of the skeleton of *Peloneustes philarchus*, drawn mainly from R. 3318. ($\frac{1}{14}$ nat. size.)

of its upper portion are strong rugosities for the insertion of muscles. The distal expansion, which is mainly postaxial, is rather more distinctly marked off from the shaft than in *Pliosaurus*. The general form and arrangement of the tibia, fibula, and the other paddle-bones will be best understood from the figure. The *tibia* is the largest of the other bones of the paddle; it is rather longer than wide. Proximally it articulates with the femur by a nearly straight surface; its outer border is gently convex, the inner (fibular) border concave. Distally it bears a long straight facet for the tibiale and a short oblique one for the intermedium. The *fibula* also unites with femur by a nearly straight border; its postaxial surface is strongly convex, its anterior (tibial) edge concave; distally it bears facets for the intermedium and fibulare, making a very obtuse angle with one another. The expansion of the femur extends considerably behind the fibula and was fringed with cartilage, which may have enclosed a posterior accessory ossicle, though no specimen has been found in which this is preserved.

The form and arrangement of the tarsals and metatarsals is the same as in other members of the group, the fifth metatarsal as usual articulating directly with the fibulare. The metatarsals are flattened and constricted in the middle. The phalanges are likewise much constricted in the middle and are oval in section; the number in each digit is not known.

Peloneustes philarchus, Seeley, sp.

[Plate IV.; text-figs. 11–27.]

1869. *Plesiosaurus philarchus*, Seeley, Index to the Fossil Remains of Aves, etc., in the Woodwardian Museum, Cambridge, p. 139.

1888. *Thaumatosaurus philarchus*, Lydekker, Geol. Mag. [3] vol. v. p. 353.

1889. *Peloneustes philarchus*, Lydekker, Quart. Journ. Geol. Soc. vol. xlv. p. 49.

Type Specimen.—A considerable portion of a skeleton including the mandible and part of the skull, from the Oxford Clay, Peterborough; Porter Collection, Sedgwick Museum, Cambridge.

This species, founded by Seeley on the above-mentioned specimen, was never adequately described by him and no figures were published. Subsequently it was tentatively referred by Lydekker to *Thaumatosaurus*, but the same author in describing a considerable part of a skeleton of this species from the Oxford Clay of Kempston near Bedford, collected by Mr. Crick (see p. 70), established the genus *Peloneustes* for its reception. Subsequently he also referred *Pliosaurus evansi*, of the Oxford Clay, and *Pliosaurus æqualis* to that genus.

In this species the mandibular symphysis bears fourteen or fifteen teeth on either side, and widens out very distinctly in the middle (text-fig. 27, A). These characters distinguish it from the mandible referred to *P. evansi*, in which there are only twelve

teeth on each side of the symphysial region, which, moreover, remains about the same width throughout (text-fig. 27, B). *P. evansi* also seems to have attained a greater size, and various other differences between it and the present species are noted below.

R. 3318. A nearly complete skeleton, the parts preserved being skull, mandible, twenty-one or twenty-two cervical (text-figs. 17–19), two or three pectoral, twenty dorsal, and twenty-eight caudal vertebræ, ribs (cervical (text-fig. 20), dorsal and ventral), scapulæ (text-fig. 21), coracoids (text-fig. 21), humeri, ilia (text-fig. 24), pubes (text-fig. 24), right ischium (text-fig. 24), right femur. This skeleton, with the pelvis and paddles restored, is mounted in the Gallery of Fossil Reptiles ; it is described and figured in the Geol. Mag. [5] vol. vii. (1910) p. 110, pl. xii., and a restoration of it is now given (text-fig. 26, p. 61).

Some approximate dimensions (in centimetres) of this specimen are :—

Skull : length from occipital condyle to tip of snout	55·7
approximate transverse diameter of occipital condyle	4·0
width between the outer ends of the lateral rami of the pterygoids	15·5
length of the posterior interpterygoid vacuities	6·6
width between outer angles of quadrates (exaggerated by crushing)	29·0
Mandible : length	67·6
„ of symphysis	21·4
distance to which splenial enters symphysis	10·0

Vertebræ :

Cervicals and pectoral	3.	5.	7.	9.	11.	18.	19.	21.	22 *.
Length of centrum in mid-ventral line	2·3	2·6	2·6	2·7	2·8	3·2	3·3	3·3	3·3
Width of posterior face	..	..	4·5	..	..	..	..	..	..
Height to top of neural spine	9·8	11·8	12·4	13·0	13·3	15·5	15·0	14·4	12·8

Cervical ribs (text-fig. 20) :			
length	3·8	6·1	7·1
width of articular head	1·3	1·5	1·5
height of articular head	2·3	2·1	2·6

Coracoid (text-fig. 21, A, C) :		
greatest length (from antero-internal to postero-external angle)		47·0
greatest length, parallel to long axis		46·5
least width of the postglenoid portion		20·2
width at posterior angle of glenoid cavity		24·3
length of glenoid surface	(approx.)	7·0
„ scapular surface	(approx.)	3·5

* Pectoral.

Scapula (text-fig. 21, A, B):	
extreme length	23·8
width of neck	5·1
greatest antero-posterior length of anterior expansion	9·4
width of dorsal ramus	4·5
length of glenoid surface	4·8
„ coracoid surface	4·1
Humerus:	
length	33·0
width of upper end	8·4
„ shaft at narrowest	7·0
„ distal end	17·6
Ilium (text-fig. 24):	
length	16·2
Ischium (text-fig. 24):	
greatest length (parallel to the long axis of the body)	37·6
width of proximal (articular) end	9·5
„ neck	8·4
length of median expansion	30·3
width of middle of median expansion (approx.)	14·0
„ acetabular surface	6·2
Pubis (text-fig. 24):	
greatest length (parallel to the long axis of the body)	33·8
greatest width	30·0
Femur:	
length	39·0
width of upper end	9·4
„ shaft at narrowest	7·2
„ distal expansion	19·3

R. 3317. Fossilized contents of the stomach lying within the ribs. The hard mass includes many stones varying in size from that of a small hen's egg downwards. The stones are of various kinds, including quartz, sandstone and gneiss; they are mostly angular with the angles somewhat rounded. The mass in which the stones are embedded, consists mainly of angular grains of quartz of various sizes, and mingled with these are numerous hooks from the arms of Cuttle-fishes, and black masses which show the characteristic structure of the ink-bags of those creatures. This is the specimen described in the Introduction to Pt. I. of this Catalogue, pages xvi–xvii.

R. 2679 (Leeds Coll. 42). Skull, mandible, teeth, atlas, and axis, together with twelve other cervical vertebræ; some portions of ribs, radius, ulna, and greater part of the remaining bones of one fore paddle. The skull (Pl. IV. fig. 2) is less crushed than usual; it was described and figured in the Ann. Mag. Nat. Hist. [6] vol. xvi. (1895) p. 242, pl. xiii. fig. 2, and forms the basis upon which the description given above is founded. The teeth figured on Pl. IV. figs. 3, 4, belong to this specimen. The cervical vertebræ for the most part still have the cervical ribs and neural arch attached, but they are much distorted.

Some approximate dimensions (in centimetres) of this specimen are :—

Skull (Pl. IV. fig. 2):		
Length from basioccipital to tip of snout		59·5
„ pineal foramen to tip of snout		46·4
„ external nares to tip of snout		30·5
Width of snout at premaxillary expansion		6·5
„ „ constriction	(approx.)	5·5
Transverse diameter of occipital condyle		4·5
Vertical diameter of occipital condyle		3·6
Mandible:		
Extreme length		71·0
Length of symphysis		24·5
Width at middle of symphysis		6·6
„ at narrowest part of symphysis		5·7
„ of articular surface		6·5
Atlas and axis: length	(approx.)	6·7

The other vertebræ are too much distorted for it to be possible to make any measurements of value.

R. 3803. Skull and mandible, both in a very good state of preservation, though the skull has been somewhat broken. The skull is figured, from the palatal surface, on Pl. IV. fig. 1, while the bones of the occipital and otic regions, which are in an extraordinarily perfect and uncrushed condition, are figured in text-figs. 11 & 12. The inner face of the skull-roof is shown in text-fig. 13. On each side of the upper jaw there are thirty-four teeth, six of which are in the premaxilla. On each side of the mandible (text-figs. 14, A, B ; 27, A) there are forty-one teeth, of which about fifteen are in the symphysial region.

The following are the approximate dimensions (in centimetres) of this specimen:—

Skull (Pl. IV. fig. 1; text-figs. 11–13):		
Length from tip of snout to occipital condyle	(approx.)	59·3
„ „ „ pineal foramen		46·5
„ „ „ anterior end of the anterior interpterygoid vacuity		27·3
Width of expansion of snout		5·7
„ constriction of snout		4·8
Vertical diameter of occipital condyle		3·3
Horizontal diameter of occipital condyle		4·1
Width of basioccipital between outer angles of ventro-lateral (pterygoid) processes		7·6
Length of basioccipital		4·7
Width of articular surface of quadrate		4·7
Mandible (text-figs. 14, A, B; 27, A):		
Extreme length		72·0
Length of symphysis	(approx.)	22·5

Width of symphysis at widest	5·8
„ „ narrowest	5·1
„ of articular surface for quadrate	5·3
Length of postarticular process	5·8
Width between outer angles of postarticular processes	20·0

R. 2440 (Leeds Coll. 4). Imperfect skull and mandible, atlas, and the centra of nineteen other cervical vertebræ, centra of about twenty-six dorsals and nineteen caudals, some cervical ribs, numerous portions of the pectoral and pelvic girdles, and the fore and hind paddles (text-fig. 23).

The middle portion of the roof of this skull has been figured in Ann. Mag. Nat. Hist. [6] vol. xvi. pl. xiii. fig. 3.

Some dimensions (in centimetres) of this specimen are :—

Skull:

Approximate length from vertex to tip of snout	64·5
Length from pineal foramen to tip of snout	50·5

Vertebræ	Middle cervical.	Anterior caudal.
Length of centrum in mid-ventral line	3·3	3·3
Width of centrum	5·7	5·9
Height of centrum	4·9	5·1

Humerus (text-fig. 23, A): approximate length	35·8
width of shaft at narrowest	8·1
„ distal expansion (approx.)	16·4
Radius: length of preaxial border	8·7
width at proximal end	8·3
Ulna: greatest length	7·3
„ width	8·3
Femur (text-fig. 23, B): width of shaft at narrowest	8·5
„ distal expansion (approx.)	18·5
Tibia: length of preaxial border	10·4
width at proximal end	9·2
Fibula: length at postaxial side	9·5
width at middle	8·2

The other parts of the skeleton are too much crushed to supply any measurements of value.

47411. A mandible almost uncrushed and in a very good state of preservation; all the dental alveoli are empty. The tip of the symphysis is broken away, so that exact measurements of length cannot be given. The number of teeth on each side is about 32, of which about 14 are in the symphysial region. This specimen has been figured by Lydekker in Catal. Foss. Rept. Brit. Mus. vol. ii. (1889) p. 150, fig. 47 A. Also noticed by the same writer in Quart. Journ. Geol. Soc. vol. xlv. (1889) p. 49, and in the Rec. Geol. Surv. India, vo xxii. (1889) p. 50.

The approximate dimensions (in centimetres) of this specimen are :—

Length	72·0+
„ of symphysis	23·0+
Width of symphysis at widest part	5·4
„ „ narrowest part	4·5
„ of the articular surface	6·2
„ between outer angles of the postarticular processes	15·4

Sharp Collection.

R. 2439 (Leeds Coll. 3). Portions of a skull and skeleton. The portions preserved are basioccipital, quadrate, mandible, numerous teeth, atlas and axis, and eighteen other cervical vertebræ, all wanting the neural arches and ribs ; also some centra of dorsal and caudal vertebræ, a few cervical and sacral ribs, scapulæ, ilia, and paddle-bones.

In the mandible the bones are well preserved and distinct, so that the structure is fairly clear. The atlas and axis (text-fig. 16) are beautifully preserved, all the constituent elements, except the neural arch of the axis, being well preserved and separate. The centra of the rest of the cervical vertebræ are likewise in a good state of preservation and uncrushed, but the other vertebræ are very imperfect; one sacral rib preserved shows well the stoutness of these bones and the large size of their outer articular end.

Some dimensions (in centimetres) of this specimen are :—

Basioccipital: greatest length	5·5
„ width at lateral processes	8·4
Quadrate: width of articular surface for mandible	6·3
Mandible:	
Greatest length	75·5
Length of symphysis	21·8
Width of symphysis at broadest point	5·8
„ „ narrowest point	5·3
Depth of ramus at coronoid angle	9·0
Width of articular surface	6·8
Length of postarticular process	5·8

Vertebræ	Atlas.	Axis.	3rd cervical.	Middle cervical.	Posterior cervical.
Length of centrum in mid-ventral line	2·5	2·2	2·9	3·4	3·6
Width of posterior face of centrum	4·8	5·1	5·3	6·6	7·0
Height of posterior face of centrum	4·0	4·2	4·5	5·4	5·6

Width of the first subvertebral wedge-bone	6·4
„ second subvertebral wedge-bone	2·7
Sacral rib: length	9·0
width of proximal end	5·0
„ distal end	3·7

Ilium: length	18·7
width of upper end	9·6
„ middle of shaft	4·2
„ articular head	7·9
Femur: length	43·4

R. 2438 (Leeds Coll. 2). Atlas, axis (text-fig. 15), and nineteen other cervical vertebræ, two pectorals, twenty-four or -five dorsals, and eighteen or nineteen caudals, numerous cervical and dorsal ribs, imperfect scapulæ and coracoids, humeri, ilia (text-fig. 25, B), pubes, ischia, and femora. Most of the vertebræ are greatly crushed and have lost the arches and in the cervical region the ribs; a few of the cervicals, however, are only slightly distorted and retain their arches; some caudal centra are likewise in good condition. The scapulæ and coracoids are much crushed and are imperfect; the humeri are nearly complete, though much crushed. In the pelvis the ilia (text-fig. 25, B) are in very good state of preservation, and the ischia, though flattened and broken in all directions, seem to be nearly complete; the pubes are not complete; the femora are nearly complete, but much flattened.

Some approximate dimensions (in centimetres) of this specimen are:—

Vertebræ	Atlas and Axis.	Anterior cervicals.		Middle cervical.	Middle cervical.	Posterior cervical.	Anterior dorsal.
Length in mid-ventral line	7·0	2·7	3·3	3·7	2·7	2·5	3·6
Width of posterior face of centrum	4·4	5·2	5·4	5·5	5·2	3·3	7·0
Height of posterior face of centrum	4·5	4·3	4·8	..	4·8	3·2	6·8
„ to tip of neural spine	9·3	..	..	17·6	..	..	..

Humerus: length	38·2
width of upper end	11·2
„ shaft at narrowest	8·5
„ distal expansion	22·0
Ilium (text-fig. 25, B): length	20·6
width of upper end	12·5
„ shaft at narrowest	4·0
„ lower articular end	8·3
Pubis: width between outer angle of acetabulum and the symphysial border	32·8
width of articular head	17·0
Ischium: greatest length	48·0
„ width	26·3
width of articular head	11·7
„ neck	9·2
„ middle of expanded blade (approx.)	17·0

Owing to the crushing and distortion which this skeleton has undergone, many of the above measurements can only be regarded as rough approximations.

R. 2444 (Leeds Coll. 8). Fragments of skull, nearly complete mandible, six centra of dorsal vertebræ, fragments of ribs, almost complete and little crushed right coracoid and scapula.

The mandible only wants two or three centimetres, and the coracoid and scapula are singularly complete and fully ossified.

Some dimensions (in centimetres) of this specimen are :—

Skull:	
Transverse diameter of occipital condyle	4·0
Vertical diameter of occipital condyle	3·5
Width of basioccipital at lateral processes	8·3
Length of basioccipital	5·0
Length of mandible (so far as preserved)	73·0
„ symphysis (so far as preserved)	16·7
Width of articular surface for quadrate (approx.)	6·0
Length of postarticular process	6·5
Coracoid: greatest length	55·0
length from antero-internal to postero-external angle	52·7
width from postero-external angle of glenoid cavity to symphysial surface (middle)	25·5
length of scapular and glenoid surfaces together	15·7
width on middle of postglenoid region	28·3
Scapula: greatest length	26·9
width from before backwards of the median expansion of ventral ramus	16·1
width of middle of dorsal ramus	5·0

R. 2441 (Leeds Coll. 5). An imperfect skeleton of a small individual including a much broken and incomplete skull, a fairly complete mandible, portions of the atlas and the centra of nineteen other cervical vertebræ, twenty-eight dorsal and sixteen caudal centra, all wanting their arches and ribs; imperfect left scapula and coracoid, the ilia (text-fig. 25, A) and pubes, the latter much broken.

Some dimensions (in centimetres) of this specimen are :—

Skull:	
Transverse diameter of occipital condyle	3·6
Vertical diameter of occipital condyle	3·1
Width of basioccipital at lateral processes	7·9
Length of basioccipital	5·0
Width of articular surface of quadrate	5·5
Mandible:	
Greatest length	65·5
Length of symphysis	21·0
Depth of ramus at coronoid angle	5·6
Width of articular surface for quadrate	5·2
Length of postarticular process	5·3
Scapula: width of articular end	7·5
„ middle of dorsal ramus	4·2
Coracoid: width from outer angle of glenoid cavity to symphysial surface (approx.)	22·0

Ilium (text-fig. 25, A): length	17·8
width of dorsal expansion	10·4
„ middle of shaft	3·3
„ articular end (the surfaces for ischium and acetabulum taken together)	6·5
Pubes: width of surfaces for ischium and acetabulum taken together	14·0

R. 2442 (Leeds Coll. 6). Portions of a skeleton including six cervical vertebræ, scapulæ, and interclavicle, left ilium, and numerous paddle-bones. The vertebræ are much crushed and distorted, and have lost their neural arches and ribs. The scapulæ and interclavicle (text-fig. 22) are well preserved; they have been described and figured by Lydekker in Quart. Journ. Geol. Soc. vol. xlv. (1889) p. 52, fig. 6, the interclavicle being regarded as an omosternum; the interclavicle has also been figured by Seeley in Proc. Roy. Soc. vol. li. (1892) p. 131, fig. 4. The ilium is complete.

The dimensions (in centimetres) of some of the above-mentioned bones are :—

Scapula: length from hindmost point of posterior ramus to anterior end of ventral ramus	25·5
width of expansion of ventral ramus	11·6
„ middle of dorsal ramus	5·8
„ articular enlargement	7·8
Interclavicle (text-fig. 22): length on middle line	11·4
„ of anterior border (width)	11·7
„ of lateral border	13·0
Ilium: width of expanded upper end	11·6
„ shaft at narrowest	4·7
„ lower end (acetabular and ischial surfaces)	8·5
extreme length	20·8

R. 1253. A considerable portion of a skeleton including the anterior part of the mandible, six teeth (Pl. IV. fig. 5) and numerous fragments, several vertebral centra from the dorsal and caudal regions, portions of ribs, portions of the pectoral and pelvic girdles, imperfect fore paddles, and nearly complete hind paddles. This specimen was described by Lydekker in Quart. Journ. Geol. Soc. vol. xlv. (1889) p. 48 *et seqq.*, the mandible being figured on pl. ii. fig. 1, a tooth in text-fig. 4, the restored coracoids in text-fig. 5, the restored pubes and ischia in text-figs. 7 & 8, a part of a fore paddle in text-fig. 9, two vertebræ on pl. ii. figs. 2 & 3. These text-figures are reproduced in Catal. Foss. Rept. Brit. Mus. pt. ii. (1889) as text-figs. 49, 51–54.

The dimensions (in centimetres) of this specimen are :—

Mandible: length of symphysis	22·3
Humerus: width of distal expansion	20·7
Radius: length of preaxial border	9·7
„ humeral border	9·1
Ulna: greatest width	9·6
„ length	9·8

Kempston, near Bedford. *Presented by F. W. Crick, Esq.*, 1888.

Peloneustes evansi, Seeley, sp.

[Text-figs. 27, B; 28, 29.]

1869. *Pliosaurus evansi*, Seeley, Index to the Fossil Remains of Aves, etc., in the Woodwardian Museum, Cambridge, p. 116.

1871. *Pliosaurus ? grandis*, Phillips, Geology of Oxford, p. 317.

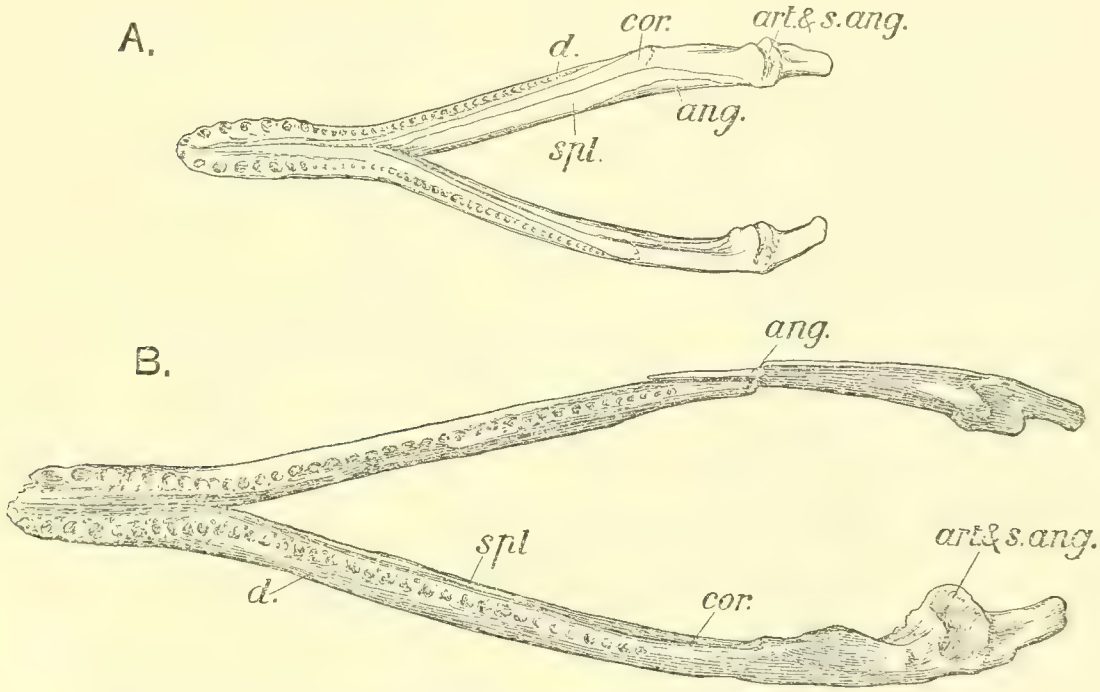
1877. *Pliosaurus evansi*, Seeley, Quart. Journ. Geol. Soc. vol. xxxiii. p. 716.

1890. *Peloneustes evansi*, Lydekker, Catal. Foss. Rept. Brit. Mus. vol. iv. (Supplement) p. 273.

Type Specimen.—Cervical and dorsal vertebræ, coracoid, and numerous fragments from the Oxford Clay of St. Neots; Sedgwick Museum, Cambridge.

The type specimen was described and figured by Seeley in the Quart. Journ. Geol. Soc.

Text-fig. 27.



Mandible of (A) *Peloneustes philarchus* (R. 3803) and (B) *Peloneustes evansi* (R. 2443). (About $\frac{1}{10}$ nat. size.)

ang., angular; *art. & s.ang.*, articular and surangular; *cor.*, coronoid; *d.*, dentary; *spl.*, splenial.

vol. xxxiii. (1877) pp. 716–723, figs. 1–7. The atlas and axis, which are not fused with one another, are figured, as also are the centra of another cervical (? fourth) and the first dorsal. The coracoid is described and figured as an ischium, an error corrected in the Geol. Mag. [3] vol. iv. (1887) pp. 478–9. Mr. Lydekker in the Supplement to the Catal. Foss. Rept. Brit. Mus. vol. iv. p. 273, suggested that the mandible (text-fig. 27, B) and the paddle (except the humerus) figured by Phillips in the 'Geology of Oxford' (1871) pp. 317 & 318 as *Pliosaurus ? grandis*, really belong

to the present species, which he at the same time included in his genus *Peloneustes*. Recently Mr. Leeds has collected the greater part of the skeleton of a large Pliosaur, including the skull and mandible. The latter, though crushed in the opposite direction, agrees closely in structure with the jaw figured by Phillips; and the vertebræ also resemble those of the type specimen of *P. evansi*, so that it appears that this skeleton may be referred to that species, and from it very large additions to our knowledge can be made. One consequence of this additional information about the species is, that it is found to differ very considerably from the typical species of *Peloneustes*, and, since some of the points of difference are of considerable importance, it is doubtful whether a new genus, in some respects intermediate between *Peloneustes* and *Pliosaurus*, should not be established for its reception. For the present, however, this species will be referred to *Peloneustes* and the differences between it and *P. philarchus* pointed out.

In addition to the specimens referred to above, some other imperfect skeletons, in which the skull and mandible are not preserved, have been referred to this species.

The *skull* is known only from specimen R. 3891 recently obtained by Mr. Leeds. It differs from that of *Peloneustes philarchus* in possessing a broader snout, the borders of which are straight, there being practically no constriction at the point where the maxillo-premaxillary suture crosses the alveolar border. The premaxillary teeth are six in number and are not greatly enlarged; the diastema betweeen the premaxillary and maxillary teeth is very short indeed, a character which distinguishes this skull from that of *Pliosaurus*. The number of maxillary teeth is smaller than in *Peloneustes philarchus*, there being only about 22 on either side. The palate is without any anterior interpterygoid vacuity, and the suborbital vacuity, if present at all, must have been very small.

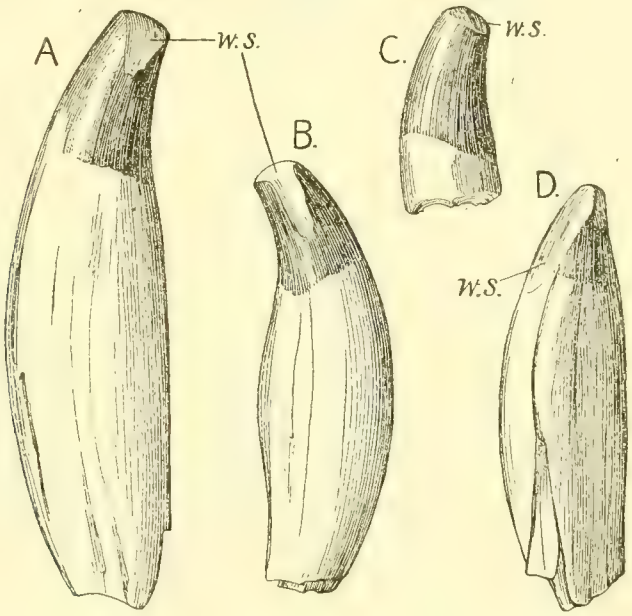
The symphysis of the *mandible* (text-fig. 27, B) differs from that of *P. philarchus* in being shorter, in carrying only 11–12 teeth on each side, and in not being at all expanded; in the number of teeth in the symphysis, the jaw is thus intermediate between those of *P. philarchus* and *Pliosaurus*. The total number of teeth on either side of the lower jaw is 32–36.

The *teeth* (text-fig. 28) differ from those of both *Pliosaurus* and *Peloneustes philarchus* in possessing smoother enamel, the ridges being fewer and in nearly all cases confined to the inner (concave) side of the crown. Another peculiarity of the teeth of this reptile is, that they undergo wear to an extent not observed in any other Plesiosaurian; in some cases they are worn down to a blunt stump (*w.s.*). This peculiarity probably indicates that this species lived on some animal protected by a hard shell or armour, for it does not seem possible that the wear can have been brought about by the grinding of the teeth against one another. A similar though much less marked state of wear is sometimes to be seen in teeth of *Pliosaurus* and of *Polyptychodon*. In spite of this extreme tooth-wear, the presence of tooth-germs on

the inner side of the teeth in use seems to show that the normal tooth-replacement was in operation.

The *atlas* and *axis* of this specimen, allowing for crushing and fracture, are similar to the atlas and axis of the type specimen described and figured by Seeley in Quart. Journ. Geol. Soc. vol. xxxiii. (1877) p. 716, figs. 1 & 2. The centra of the other cervicals are also like that of the fourth cervical figured by Seeley. As in *Peloneustes philarchus*, the length of the centrum in the mid-ventral line is greater than that of the dorsal side. The neural arches are high; the zygapophyses are strongly developed, the articular surface of the anterior zygapophysis in most of the cervicals being gently convex, the surface of the post-zygapophysis being correspondingly concave. The neural spines seem to have increased in height from before backwards; they differ

Text-fig. 28.



Teeth of *Peloneustes evansi*. (R. 3891, $\frac{2}{3}$ nat. size.)

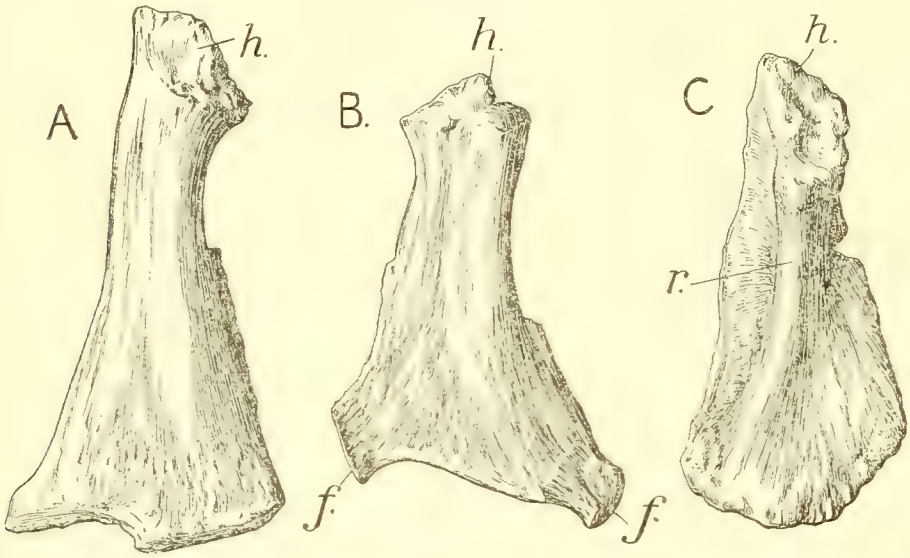
w.s., surface of wear.

widely in form from those of *Peloneustes philarchus* in that, instead of being compressed from side to side, they are flattened from before backwards, particularly at their upper ends, towards which they widen out; the anterior face bears a number of rough ridges, running from the base of the spine to the summit. This flattening may have been produced in part by post-mortem pressure, but since it occurs on the neural spines of all the cervicals, it was no doubt present in the living animal and indicates that the movements of the neck were in some way different from those habitual to *Peloneustes philarchus*; the cervical ribs are similar to those of that species. The dorsal centra are much crushed, but were perhaps rather shorter

in proportion to their width than in the other species; the chevron-facets on the caudals are large.

A number of peculiarly shaped bones (text-fig. 29), preserved with this skeleton, are here regarded as sacral or anterior caudal ribs. At their proximal end they bear a head (*h.*) with two facets for union with the lower part of the neural arch and with the centrum; distally they expand into a broad blade, which curves somewhat downwards and is strengthened on the ventral surface by a ridge (*r.*) running out from the head. They vary in form at their outer ends: in some there is a large terminal facet, perhaps for union with the ilium; in most the outer end is produced forwards and backwards into a short process terminating in a flat facet (*f.*), which probably united with the corresponding facet on the rib before and behind. This arrangement would add greatly to the rigidity of the sacral and anterior caudal regions, a condition probably connected with the great development of the hind paddles.

Text-fig. 29.



Sacral ribs (?) of *Peloneustes evansi*: A, B, from above; C, from below. (R. 3891, ½ nat. size.)
f., facet for contact with next rib; *h.*, articular head; *r.*, strengthening ridge.

Of the pelvis only the *ilia* are preserved. These expand dorsally into a broad triangular blade much as in *Pliosaurus*, and, as will be seen from text-fig. 25, B, in *Peloneustes philarchus* also. The upper border is greatly roughened and bears a surface probably for union with the outer end of one or more of the expanded ribs noticed above. The upper part of the outer face of the posterior border has a strongly developed rugosity for muscle-attachment.

The fore and hind paddles are much the same as in *Peloneustes philarchus*, except that the distal expansion of the humerus and femur is perhaps a little more marked, and the femur a little larger in proportion to the humerus.

47837. Plaster cast of the imperfect atlas and axis of the type specimen ; described and figured by Seeley in Quart. Journ. Geol. Soc. vol. xxxiii. (1877) p. 717, figs. 1 & 2. The original, in the Sedgwick Museum, Cambridge, is from the Oxford Clay of St. Neots.

The dimensions (in centimetres) of this specimen are :—

Length of the centra of atlas and axis and anterior wedge-bone .	9·7
Combined length of the neural surfaces of the atlas and axis . .	8·1
Width of posterior face of axis . . . . . (approx.)	7·9

Presented by Prof. H. G. Seeley, F.R.S., 1876.

R. 1713, R. 1713 a. Plaster casts of the centra of the fourth and fifteenth cervical vertebræ of the type specimen ; described and the fourth vertebra figured by Seeley in Quart. Journ. Geol. Soc. vol. xxxiii. (1877) pp. 718–9, figs. 3 & 4. These figures reproduced by Lydekker in Catal. Foss. Rept. Brit. Mus. pt. ii. (1889) p. 129, fig. 39. The originals in the Sedgwick Museum, Cambridge, are from the Oxford Clay of St. Neots.

The dimensions (in centimetres) of these centra are :—

	Fourth.	Fifteenth.
Length in mid-ventral line	4 (approx.)	4·5
Width of articular face	7·5	8·9
Height of articular face	6·5	7·6

Made in the Museum.

R. 2443 (Leeds Coll.). Mandible and hind paddles (except femur) of a large individual. The mandible is larger than any other jaw of *Peloneustes* in the Collection ; it differs from the others also in having only twelve teeth on each side of the symphysis, which is only slightly expanded, and the length of which is less than a quarter of the total length of the jaw, instead of about a third as in *Peloneustes philarchus*. On account of these differences from the last-mentioned species, these specimens are here provisionally referred to *P. evansi*, as suggested by Lydekker. The mandible is figured by Phillips in the 'Geology of Oxford' (1871) p. 318, fig. 122, as *Pliosaurus ? grandis*. The hind paddle, which presents no important peculiarities, is figured by the same author (*tom. cit.* p. 317, fig. 121), but the femur shown in the figure is certainly not that of *Peloneustes* and probably belongs to a *Cryptocleidus*.

Some dimensions (in centimetres) of these specimens are :—

Mandible (text-fig. 27, B) : extreme length	115·0
length of symphysis	25·4
greatest width of symphysis	8·6
length of postarticular process	8·3
Hind paddle :	
Tibia : length of preaxial border	13·1
greatest width	11·7
Fibula : length	12·2
width	11·6

R. 3891 (Leeds Coll.). A large part of the skeleton, including the skull, mandible, atlas and axis, and sixteen other cervical vertebræ, thirty pectorals, dorsals and (?) sacrals, sixteen caudals,

numerous separate neural arches, cervical, dorsal, sacral, and caudal ribs, fore paddles, ilia, hind paddles. The skull is covered with serpulæ, which seem to indicate that it was exposed on the sea-bottom for some time before becoming embedded in the sediment. It is greatly crushed, and the same is the case with the mandible, in which the lateral compression has much deepened the rami, thus giving the jaw a very different appearance from the mandible figured by Phillips (see also text-fig. 27, B), in which the compression is in the opposite direction. Four teeth are shown in text-fig. 28. Most of the neural arches and the cervical and caudal ribs are separated from their centra.

Some dimensions * (in centimetres) of this specimen are :—

Skull : length from occipital condyle to tip of snout		95·0
length from anterior end of pineal foramen to tip of snout		71·0
width where the maxillo-premaxillary suture crosses the alveolar border	(approx.)	9·5
Mandible : length		116·0
„ of symphysis	(approx.)	25·5
„ of postarticular region		9·2
depth at coronoid process		16·8
„ hinder end of symphysis		7·6

Vertebræ	Atlas † and axis.	Anterior cervical.	Posterior cervical.	Middle † dorsal.	Anterior caudal.
Length in mid-ventral line	9·5	4·0	4·6	5·5	4·0
Width of posterior face of centrum	6·7	7·4	8·4	9·7	8·2
Height of posterior face of centrum	5·7	6·4	6·8	10·4	7·6
Height to summit of neural spine	..	16·9	..	22·8	..

Humerus : length	44·5
width of upper end	12·4
„ shaft at narrowest	10·6
„ distal expansion	24·0
Ilium : length	31·0
„ of upper border	16·8
width of shaft at narrowest	5·8
„ articular end	11·2
Femur : length	55·5
width of upper end	17·5
„ shaft at narrowest	11·5
„ distal expansion	28·1

R. 2445 (Leeds Coll. 9). Basioccipital, one exoccipital, atlas, axis, and the centra of thirteen other cervicals, all wanting the neural arches and ribs, numerous separate cervical ribs,

* The errors due to distortion are very considerable, especially in the skull and mandible.

† These measurements are only approximate.

portions of the coracoids. This individual, though large, is still young, judging from the condition of the atlas and axis; it is therefore possible that it may be a young Pliosaur.

In the atlas all the elements are separate and the centrum is not fused with that of the axis; this latter is fused with the second subvertebral wedge-bone, though the line of union is for the most part distinct; there are some indications that there may have been a small third subvertebral wedge-bone between the axis and the third cervical.

Some dimensions (in centimetres) of this specimen are :—

Basioccipital:	transverse diameter of occipital condyle	5·5
	vertical diameter of occipital condyle	4·0
	width between outer angles of the lateral processes	10·2
	length (approx.)	7·5
Atlas:	length of the neural surface	3·7
	width of posterior face	5·7
	„ first subvertebral wedge-bone	6·3
Axis:	length of centrum	3·5
	width of posterior face of centrum	5·9
	height of posterior face of centrum	4·9

Cervicals	Middle.	Posterior.
Length of centrum on mid-ventral line	3·4	4·2
Width of posterior face of centrum	6·2	7·0
Height of posterior face of centrum	5·9	6·2

R. 2437 (Leeds Coll. 1). Portions of a skeleton; the parts preserved are :—atlas and axis with seventeen other cervical vertebræ, some with the neural arches and ribs still *in situ*, but apparently not yet fused; two pectorals, twenty-four dorsals, and one caudal (mostly wanting the neural arches), ribs, scapulæ, coracoids, humeri, radii, ulnæ, ilium, pubes, ischia, femur, tibiæ, fibulæ, numerous paddle-bones.

The absence of any part of the skull makes it difficult to be certain that this may not be a small individual of *Pliosaurus ferox*.

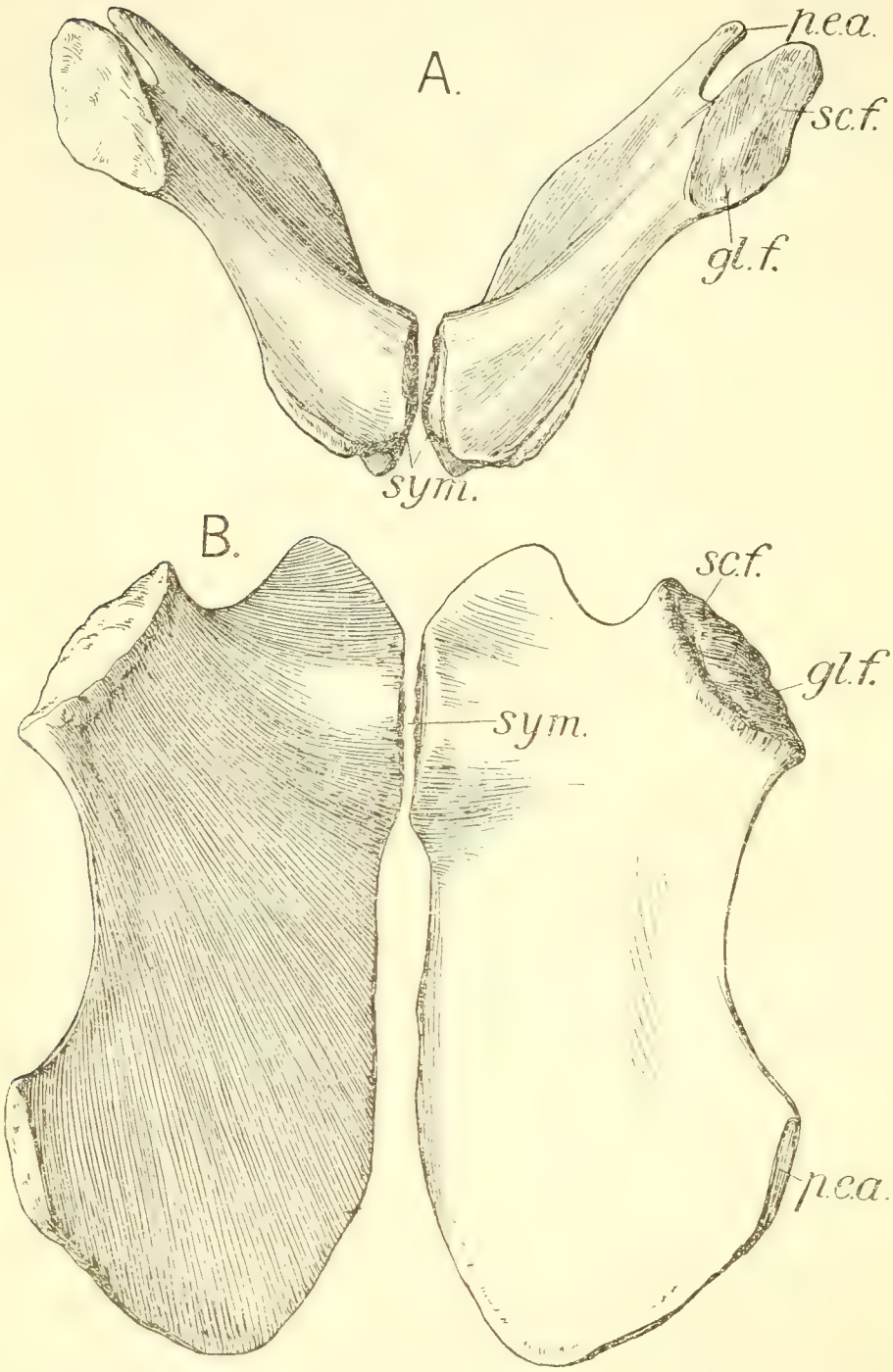
The vertebræ are nearly all too much crushed and distorted to give measurements of any value. The approximate sizes of some of the cervicals are :—

	Atlas and axis.	Cervicals.	
Length in mid-ventral line	9·0	3·9	3·9
Width of posterior face of centrum	..	7·5	7·9
Height of posterior face of centrum.	..	6·7	6·6

The dimensions (in centimetres) of other parts of this specimen are :—

Scapula:	width of articular surface	10·3
	„ dorsal ramus at narrowest point	7·4
Humerus:	length	44·5
	width of proximal end (crushed)	11·7
	„ shaft at narrowest	9·7
	„ distal end	22·7

Text-fig. 30.



Coracoids of *Peloneustes evansi*: A, from front; B, from above. (R. 3897, $\frac{1}{5}$ nat. size.)
gl.f., glenoid facet; *p.e.a.*, postero-external angle; *sc.f.*, facet for scapula; *sym.*, symphysial surface.

Radius: length (preaxial border)		8·8
width (proximal end)		8·5
Ulna: length		8·8
width (in middle)		10·0
Ilium: length	(approx.)	24·2
width of shaft		4·3
„ lower end	(approx.)	5·6
Pubis: length		62·5
greatest width		44·0
width of articular head		16·6
Femur: length		52·5
width of proximal end		12·3
„ shaft at narrowest		10·2
„ distal end		25·4
Tibia: length (preaxial border)		10·6
width (proximal end)		9·9
Fibula: length		10·6
width (in middle)		10·0

R. 3897. Coracoids and left scapula probably of this species. The coracoids (text-fig. 30) are quite uncrushed and undistorted, so that they show their exact relations to one another. When the symphysial surfaces are in contact, the ventral faces of the bones make an angle of about 90° with one another.

The dimensions (in centimetres) of these coracoids are:

Greatest length	58·4
Width from middle of symphysis to posterior angle of glenoid surface	36·3
Least width behind glenoid cavity	31·7
Combined width of scapular and glenoid surfaces	17·8

Order CROCODILIA.

Lacertiform reptiles, mostly of large size. Skull with fixed quadrates, upper and lower temporal arcades, and a secondary palate formed posteriorly by the palatines (in the Mesosuchia) or by the palatines and pterygoids (in the Eusuchia); no parietal foramen. Teeth confined to the margins of the jaws and implanted in deep sockets. Vertebræ amphicœlous, amphiplatyan, or procœlous. Cervical ribs mostly short, with double heads articulating with processes of the neural arch and centrum; dorsal ribs articulating by their head and tubercle with the transverse processes of the neural arch only. Two sacral vertebræ. Dermal ossifications usually present.

Suborder MESOSUCHIA.

Internal nares opening at the hinder end of the secondary palate formed by the palatines, the pterygoids having no ventral processes. The lateral eustachian passages forming open grooves on the basisphenoid. Vertebræ amphicœlous or amphiplatyan.

Family TELEOSAURIDÆ.

Mesosuchia with a greatly elongated rostrum formed mainly by the maxillæ, the premaxillæ being small and separated by a long interval from the anterior end of the nasals. The prefrontals are small and do not form an overhanging roof to the orbit, which is round or oval in outline and looks mainly upwards, but to some extent also outwards and forwards. The lachrymal is large. Supratemporal fossæ tending to become very large and longer than wide. Fore limb much smaller than hind limb. Two rows of keeled dorsal scutes, numerous ventral scutes.

Lias to (?) Upper Cretaceous.

Genus **STENEOSAURUS**, Geoffroy (emend. Deslongchamps).

[Mémoires du Museum, vol. xii. p. 146 (1825); emend. E. E. Deslongchamps, Notes Paléontologiques, p. 126 (Caen, 1867).]

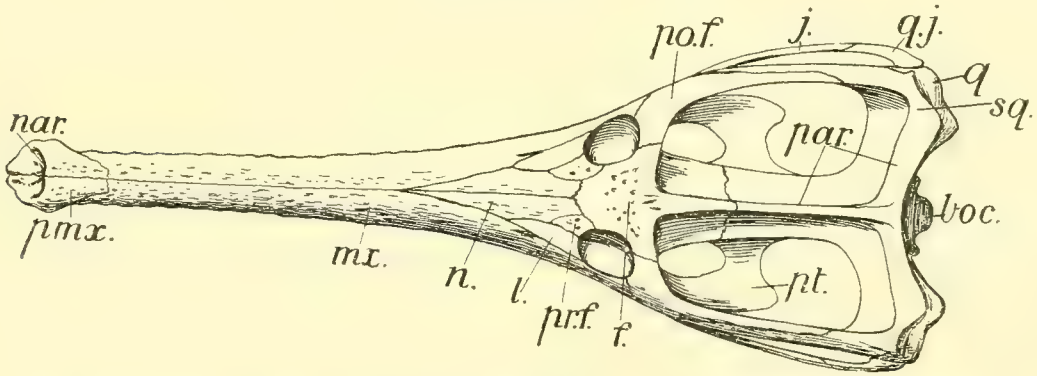
1837. *Leptocranius*, Bronn, Leth. Geogn. i. p. 516.
1845. *Sericodon* (*Sericosaurus* in index), von Meyer, Neues Jahrb. f. Min. etc. p. 310.

Premaxillary region expanded and bearing the united anterior narial openings. Orbits completely surrounded by bone, usually nearly circular in outline, and

looking almost directly upwards; a small preorbital opening usually present. Frontal small and the skull-roof much flattened, passing quite gradually into the upper surface of the snout. The alveolar border straight, without undulations. Internal narial opening rounded, palatal vacuities of moderate size. Teeth numerous, with the enamel marked by longitudinal ridges, of which, as a rule, one on the anterior and one on the posterior side of the crown, at least near the point, form well-marked carinæ.

Vertebræ slightly concave, the posterior caudals all with backwardly directed spines, there being no sharp deflection of the end of the tail, such as occurs in the Metriorhynchidæ. Fore limb not reduced to a paddle-like structure as in the above-mentioned family. The tibia about half the length of the femur, and the sum of the length of the femur and tibia considerably more than twice the sum of the lengths of the humerus and radius. Armour consisting of a double row of keeled plates running down the mid-dorsal line, the successive plates uniting by an overlapping and peg-and-

Text-fig. 31.



Semi-diagrammatic figure of the upper surface of the skull of *Steneosaurus durobrivensis*. (About $\frac{1}{8}$ nat. size.)

boc., basioccipital; *f.*, frontal; *j.*, jugal; *l.*, lachrymal; *mx.*, maxilla; *n.*, nasal; *nar.*, external nares; *par.*, parietal; *pmx.*, premaxilla; *po.f.*, postfrontal; *pr.f.*, prefrontal; *pt.*, pterygoid; *q.*, quadrate; *q.j.*, quadrato-jugal; *sq.*, squamosal.

socket articulation; also numerous other plates, probably ventral, the arrangement of which is uncertain.

Middle and Upper Jurassic.

Mystriosaurus of Kaup (in Bronn's Lethæa Geogn. ed. 1, vol. i. 1837, p. 525) is by many writers regarded as a synonym of *Steneosaurus*, but it should be used for the Liassic forms, which, though closely similar and probably ancestral to *Steneosaurus*, are distinguished by the form of the ventral border of the internal nares, which, instead of being a continuous curve, is sharply pointed, the palatines meeting in the middle line in an acute angle; moreover, the frontals are larger and the temporal fossæ relatively smaller. A number of other names given to fragmentary material and insufficiently

defined, may be synonyms of *Steneosaurus*, but need not be referred to here. A complete history of the genus is given by Deslongchamps in his 'Notes Paléontologiques,' p. 95 (1867), and also more recently by Dr. Erwin Auer in his important paper "Ueber einige Krokodile der Juraformation" (Palæontographica, vol. lv. (1909) p. 219 *et seqq.*).

Skull (Pls. V.–VII.; text-figs. 31–33).—The following account of the skull in this genus is founded, so far as possible, on a nearly complete and comparatively uncrushed skull of *Steneosaurus leedsi* (R. 3806) found in association with a nearly perfect skeleton.

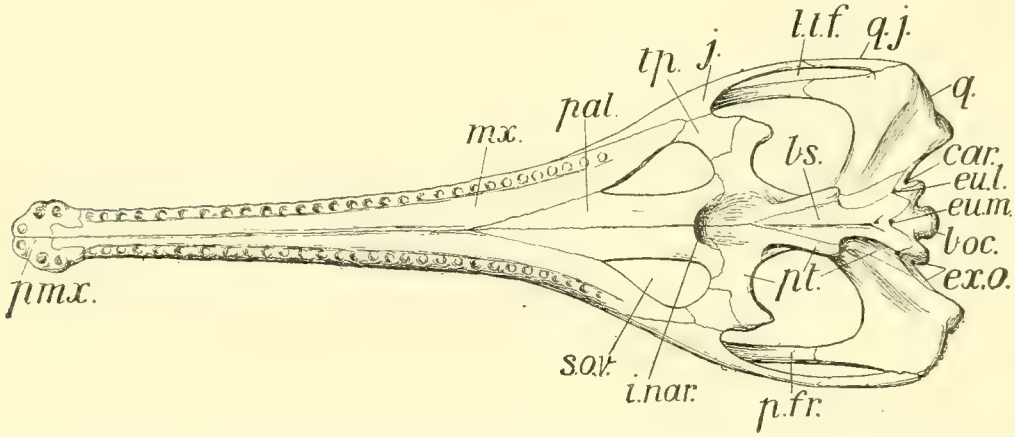
It may be noted that in the case of the skulls of the various species of Crocodiles from the Oxford Clay of Peterborough, the bones do not, as a rule, become separated from one another, as is often the case with skulls of the Sauropterygia, and consequently it is not possible in any case to describe the individual bones in such detail as has been done, for instance, with the occipital and auditory bones of *Peloneustes* (see above, pp. 35–39, text-figs. 11–12). Indeed, the dorso-ventral crushing undergone by most of the skulls of *Steneosaurus* makes it very difficult to determine the form and arrangement of their constituent elements, particularly in the cranial portion, and the difficulty is still further increased by the obscurity of the sutures.

The *premaxillæ* (*pmx.*) are small bones forming the expanded anterior end of the snout and completely surrounding the external narial opening (*nar.*). This extends nearly the whole width of the expanded portion of the snout; its anterior border is thickened and rounded, and in the middle line where the two premaxillæ meet, it is raised into a small prominence. The posterior border, which is also rounded and thickened, is nearly straight in most specimens, but this seems to be in part the consequence of the compression to which the bones have been subjected; in the middle of the posterior border there is a slight projection. The middle of the floor of the narial opening is occupied by a small incisive foramen, which is about twice as long as wide. Behind the nostrils the broad facial processes of the premaxillæ extend back between the maxillæ to a point about opposite the third maxillary tooth. On the palatal face, on the other hand, the maxillæ usually send forwards a tongue-like process between the premaxillæ as far as the level of the anterior edge of the alveolus of the fourth premaxillary tooth. The palatal surface of the united premaxillæ is gently concave from side to side and bears, near its middle, the incisive foramen to which reference has been made. Each premaxilla bears four teeth: the anterior pair are close to the middle line, the walls of their alveoli being separated by a small notch between the anterior end of the bones; they are the smallest. Behind and a little to the outer side of these is the next pair, which are somewhat larger. Behind these there is a diastema, the surface of which is concave from before backwards and convex from side to side. Then come the sockets for the third and fourth teeth, which are immediately behind one another and separated only by a narrow alveolar wall: these two teeth are large and nearly equal in size.

The widest part of the united premaxillæ is opposite the alveoli of the fourth pair of teeth. Behind them there is a long diastema, concave from before backwards and crossed at its hinder end by the maxillo-premaxillary suture; the jaw is somewhat constricted at this point. The facial surface of the premaxillæ is usually marked by a sculpture of vermiculate grooves.

The *maxillæ* (*mx.*) are very large bones forming the greater part of the rostrum. From the point where their suture with the premaxillæ crosses the alveolar border to opposite the anterior angle of the nasals (about opposite the twenty-first maxillary tooth in *Steneosaurus leedsi*) the sides of the rostrum are nearly parallel, the widening being very gradual in this region, particularly in species, such as *St. leedsi*, with a long narrow rostrum. At the level of the anterior angle of the nasals the divergence of the sides of the jaw becomes more marked, but is still gradual, the passage into the post-

Text-fig. 32.



Semi-diagrammatic figure of the palatal surface of the skull of *Steneosaurus durobrivensis*.
(About $\frac{1}{8}$ nat. size.)

boc., basioccipital; *bs.*, basisphenoid; *car.*, carotid foramen; *eu.l.*, lateral eustachian opening; *eu.m.*, median eustachian opening; *ex.o.*, exoccipital; *i.nar.*, internal nares; *j.*, jugal; *l.t.f.*, lateral temporal fossa; *mx.*, maxilla; *pal.*, palatine: *p.fr.*, postfrontal; *pmx.*, premaxillæ; *pt.*, pterygoid; *q.*, quadrate; *q.j.*, quadrato-jugal; *s.o.v.*, suborbital vacuity; *tp.*, transpalatine.

orbital region of the skull being quite a gentle one. From the hinder point of the facial processes of the premaxillæ to the anterior angle of the nasals the maxillæ unite with one another in the middle dorsal line; behind this they unite in suture with the nasals, which are thrust wedge-like between them. Behind these, again, they join the lachrymals for a short distance, and then, narrowing gradually, run back beneath the anterior prolongations of the jugals, terminating at a point just behind the orbits, where they join, for a short distance, the transpalatine bone. It does not appear that the maxillæ form any part of the lower border of the orbits, being excluded by the jugals and lachrymals.

On the palatal surface (text-fig. 32) the maxillæ meet in the middle line from their anterior end to the anterior angle of the palatines. In front they usually send forwards a tongue-like prolongation between the palatine processes of the premaxillæ as described above. Posteriorly they diverge and unite in suture with the palatines for some distance, but at a point a little in front of the anterior edge of the orbit they are separated from them by the anterior portion of the suborbital vacuity (*s.o.v.*). The alveolar borders are nearly straight, being slightly concave in the posterior portion only. The alveoli have well-developed borders and form slight projections on the outer edge of the jaw. The number of alveoli varies much in the different species. In *S. leedsi*, in which the greatest number occurs, there are thirty-eight maxillary teeth on either side of the jaw. In all species the first maxillary tooth is small and is often situated at a rather higher level than the rest. Behind this the teeth remain almost equal in size till the last few, which gradually diminish. The palatine plates of the maxillæ are sharply separated from the alveolar border by a groove, on the inner side of which they are sharply convex, then nearly flat to the middle line; in some cases the suture between them may run along the summit of a slight median ridge. Their union with the palatines has already been referred to: at the suborbital vacuities, of which they form the outer boundaries, they narrow to their posterior end, uniting behind for a short distance with the transpalatines (*tp.*), which behind them join the jugals (*j.*). In the region of the palatines, the palatine plates of the maxillæ are somewhat inflated and convex from side to side.

The *palatines* (*pal.*) meet one another in median suture on the palate. Anteriorly they send forwards a narrow process between the maxillæ, then, still united in suture with the palatine plates of the maxillæ, they widen out to the anterior angle of the suborbital vacuity, of which they form the inner border. Here they narrow slightly till a little in front of the opening of the internal nares, behind which they widen out again and join the pterygoids. The ventral border of the internal nares (*i.nar.*) is formed entirely by the secondary palatal plates of the palatines; it is gently concave and is somewhat thickened and irregularly notched, at least near the middle. The roof and part of the sides of the narial passage are formed by the pterygoids (*pt.*, text-figs. 32, 33). The upper portion of the palatines, which should form the roof of the nasal canal in front of the pterygoids, is wanting in all cases, so that it cannot be seen whether or not they completely enclosed a portion of the canal, as described by Deslongchamps *. The *vomer* also has not been seen in any of the specimens, so that its form and relations to the surrounding bones cannot be described.

The *pterygoids* (*pt.*, text-figs. 32–33) are very large bones with a great antero-posterior extent. As already mentioned, they form the roof of the posterior narial opening, the suture between them and the palatines crossing just behind that aperture on the

* 'Notes Paléontologiques' (1867) p. 208.

ventral surface, while on the dorsal surface they send forwards, along the palatines, long overlapping processes which extend at least to the level of the anterior border of the orbits. Behind the narial opening the pterygoids widen out greatly, and their palatal surface is hollowed into a large shallow pterygoid fossa, which is bordered by a rounded ridge, most strongly developed on the posterior side. At the sides of the pterygoid fossa the bones run outwards into a large lateral wing, the anterior border of which is continuous internally with the edge of the palatines and externally with the anterior edge of the transpalatines, the short free edge between the two helping to form the hinder border of the suborbital vacuity (*s.o.v.*). Antero-externally the lateral wing joins the transpalatine in an L-shaped suture, while posteriorly its border is thickened and concave, passing externally into the large process which bears on its outer face a flat roughened facet: this process does not project below the level of the rest of the palatal surface to nearly the same extent as it does in the recent Crocodiles, in which both the outer wing of the pterygoid and the transpalatine project considerably below the level of the alveolar border. Behind the pterygoid fossa the pterygoids are separated in the middle line by the wedge-shaped surface of the basisphenoid (*bs.*), which is thrust between them, and with the sides of which they unite in sutures which are usually raised into prominent ridges (text-fig. 33). In this region the pterygoids form shelf-like wings along the sides of the basis cranii, the wings terminating in a prominent angle a little in front of the basisphenoid-basioccipital suture. At their posterior end the pterygoids send up to the sides of the skull tongue-like processes, which unite with the quadrates in front and terminate in a suture with the exoccipitals, which is continuous externally with that between the quadrate and exoccipital. This posterior process of the pterygoid seems to help in forming the anterior edge of the lateral eustachian aperture (*eu.l.*, text-fig. 33).

The *transpalatine* (*tp.*) unites with the anterior border of the lateral wing of the pterygoid in an L-shaped suture; it then runs forwards and outwards, uniting at its outer end with the jugal behind and the posterior prolongation of the palatine plate of the maxilla in front.

The *nasals* (*n.*) are large elements which unite in suture in the middle line and extend forwards like a wedge between the hinder ends of the maxillæ on the upper surface of the skull, to a degree varying in the different species, though in all cases their anterior angle is separated by a long interval from the facial processes of the premaxillæ. Behind their union with the maxillæ, the nasals unite first with the lachrymals, then with the prefrontals. Posteriorly they diverge from one another to receive the more or less wedge-like anterior end of the frontals, the exact form and relations of which are of much value in the determination of the species.

The *lachrymals* (*l.*) are large triangular bones: on their inner border they join the nasals, externally they unite with the maxillæ, and there is usually a small lachrymal (autorbital) vacuity on, or close to, the line of suture between the two bones; the

opening is usually situated nearer to the anterior angle of the lachrymals than to their orbital border, which is thickened and concave.

The *prefrontals* (*pr.f.*) are small and form the supero-anterior portion of the border of the orbit, which, however, they do not overhang, as in the Metriorhynchidæ. Internally they join the nasals in front in a convex suture, and for a short distance posteriorly they unite with the frontals; externally they join the lachrymals in a nearly straight suture. In some cases there is a trace of the presence of a downwardly projecting process from the ventral face of the prefrontal; this, no doubt, is the process which, in *Mystriosaurus* and in modern Crocodiles, runs down to join the upper surface of the palatine and helps to define the orbit antero-internally.

The *frontals* (*f.*) are, as usual in the group, represented by a single bone. This terminates anteriorly in a point which is thrust between the nasals to a degree varying in the different species, so that the form of the anterior portion of the frontals usually supplies important diagnostic characters. Behind their union with the nasals, the frontals widen out and for a short distance join the prefrontals. Behind this again they curve outwards and backwards, forming the postero-superior portion of the border of the orbit. Posteriorly, the united bones are produced into three processes, a pair running outwards and, in some cases, a little backwards, and joining the postfrontals in an oblique suture, thus completing the bars of bone separating the orbits from the supratemporal fossæ. The third process is a median one, which joins the parietals and forms the anterior portion of the narrow crest dividing the two supratemporal fossæ from one another; the summit of this bar is flattened or rounded. In the angle between the median and lateral bars the frontals also help to form the skull-roof. The upper surface of the body of the frontals is gently concave from side to side and, even if the rest of the surface of the skull is unsculptured, usually bears an ornament of rounded pits, which may be very strongly or very slightly developed. Probably on this point there is considerable individual, as well as specific, variation.

The *parietals* (*par.*) unite in front with the frontals and form the greater part of the narrow sagittal ridge between the supratemporal fossæ: the sides of this ridge are vertical and a little concave from above downwards. Below the parietals widen out to help to form the cranial roof, but in no case could sutures between them and the surrounding bones be well seen; it appears probable, however, that the cranial part of the parietals unite with two bones, the anterior being the alisphenoid, the posterior the proötic. Behind the hinder end of the sagittal ridge the upper surface of the parietals forms a triangular area which may bear a sculpture of pits. Ventrally the united bones join in suture the upper surface of the supraoccipital; the line of union seems to be marked by a groove, at each end of which there may be a perforation. The lateral processes of the parietals join the squamosals to form the posterior wall of the supratemporal fossa; the outer end of the lateral ramus of the parietals seems to form part

of the upper border of a vascular groove which crosses the back wall of the temporal fossa (see below).

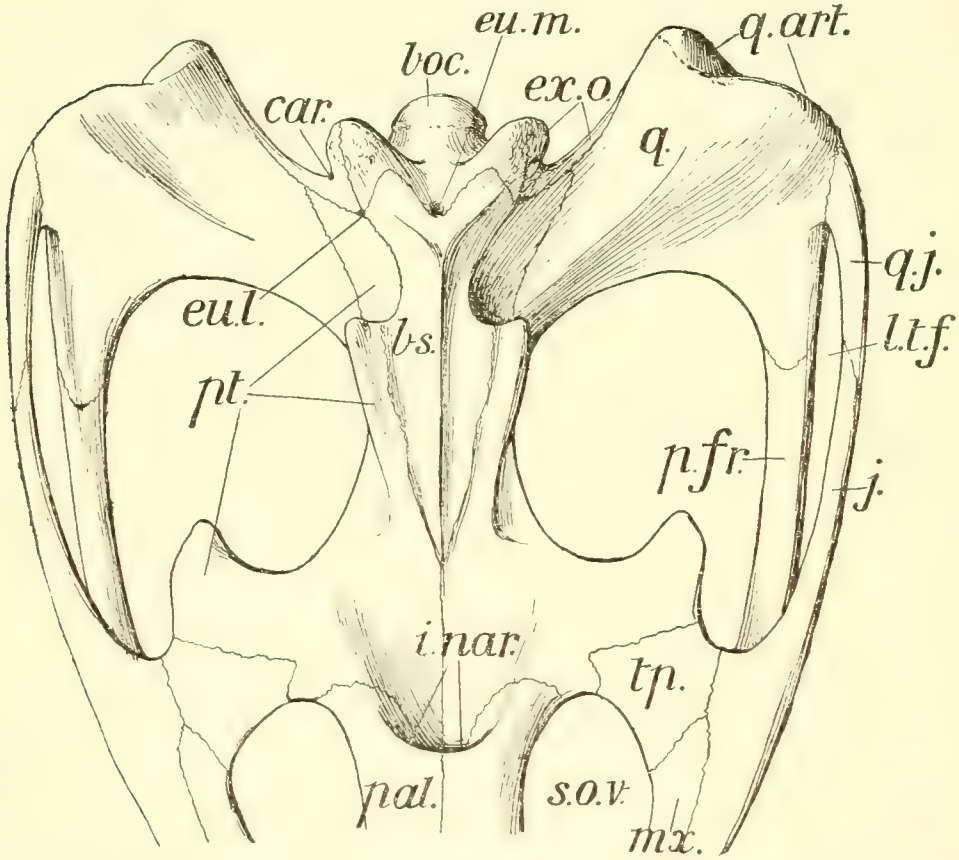
The *postfrontal* (*po.f.*) unites by an oblique suture with the outer (postorbital) process of the frontal, and forms the lower part of the bar of bone separating the orbit from the supratemporal fossa: at its ventral end it unites with the jugal, and behind this it is prolonged backwards as a broad band of bone to the zygomatic process of the squamosal (*sq.*), uniting with it in an oblique suture; this posterior bar, which constitutes the anterior two-thirds of the upper temporal arcade, is somewhat thickened along its upper border, but is thin and sharp below, the lower part of the outer face being marked by a longitudinal groove.

The *squamosal* (*sq.*) is an L-shaped bone. One arm of the L extends up to the parietal, with which it forms the posterior boundary of the supratemporal fossa. Its posterior face is almost completely concealed by the overlap of the exoccipital. Its anterior face is marked by a deep but short transverse groove, the inner end of which passes by a foramen into the skull, the outer probably passing out at the back of the skull by an opening between the squamosal and upper edge of the quadrate. Mr. D. M. S. Watson drew my attention to this canal in a skull of *Mystriosaurus* from the Whitby Lias; it seems to occur commonly in the whole group and probably transmitted a blood-vessel. The zygomatic branch makes nearly a right angle with that running up to the parietals, but the actual angle is truncated by an oblique surface, concave above and convex below, and defined in front by a strong ridge, roughened and sloping downwards and backwards. The surface probably served for the attachment of muscle, while the anterior ridge perhaps had some relation to the tympanic membrane, or perhaps to the muscles connected with a flap closing the outer ear. The zygomatic bar itself is comparatively short and narrow; it unites in front with the postfrontal. Ventrally it joins the quadrate, which sends a process forwards along its ventral edge probably to the postfrontal, and another backwards, forming the upper edge of the narrow cleft-like opening of the tympanic recess, the lower edge of which is formed by the body of the quadrate. The backward process of the quadrate along the squamosal extends nearly to the prominent ridge on the latter bone referred to above.

The *quadrate* (*q.*), of which the prolongation upwards to the squamosal has just been described, is a very large and strongly built bone fixed immovably among the surrounding bony elements; it is directed downwards, outwards, and backwards and terminates in the articular surface for the mandible. This surface consists of an inner and an outer convex portion separated by a shallow groove which passes across it obliquely from above downwards and inwards. Immediately above the outer angle of the articulation the outer border of the bone unites in suture with the expanded posterior end of the quadrato-jugal, and above this runs up to the squamosal, with which it unites in the manner described above. The upper surface of the ascending

portion is, speaking generally, convex from side to side, and is, to a great extent, overlapped and concealed by the adherent outer wing of the exoccipital, which extends along it to within a short distance of the articular surface. From this point the suture with the overlapping exoccipital runs close to the hinder edge of the quadrate as far as the outer angle of the posterior wing of the pterygoid, with the outer edge of which the quadrate unites, sending on to the side of the brain-case a prolongation, the precise relationships of the inner end of which cannot be observed.

Text-fig. 33.



Palatal view of the posterior part of the skull of *Steneosaurus durobrivensis*. (about $\frac{1}{3}$ nat. size.)

boc., basioccipital; *bs.*, basisphenoid; *car.*, carotid foramen; *eu.l.*, lateral eustachian opening; *eu.m.*, median eustachian opening; *ex.o.*, exoccipital; *i.nar.*, internal nares; *j.*, jugal; *l.t.f.*, lateral temporal fossa; *mx.*, maxilla; *pal.*, palatine; *p.fr.*, postfrontal; *pt.*, pterygoid; *q.*, quadrate; *q.art.*, articular surface of quadrate; *q.j.*, quadrato-jugal; *s.o.v.*, suborbital vacuity; *tp.*, transverse bone.

The *quadrato-jugal* (*q.j.*) unites by a posterior expansion with the outer edge of the quadrate, then narrows into a rod of bone which, after running forwards a short distance, joins the jugal in an overlapping suture. The *jugal* (*j.*) is also rod-like posteriorly; anteriorly it widens out and becomes compressed from side to side. In front of the

lateral temporal fossa it unites above with the postfrontal for a short distance; in front of this it widens further and forms the lower border of the orbit, in front of which again it unites for some distance with the lower edge of the lachrymal, terminating forwards in a point. The ventral edge of the anterior portion of the jugal unites with the maxilla in front and with the transpalatine posteriorly.

The occipital surface (Pl. V. fig. 3) shows well the great compression of the skull from above downwards, its width being much greater than its height. The *supra-occipital* (*s.oc.*) is a small bone completely shut off from the foramen magnum (*f.m.*); it unites with the exoccipitals below in a convex suture, and with the parietals above in a nearly straight one. Along its junction with the parietals there are two depressions separated by a slight median vertical ridge which extends up on to the parietals; it is probable that a foramen opens into each of the depressions. The *exoccipitals* (*ex.o.*) are large bones which meet in the median line above the foramen magnum in a vertical suture, and thus, as already noticed, completely exclude the supraoccipital from that opening. They form a great part of the occipital surface of the skull, being produced outwards into large paroccipital wings. At their lower end they unite with the basioccipital, and take a very small share in the formation of the occipital condyle; beneath this they unite with the outer sides of the ventro-lateral processes of the basioccipital (*boc.*) and thus form the outer portion of those prominences. External to this the border turns sharply outwards, passing into the lower edge of the paroccipital process; at the angle thus formed there is a large foramen which transmitted the carotid artery (*car.*), and perhaps also the vagus group of nerves. The lateral wing of the exoccipital is very large; it consists of a lower portion, convex from above downwards and closely united with the upper surface of the quadrate, and an upper (paroccipital) portion which forms a strong overhanging ledge separated from the lower part by a groove which deepens greatly from within outwards, so that at its outer end the exoccipital is deeply notched into an upper and a lower division. The anterior face of the upper portion unites closely with the upper ramus of the squamosal and with it forms the posterior wall of the supratemporal fossa.

The *basioccipital* (*boc.*) forms the whole of the occipital condyle, with the exception of the small portions of the upper outer sides borne by the exoccipitals. The upper border between the bases of the exoccipitals is flattened or gently concave, but the remainder of the condyle is nearly evenly convex, the transverse diameter being a little greater than the vertical one; about the middle of the convexity there is a slight dimple. Ventrally the condyle is sharply marked off from the rest of the bone by a strong transverse groove, forming a kind of short neck. Ventro-laterally it bears a pair of large tuberosities, directed outwards and downwards and projecting most prominently at their posterior angle; the hinder part of the outer face of these projections is overlapped by and unites closely with processes of the exoccipitals; ventrally they are separated by a deep fossa, narrowing and deepening forwards to an

angle, at the bottom of which opens the median eustachian canal (*eu.m.*); the anterior border of this seems to be formed by the basisphenoid, although in one case observed it appears that the opening may be completely surrounded by the basioccipital. Almost immediately within this opening are the orifices of two lateral canals which run outwards and slightly upwards between the basioccipital and the basisphenoid, narrowing in the middle and opening laterally into the lateral eustachian openings (*eu.l.*), which appear to lie in the depression at the point where the sutures between the basioccipital, exoccipital, and basisphenoid meet; the posterior prolongation of the pterygoid also appears to help in forming the anterior border of the opening (text-fig. 33). In some cases there is a groove running from the lateral eustachian openings down the sides of the basis cranii towards the median opening, but in the present genus this character is not very well marked. In addition to the lateral eustachian opening, just within the median aperture there seems to be a median canal running forwards and upwards into the body of the basisphenoid, dividing above into two lateral branches; there is also a small, probably vascular, foramen running back into the body of the basioccipital.

The position of the foramina for nerves and blood-vessels on the occipital surface (Pl. V. fig. 3) is not easy to determine with certainty. On either side of the foramen magnum is a pair of small openings which probably transmitted the hypoglossal nerve. Below these and in the line of the suture between the exoccipital and basioccipital, there is another foramen, with in some cases one or more small apertures near it; this opening is regarded by Auer * as transmitting the vagus group of nerves, but it seems in all cases observed by me to be too small for this, and more probably received some small blood-vessel. If this is so, then it would appear that there is no separate external opening for the vagus, the foramen for which is confluent with the carotid foramen situated in the notch between the outer face of the ventro-lateral process of the exoccipital and its prolongation on to the quadrate. Above and external to this there is another opening on the paroccipital process, probably for the facial (VII) nerve. In a skull of *Mystriosaurus* (B.M. no. 33095) the vagus opening is distinct from that for the carotid, and the latter is not in the angle as just described in *Steneosaurus*, but on the occipital surface and in the same plane as the hypoglossal and vagus foramina.

Mandible (Pl. V. fig. 4).—The mandible is chiefly remarkable for the great length of the symphysis, which is formed mainly by the dentaries, but posteriorly also to a varying extent by the splenials; an anterior prolongation of the coronoid also extends on to the dorsal face of the symphysis (Pl. V. fig. 4). The relative length of the symphysis and the number of teeth carried by it vary much in the different species, affording an important means of identification. The bones forming the mandible are the six pairs usual in the group, viz., dentaries, splenials, coronoids, angulars, surangulars, and articulars.

The *dentaries* (*d.*) are the largest elements: for the greater part of their length they

* Palæontographica, vol. lv. (1909) p. 273.

unite in median suture; anteriorly they may be separated by a small notch, while posteriorly the splenials are thrust in the form of a wedge between them to a varying degree. Their buccal surface is more or less convex from side to side—this is especially well seen in the mandible of *St. leedsi* (Pl. V. fig. 4). The alveolar borders are straight, and bear a varying number of teeth which seem to have been directed upwards, forwards, and outwards. At the level of the third and fourth teeth, which are enlarged and close together, there is an expansion, behind which the jaw is much narrowed; behind this point again there is a gradual widening towards the hinder end of the jaw, varying in extent in the different species. The ventral face of the symphysial region is convex from side to side, and marked by a number of irregular longitudinal grooves. Behind the symphysis the dentaries are overlapped on the upper surface by the narrow coronoids, which for some distance run in between them and the splenials. At its posterior end the dentary bifurcates, the bottom of the fork forming the anterior angle of the elongated lateral vacuity; the ventral ramus unites in overlapping suture with the anterior end of the angular, while the dorsal ramus is overlapped by the anterior prolongation of the surangular.

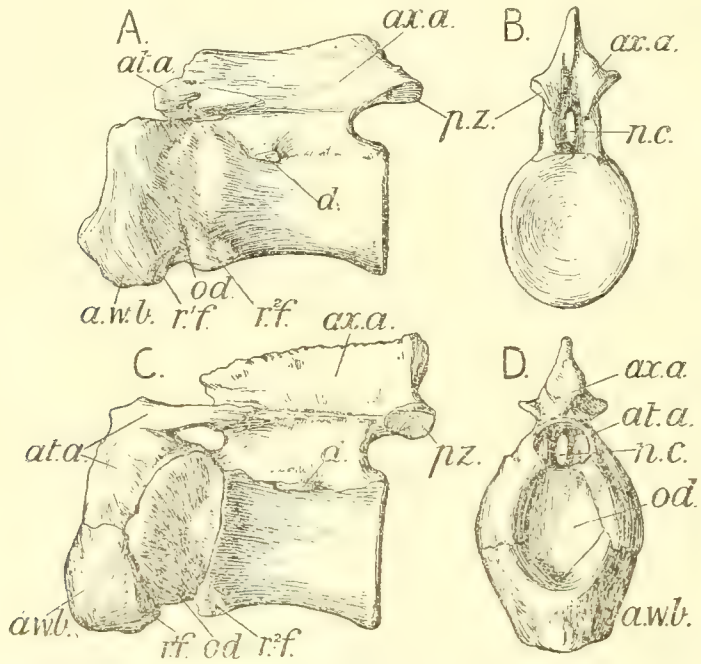
The *splenials* (*spl.*), as above noted, unite in median symphysis anteriorly, and are thrust like a wedge between the dentaries. The angle at which they meet is marked by a deep pocket-like fossa, their ventral union extending further back than the dorsal and thus forming a floor to the fossa. In the posterior portion of their symphysial region, and behind this, they are separated above from the dentaries by the narrow coronoid. Posteriorly the splenial overlaps the inner face of the anterior end of the angular and surangular; it is here thin and forms an inner wall to the anterior part of the lateral vacuity.

The *coronoid* (*cor.*) differs considerably in form and position from the bone usually so called in recent Crocodiles. In these it is a small splint of bone on the inner side of the jaw at the anterior end of the lateral fossa. In *Steneosaurus*, on the other hand, as has been described by Deslongchamps ('Notes Paléontologiques,' pp. 226–7), it is a narrow ribbon of bone on the upper surface of the jaw; its anterior portion being interposed between the dentary and splenial, while posteriorly it overlaps the surangular. Deslongchamps states that it helps to form the border of the lateral vacuity, but this does not seem to be the case in any of the specimens examined. The arrangement and form of the other bones of the mandible are much as in recent Crocodiles. The *surangular* (*s.ang.*) at its narrow anterior end unites with the splenial and dentary, and is overlapped by the hinder end of the coronoid; behind this it forms the upper boundary of the elongated lateral vacuity. Posterior to this again, it supports the articular as in recent species. The *angular* (*ang.*) forms the whole of the lower portion of the hinder part of the jaw: in front it joins the dentary; behind this it forms the lower boundary of the lateral vacuity, and behind this again its upper edge joins the surangular. The *articular* (*art.*) bears the whole of the articular

surface for the quadrate, except a small portion of the outer concavity which is on the surangular. The articular surface consists of two concavities, the outer much the larger and separated from the other by a slight ridge; the surface, as a whole, looks upwards and forwards. Behind this surface the articular is prolonged backwards, forming the upper portion of the postarticular process and terminating behind in a blunt angle.

Vertebral Column (Pl. VI. figs. 6, 6 *a*; Pl. VII. figs. 5, 5 *a*; text-figs. 34–38).—Several almost complete examples of the vertebral column in various species of *Steneosaurus* are preserved in the Leeds Collection; in some cases the vertebræ are

Text-fig. 34.



Atlas and axis of *Steneosaurus leedsi*: A, from the left side; B, from behind. (R. 3806, ½ nat. size.) Also of *Steneosaurus durobrivensis*: C, from left side; D, from front. (R. 3701, ½ nat. size.)

at.a., neural arch of atlas; *a.w.b.*, anterior wedge-bone (hypocentrum); *ax.a.*, neural arch of axis; *d.*, diapophysis of axis; *n.c.*, neural canal; *od.*, odontoid (centrum of atlas); *p.z.*, posterior zygapophysis; $r^1.f.$, $r^2.f.$, facets for the heads of the ribs of the atlas and axis.

almost uncrushed and undistorted. The specimens upon which the following account of the vertebral column in this genus is founded, are (1) a nearly complete and uncrushed series of vertebræ of *St. leedsi* (R. 3806), consisting of the atlas, axis, and seven other cervical vertebræ (? one wanting), fifteen dorsals, two sacrals, and thirty-six caudals; (2) the vertebral column of the type specimen of *St. durobrivensis* (R. 3701), consisting of atlas, axis, and eight other cervicals, thirteen dorsals, two sacrals, and thirty-eight caudals.

It is interesting to note that the greater elongation and slenderness of the skull in *St. leedsi* as compared with that of *St. durobrivensis* are seen also in the proportions of the vertebral centra of the two species, particularly in those belonging to the cervical and caudal regions.

The *atlas* and *axis* (text-fig. 34) of the Oxford Clay Steneosaurs were described by Hulke * in 1888, and recently by Auer † who has published a more detailed account, with a useful and complete summary of the views that have been put forward as to the homologies of the constituent parts of the atlas-axis complex. Here the interpretation adopted is the same as that employed in the description of the atlas-axis of *Peloneustes* given above (p. 47) ‡.

The atlantal ring is composed, as usual, of the anterior ventral wedge-bone (*a.w.b.*) and the two supero-lateral pieces, which are produced up into the two halves of the neural arch (*at.a.*). The surface of the ventral wedge-bone, forming the lower portion of the atlantal cup, is strongly concave; beneath this it becomes roughened and strongly convex, forming a well-developed ventral prominence. On its lateral surfaces is a pair of short projections, each bearing a triangular articular surface for the first pair of ribs ($r^1.f.$); these surfaces look nearly directly backwards. Above the rib-facets the wedge-bone narrows, terminating dorsally on either side in a small facet looking directly upwards, for union with the lower ends of the lateral (neural) pieces (*at.a.*); these form the supero-lateral portions of the atlantal cup. From their union with the upper ends of the anterior wedge-bone they widen out upwards, spreading backwards over the odontoid (*od.*) (centrum of atlas), with the obliquely truncated anterior upper surface of which they closely unite. The pedicles of the neural arch extend nearly the whole length of the lateral pieces, and are only slightly notched on their posterior side. The arch itself in some cases seems to have been complete above; in other Crocodiles the sides of the arch do not unite in the mid-dorsal line, there being a separate roofing-piece. Possibly the condition observed in some of the present specimens is due to the fusion of the lateral pieces with the roofing-piece. Posteriorly the arch is produced backwards into a pair of prominent posterior zygapophyses, which usually fuse with the anterior zygapophyses of the axis.

The odontoid (*od.*) (centrum of the atlas) is a large massive element: anteriorly it

* Hulke, "Contributions to the Skeletal Anatomy of the Mesosuchia, based on Fossil Remains from the Clays near Peterborough, in the Collection of A. Leeds, Esq.," Proc. Zool. Soc. 1888, p. 417.

† Auer, "Ueber einige Krokodile der Juraformation," Palæontographica, vol. lv. (1909) p. 217.

‡ There seems to be little doubt that the atlas and axis, such as have been described in the Sauropterygia and are here found in *Steneosaurus*, are really two vertebræ in which a temnospondylous condition has to a great extent persisted; the ventral wedge-bones being the hypocentra (the posterior one is not ossified in the Crocodiles), the odontoid and the centrum of the axis the fused pleurocentra, and the neural arches the neurocentra of such vertebræ as are found in *Desmospondylus*, *Trimerorhachis*, &c. This was Cope's original view, which has been strongly advocated by Baur (Amer. Nat. 1897, p. 975), and quite recently by Williston (Journal of Geology, vol. xviii. (1910) p. 594).

forms the middle and upper part of the cup for the occipital condyle; external to this concave surface it is truncated by three oblique facets, one looking downwards and forwards for union with the anterior wedge-bone, and two looking upwards, forwards, and outwards for junction with the lateral (neural) pieces of the atlas. Behind these the side of the odontoid is exposed to a considerable extent, its surface being gently concave in all directions and much roughened anteriorly. Ventrally the bone is more or less overlapped by the posterior angle of the atlantal wedge-bone, and on its postero-lateral angle it bears the anterior portion of the surface of attachment for the head of the second rib, the posterior part being borne on the anterior angle of the centrum of the axis. No second ventral wedge-bone (between the odontoid and the centrum of the axis) has been observed in any specimen.

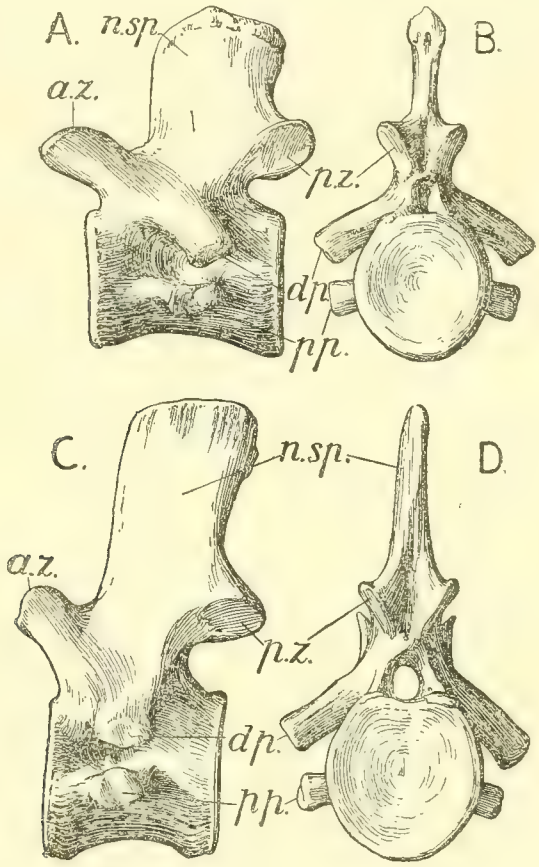
In the axis the anterior face of the centrum is usually closely fused with the odontoid, but when fusion has not taken place it can be seen to be flat or slightly concave and much roughened, as if for a pad of cartilage: it is quadrilateral in outline; the nearly straight upper and lower borders are parallel with one another, but the latter is the longer, so that the straight or very slightly concave lateral borders diverge a little from above downwards. At their lower ends they are separated from the slightly convex ventral border by the prominences bearing the two facets, which form the posterior halves of the facets ($r^2.f.$) for the heads of the second ribs. The sides of the centrum are somewhat concave, and the ventral face somewhat flattened. The posterior articular surface is gently concave and nearly circular in outline, the vertical being a little longer than the transverse diameter.

The bases of the pedicles of the neural arch (*ax.a.*) are very long, and, in fact, anteriorly they project beyond the centrum of the axis and have a short union with the odontoid; posteriorly they extend to the edge of the axial centrum. The neural arch bears a long low neural spine, the form of which differs somewhat in the different species (see text-fig. 34). The upper border of the spine is somewhat thickened and roughened in front; it slopes gently upwards posteriorly where its edge is thin, and projects a little behind the centrum. The anterior zygapophyses are very small; usually they are fused with the posterior zygapophyses of the atlas. The posterior zygapophyses (*p.z.*) are large and their articular surfaces look downwards and outwards; between their bases there is a deep cleft, into which the lower end of the posterior border of the neural spine passes as it dies away. On the side of the arch there is a well-defined ridge running backwards and gently upwards from the anterior to the posterior zygapophysis. A little behind the middle of the base of the neural arch, close to the neuro-central suture, there is a small, short, diapophysial process (*d.*) which seems to have been directed downwards and forwards and articulated with the tubercle of the second rib, the head of which, as noted above, united with a facet borne partly on the odontoid and partly on the centrum of the axis.

The length of the atlas-axis, the form of the neural spine, and some other points

differ in the various species: these differences will be referred to below. The remainder of the cervical series consists of eight vertebræ (text-fig. 35) probably in all cases, though in some specimens one or more may be missing. These, like the atlas and axis, differ from one another in the various species to a considerable degree, particularly in the length of the centrum in proportion to its other dimensions, and in the height of the neural spine. Speaking generally, the centra have slightly concave articular ends, the posterior concavity being the deeper; the concavity is most

Text-fig. 35.



Middle cervical vertebræ of *Steneosaurus leedsi*: A, from left side; B, from behind. (R. 3806, ½ nat. size.)
Also of *Steneosaurus durobrivensis*: C, from left side; D, from behind. (R. 3701, ½ nat. size.)

a.z., anterior zygapophysis; *dp.*, diapophysial process; *n.sp.*, neural spine; *pp.*, parapophysial process; *p.z.*, posterior zygapophysis.

marked in the middle, the edges being flat or even a little convex in some cases. The ends of the centra are nearly circular in outline, the vertical diameter being a little the greater; as a rule, the upper border is a little flattened beneath the neural canal. The sides of the centra are strongly concave from before backwards, and near the sharply defined edges of the articular surfaces bear numerous fine plications. The

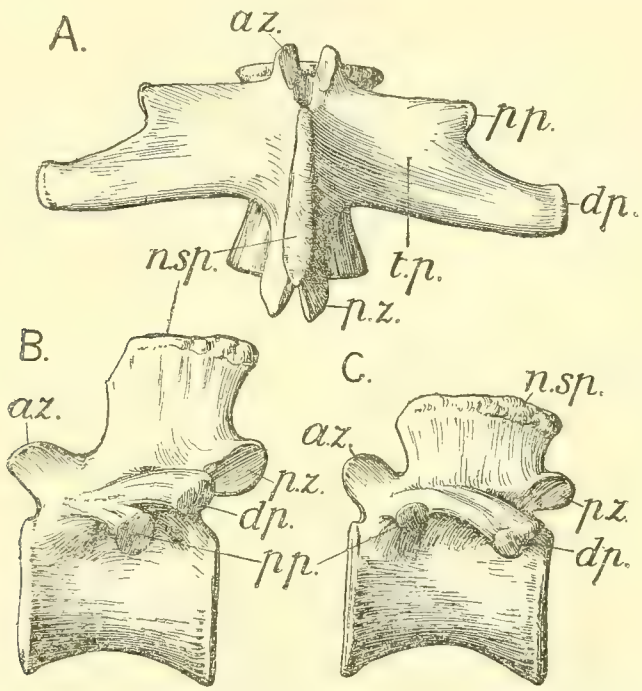
ventral surface in the third cervical (first postaxial) is flattened or even slightly concave from side to side between the bases of the parapophyses (*pp.*), but in the more posterior vertebræ the ventral face is convex from side to side. There is no hypapophysis. The parapophyses (*pp.*) are short stout processes, compressed from above downwards and terminating in an oval concave surface for articulation with the head of the rib; the long axis of this surface is horizontal. In the anterior cervicals they are situated somewhat nearer the anterior than the posterior end of the centrum and are low down, so that they may project below the level of the centrum. Followed back in the series they pass upwards on to the sides of the centrum and, in *Steneosaurus leedsi* at any rate, become about equidistant from the anterior and posterior ends; at the same time they become rounder in section and their articular ends convex. In the tenth cervical the parapophyses are separated from the diapophyses (*dp.*) by a notch only, and in the first dorsal they arise with the diapophyses from a common base borne on the neural arch. At their base the cervical parapophyses are connected with the anterior edge of the centrum by a ridge, on their posterior side they arise abruptly.

The neural arch in the cervical region differs in the different species in several respects, particularly in the height and width of the neural spine (*n.sp.*). In all, the pedicles of the arch rise from long bases which extend the whole length of the centrum, and may even form a very small part of the terminal articular surfaces. Above their base, the borders of the pedicles are concave, both in front and behind. Close to the neuro-central suture, which in old animals may be obliterated, are the prominent diapophyses (*dp.*), which are oval in section, the long axis being horizontal. These processes terminate in a slightly concave, flat, or slightly convex facet for union with the tubercle of the rib. They are directed downwards and shift backwards as they are followed back in the series, so that in the posterior cervicals they are situated a little behind the parapophyses. The large anterior zygapophyses (*a.z.*) project considerably in front of the anterior end of the centrum; their outer surface is convex and is connected by a slight ridge with the base of the diapophysis; in some cases (e. g., *St. leedsi*, text-fig. 35, A) there may be a low ridge running from thence to the outer edge of the posterior zygapophysis (*p.z.*); the articular surfaces are oval, very slightly concave, and inclined to one another at an acute angle. The posterior zygapophyses are borne on the posterior margin of the arch, the hinder edge of the neural spine (text-fig. 35, B) passing down into a deep groove between their bases; the articular facets are flat or slightly concave and are inclined to one another at an acute angle. The neural spines (*n.sp.*), as above noted, differ somewhat in form in the different species. They incline a little backwards, especially in the posterior cervicals. Their anterior border is thin and sharp, the posterior thickened and roughened; the truncated upper end is also roughened. The neural canal seems to be relatively small.

The number of dorsal and lumbar vertebræ is not quite certain, but, judging from several skeletons which are probably complete in this region, there would seem to have been 12–13 dorsals (rib-bearing) and two lumbars.

The dorsal vertebræ (text-figs. 36, 37) differ from one another in the various species to a less degree than do the cervicals and caudals, though in them also the relative length of the centrum is correlated with the greater or less elongation of the skull. The centra are strongly constricted in the middle, both the ventral and lateral surfaces being concave in a longitudinal direction; at the rim of the articular surfaces they are thrown into numerous small plications which may become strong rugosities, especially

Text-fig. 36.



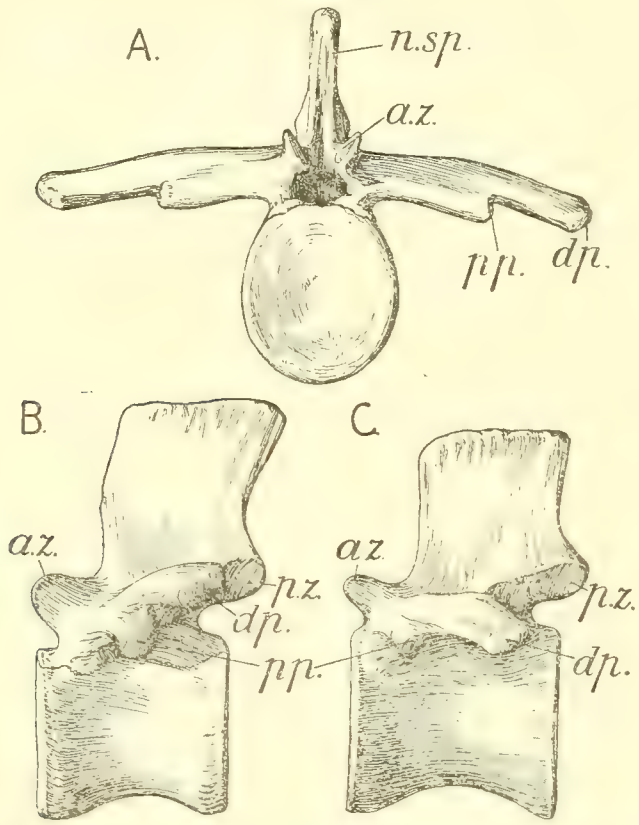
Dorsal vertebræ of *Steneosaurus leedsi*: A, middle dorsal from above; C, the same from left side; B, anterior dorsal from left side. (R. 3806, $\frac{1}{2}$ nat. size.)

a.z., anterior zygapophysis; *dp.*, diapophysial process; *n.sp.*, neural spine; *pp.*, parapophysial process; *p.z.*, posterior zygapophysis; *t.p.*, transverse process.

on the postero-ventral border. The ventral face is sometimes slightly flattened, but in no case is there any hæmapophysial ridge or process. The articular ends are gently concave, at least in the middle; in some cases towards the rim they may be flattened or even a little convex. The vertical diameter is a little greater than the transverse, this difference being in some cases a little more marked on the posterior than on the anterior face; usually the upper border beneath the neural canal is flattened or slightly concave.

The pedicle of the neural arch rises from a long base which extends the whole length of the centrum, and posteriorly may even form a small portion of the edge of the articular surface for the succeeding vertebra. Above the neuro-central suture the anterior and posterior borders are notched to allow of the passage of the spinal nerves; the posterior notching is the deeper. The transverse process (*t.p.*), which in this region bears the articular surfaces for both the head and tubercle of the rib, is borne entirely on the neural arch, and is lower down in the anterior dorsals than it is further back. In the first dorsal, although the two articular processes for the rib are borne

Text-fig. 37.



Dorsal vertebræ of *Steneosaurus durobrivensis*: A, middle dorsal from the front; C, the same from the left side; B, anterior dorsal from left side. (R. 3701, $\frac{1}{2}$ nat. size.)

a.z., anterior zygapophysis; *dp.*, diapophysial process; *n.sp.*, neural spine; *pp.*, parapophysial process; *p.z.*, posterior zygapophysis.

on a common base, they are still distinctly separated from one another by a deep groove; the parapophysis (*pp.*) is situated in front of and below the diapophysis (*dp.*), which is much the longer of the two and is directed a little upwards and backwards. At the same time it is slightly curved, the convexity being dorsal; the rib-facets of both the para- and diapophyses are flat or somewhat convex. As it is followed back in the

series the base of the transverse process rises a little on the arch, to the anterior edge of which it reaches, though separated by a short interval from the posterior edge; the basal portion of the process is nearly horizontal and is strongly compressed from above downwards, this character being more marked towards the hinder end of the series. The separation of the parapophysial and diapophysial parts of the process is marked on the ventral surface by the presence of two rounded ridges running out to the articular surfaces and separated by a shallow groove; this separation becomes less distinct in the posterior dorsals, where the parapophysial surface forms a mere step on the anterior edge of the compressed, broad, and here shortening diapophysial process which bears at its extremity the surface for the tubercle of the rib. As in the anterior dorsal, so in the rest of the series, the transverse process is gently convex above and concave below, and is directed a little backwards.

The neural spines (*n.sp.*) vary a little in width and height in the different species. In all they are broad, slope a little backwards, and terminate above in a straight border, which is thickened and raised into a series of ridges running down the sides of the spine; this thickening and roughening is, no doubt, correlated with the support of the dorsal scutes. The anterior zygapophyses (*a.z.*) are separated by a deep groove for the attachment of ligament; they are larger in the anterior than in the posterior dorsals. The posterior zygapophyses (*p.z.*) are separated by a deep pit, into which probably a ligament was inserted; their upper edge is continued backwards on the side of the arch as a slight ridge which may extend down to the posterior border of the transverse process; their articular surface is sometimes a little concave from side to side.

The number of the lumbar vertebræ is not certain. In no skeleton in the collection have more than two been observed that can be definitely assigned to this position. Their general form is similar to that of the dorsals, except that the transverse processes bear no facets for ribs; in one case it appears as if a short rib may have been fused with the outer end. The posterior face of the centrum of the last lumbar is much wider in proportion to its height than in the vertebræ in front, and though still somewhat concave is slightly bevelled off at its sides to fit the concavity of the first sacral. The neural spine is nearly vertical and greatly thickened at its summit, which is occupied by a smooth convex surface, beneath which the sides of the spine are raised into numerous prominent ridges.

There are two sacral vertebræ (Pl. VI. figs. 6, 6 *a*), which are modified much as in recent Crocodiles. In the anterior sacral the anterior portion of the centrum is deeper and broader than it is at the posterior flattened surface for union with the second sacral. The anterior surface for union with the lumbar is wider than high, and concave, especially from side to side; its upper and outer portion in some cases is formed by a facet borne on the base of the sacral rib (Pl. VI. fig. 6 *a*), which unites extensively with the side of the anterior portion of the centrum. The posterior articular surface of the anterior sacral is, as already noted, much smaller than the anterior, and is circular and nearly flat.

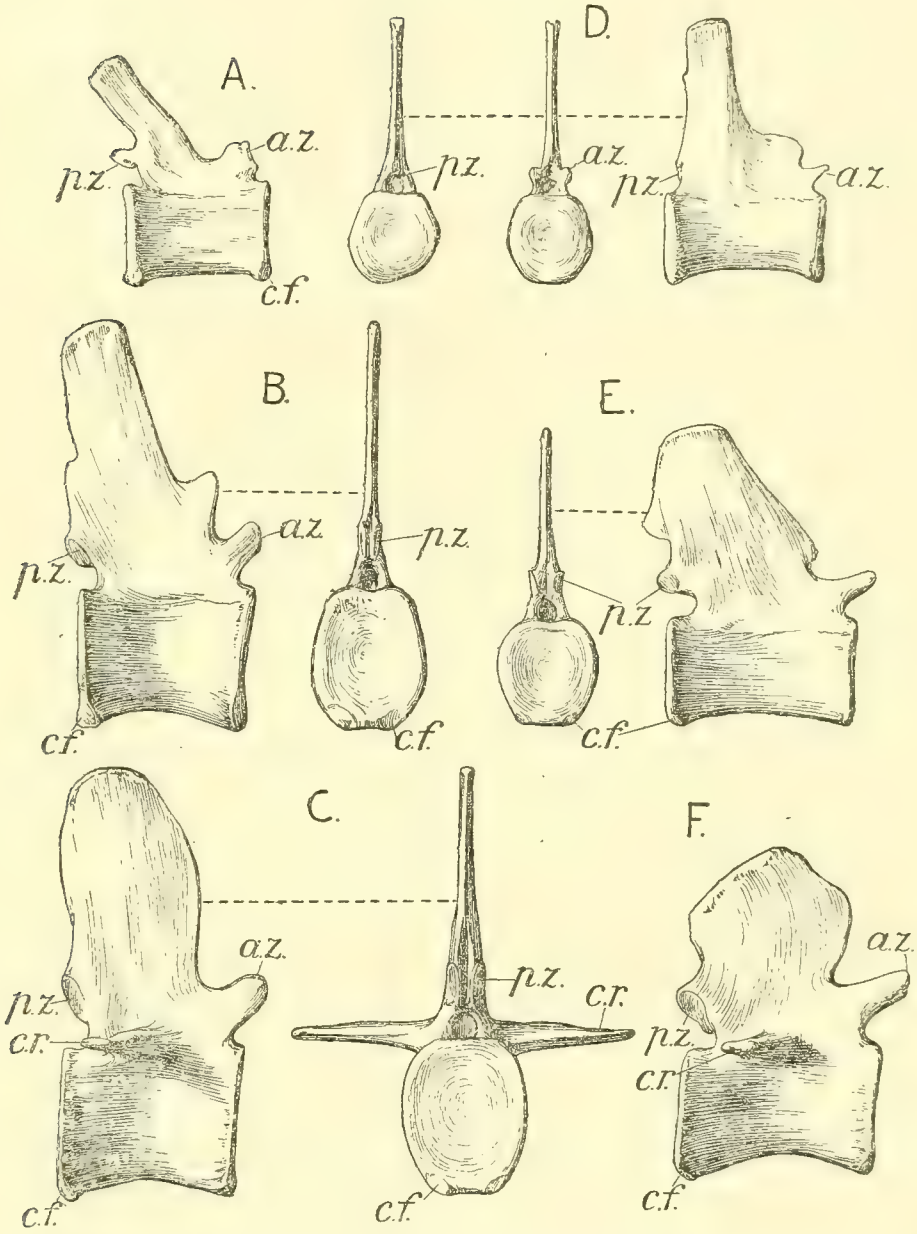
Behind the base of the sacral ribs the edges of the centra are strongly concave from before backwards. The neural arch unites with the centrum and the upper part of the base of the sacral rib, sending out a short lateral process along it. The anterior zygapophyses are fairly large and resemble those of the dorsal vertebræ. They are separated anteriorly by a deep fossa for the attachment of ligament, which is continued up the anterior edge of the neural spine as a roughened groove. The laterally compressed neural spine is broad and curved slightly forwards; its upper end is abruptly truncated and somewhat thickened. The posterior zygapophyses seem to have been small, but are not well preserved in any specimen.

The second sacral vertebra has the anterior articular surface smaller than the posterior, and nearly circular in outline. The base of the sacral rib is attached to the middle portion of the centrum, not extending to the articular face at either end. The ventral surface of the centrum between the bases of the sacral ribs is convex from side to side and strongly concave from before backwards. As in the dorsal vertebræ, the edges of the centra are thrown into numerous plications. The posterior articular face is gently concave; in *St. durobrivensis* it is nearly as high as wide, but in *St. leedsi* the transverse diameter is considerably the greater. The neural spine is similar to that of the first sacral, but the posterior zygapophyses are better developed.

The number of caudal vertebræ (text-fig. 38) is uncertain, none of the series preserved being complete. In the type specimen of *St. durobrivensis* there are 38 or 39, but the terminal vertebræ are wanting. In a specimen of *St. leedsi* (R. 3806), in which also several terminal caudals are missing, there are 36.

In all the skeletons the anterior one or two caudals seem to be missing—at least, none showing the peculiar characters seen in the anterior caudals of *Mycterosuchus nasutus* (see p. 137) have been observed. In the remainder of the caudal region the various species differ considerably in the form of the vertebræ, especially, as in the case of the cervicals, in the length of the centrum and the form of the neural spine. These differences, which are correlated with the form of the skull, will be referred to under the several species. Speaking generally, the caudals in this genus have the centra much constricted in the middle, while at the same time the ventral surface is flattened, or even concave, from side to side; in the anterior portion of the tail the ridges separating the ventral from the lateral surfaces of the centra are truncated at their posterior ends by oblique facets for the chevrons, which seem to have little or no contact with the anterior face of the succeeding centrum. The articular ends of the centra vary considerably in form; thus in *St. durobrivensis* they are gently concave throughout the series, while in *St. leedsi* the faces of the anterior caudals are very gently concave, but in the posterior region they tend to form a convex border round a central concavity. The outlines of the articular faces vary in different parts of the column. The vertical is always greater than the transverse diameter and, in the region where the chevrons occur, the form is somewhat barrel-shaped, the sides being

Text-fig. 38.



Caudal vertebræ of *Steneosaurus durobrivensis*: A, posterior caudal from right side; B, middle caudal from right side and behind; C, anterior caudal from right side and behind. (R. 3701, ½ nat. size.) Also of *Steneosaurus leedsi*: D, posterior caudal from back, front, and right side; E, middle caudal from back and right side; F, anterior caudal from right side. (R. 3806, ½ nat. size.)

a.z., anterior zygapophysis; *c.f.*, facet for chevron; *c.r.*, caudal rib (transverse process); *p.z.*, posterior zygapophysis.

convex, the neural and ventral borders nearly straight; towards the hinder part of the tail the degree of lateral compression of the centra increases. Caudal ribs (transverse processes, *c.r.*) are confined to the anterior 12–14 vertebræ, decreasing in size from before backwards. They are compressed from above downwards and curve a little downwards; they are borne wholly or, at least, mainly on the neural arch.

The neural arches are supported by a long base which extends nearly from one end of the centrum to the other. The anterior zygapophyses (*a.z.*) are borne on the front of the arch; they project sharply upwards and forwards beyond the articular surface of the centrum, and their articular facets are inclined to one another at a very acute angle. The posterior zygapophyses (*p.z.*) are borne at the base of the hinder border of the neural spine; they are separated by a deep pit, and inclined to one another at a very acute angle. Both the anterior and posterior zygapophyses decrease in size as they are followed back in the series, and finally disappear some distance from the end of the tail. The neural spines differ much in the different species. In *St. leedsi* the thin but broad spine is comparatively low; in the anterior caudals it slopes a little forwards, but further back comes to incline backwards. At about the middle of the tail it bears a projection on its anterior border separated from the zygapophyses by a notch. Further back (text-fig. 38, D) it becomes much narrowed, nearly vertical, and situated over the hinder part of the arch; the anterior portion of the spine is represented by a sharp ridge, rising a little at its anterior end. In *St. durobrivensis* the spine is higher; in the first few vertebræ it is inclined forwards, but further back it slopes backwards. At about the junction of the middle and anterior thirds of the tail the upper part of the anterior border of the spine is cut away, and this narrowing is increased in the vertebræ further back, till here also the spine becomes very narrow and is situated mainly over the hinder part of the arch.

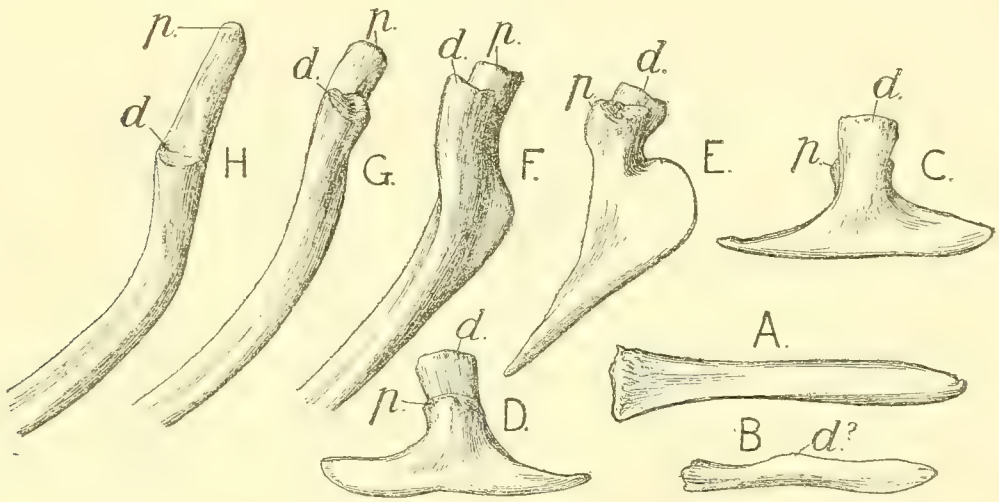
Ribs (text-fig. 39).—In *Steneosaurus durobrivensis* (R. 3701) the first (atlantal) rib is a straight bar of bone (text-fig. 39, A); at its wider anterior end it bears a flat facet for union with the corresponding surface on the postero-inferior border of the anterior wedge-bone (text-fig. 34). The outer face is convex in its anterior half, but flattened posteriorly, where its lower edge forms a sharp and rather roughened ridge. In *St. leedsi* the outer face is roughened throughout. The anterior part of the inner face is concave from above downwards, apparently for apposition to the outer face of the second (axial) rib; posteriorly the inner surface is slightly convex. The rib terminates in a blunt roughened point, probably tipped with cartilage in life.

The bone here regarded as the second (axial) rib (text-fig. 39, B) is peculiar; it is very much smaller than the rib in front, and from its somewhat irregular form probably undergoing reduction. At its anterior end it bears a roughened oblique facet for union with the surface borne half on the odontoid and half on the axis (text-fig. 34). Towards its posterior end it becomes strongly compressed and terminates in a point; on its upper border near the anterior end there is a sharp ridge which may represent

a remnant of the diapophysial process (tubercle, *d.?*), and this was perhaps united by a ligament with the small diapophysis of the axis (text-fig. 34, *d.*). If this bone is not the rib of the axis, then even in the nearly complete skeletons of *St. leedsi* (R. 3806) and *St. durobrivensis* (R. 3701) there is no other bone that can be assigned to this position.

The ribs of the succeeding cervicals (text-fig. 39, C–E) are of the normal Crocodilian type—that is, each consists of a body lying nearly parallel with the long axis of the vertebral column and bearing well-developed diapophysial and parapophysial processes for union with the vertebra. The body of the rib is convex externally and concave internally; the anterior limb terminates in a blunt point, the posterior end is much sharper; the upper surface of the posterior limb is concave and fits against the lower

Text-fig. 39.



Ribs of *Steneosaurus durobrivensis*: A, left rib of atlas; B, ? left rib of axis; C, outer side of middle right cervical rib; D, inner side of middle right cervical rib; E, inner side of posterior left cervical rib; F, anterior right dorsal rib; G, middle right dorsal rib; H, posterior right dorsal rib. (R. 3701, ½ nat. size.)

d., diapophysial process (tubercle); *p.*, parapophysial process (head).]

surface of the anterior limb of the rib behind. The diapophysial process (*d.*) is longer than the parapophysial and terminates at its upper end in an elongated oval facet; the shorter parapophysial process (*p.*) also terminates in an articular facet, which in the anterior cervicals is wider than that of the diapophysis. Towards the back of the neck the anterior limb of the rib widens and shortens, while the posterior lengthens and thickens and assumes the form of the dorsal ribs; in the last cervical (text-fig. 39, E) the anterior limb is merely a sharp flange on its anterior border.

In the ribs of the most anterior dorsal region (text-fig. 39, F), the diapophysial (*d.*), and parapophysial surfaces (*p.*) are still borne on distinct processes, that for the

diapophysis (tubercle) being the shorter and stouter and terminating in a large concave facet. The parapophysial process projects considerably beyond the diapophysial, and terminates in a smaller convex facet (the head); the two processes may be more or less united by a thin plate or web of bone. Further back in the series (text-fig. 39, G, H) the diapophysial facet becomes a mere step on the posterior border of the rib and articulates with a facet on the outer end of the transverse process. The body of the middle dorsal ribs is rather strongly curved; its anterior face is convex, the posterior flat or slightly concave; it widens out considerably at its distal end and is strongly compressed from before backwards. The hindmost rib is a sickle-shaped blade of bone, curving strongly forwards; at its inner end is the facet for the parapophysis, while a small surface on its posterior border united with the diapophysis. In the posterior dorsals of these Crocodiles the parapophysial and diapophysial facets do not approach one another to the same degree as in recent forms, and even in the last dorsal are separated by a considerable interval.

There were probably at least two lumbar vertebræ bearing no ribs.

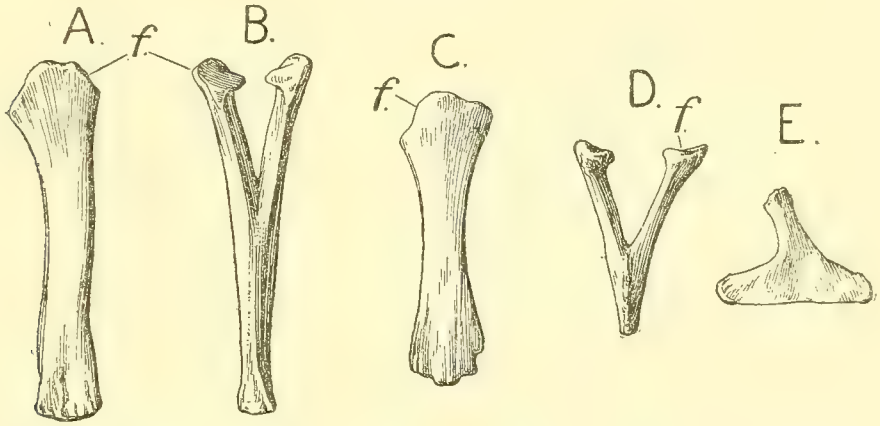
The form and arrangement of the sacral ribs (Pl. VI. figs. 6, 6 *a*) in *Steneosaurus* are very similar to those of *Mycterosuchus*, and reference may be made to text-figures 51–53. The anterior sacral rib unites at its inner end with the anterior portion of the first sacral centrum, and as described above may help to form the surface for articulation with the last lumbar. The rib, as a whole, is somewhat compressed from before backwards except at its outer end; its upper edge is strengthened by a strong ridge continuous at its inner end with the overlapping process from the neural arch. The anterior face of the rib is nearly vertical or sloping a little backwards; externally the bone expands greatly and bears a large iliac surface which is deeply concave, rugose, and roughly triangular in outline, the lower and antero-superior angles being rounded off, while the postero-superior angle is truncated by another surface which looks directly backwards and unites with a corresponding surface on the front of the second sacral rib. The inner end of this latter is firmly united with the side of the second sacral centrum, and to some degree with the base of the neural arch. At its outer end it is much thickened, the thickened portion being compressed so that its anterior face looks upwards and forwards, the posterior downwards and backwards, and at the same time its postero-superior border is produced into a thin flange of bone, which in most specimens is broken away; at the outer end there is a deeply concave surface fitting against the hinder part of the inner face of the ilium, and a forwardly directed triangular surface for union with the anterior sacral rib.

In the type specimen of *Steneosaurus obtusidens* it appears that the rib of the anterior caudal is thickened and expanded like the sacral ribs (text-fig. 50), and although it may not have actually united with the ilium, it joined the outer end of the posterior sacral rib, which bears a facet for this union. In this case therefore there were practically three sacrals, a condition, so far as I am aware, not

met with elsewhere in the group. Usually the anterior caudals bear fused caudal ribs, which seem to have united either entirely with the neural arch or perhaps to a small extent with the centrum; the first two or three are somewhat thickened, but further back they become strongly compressed from above downwards and seem to have curved a little downwards at their outer ends.

The *chevrons* (text-fig. 40) begin two or three vertebræ behind the sacrum. They articulate between the centra, but the facet (*f.*) for the posterior end of the centrum is much better developed than that for the anterior end of the succeeding centrum. The chevrons vary very much in form in the different parts of the tail. Judging from some bones preserved with one of the skeletons, it appears that in a few of the more anterior vertebræ the two arms of the chevrons remained separate, not uniting below to produce the **Y**-shaped bone, the form in which they appear in the greater part of the tail. In the anterior of these **Y**-shaped chevrons (text-fig. 40, A, B)

Text-fig. 40.



Chevrons of *Steneosaurus leedsi*: A, anterior chevron from side; B, anterior chevron from front; C, middle chevron from side; D, posterior chevron from front; E, posterior chevron from side. (R. 3806, $\frac{2}{3}$ nat. size.)

f., facet for union with the caudal centra.

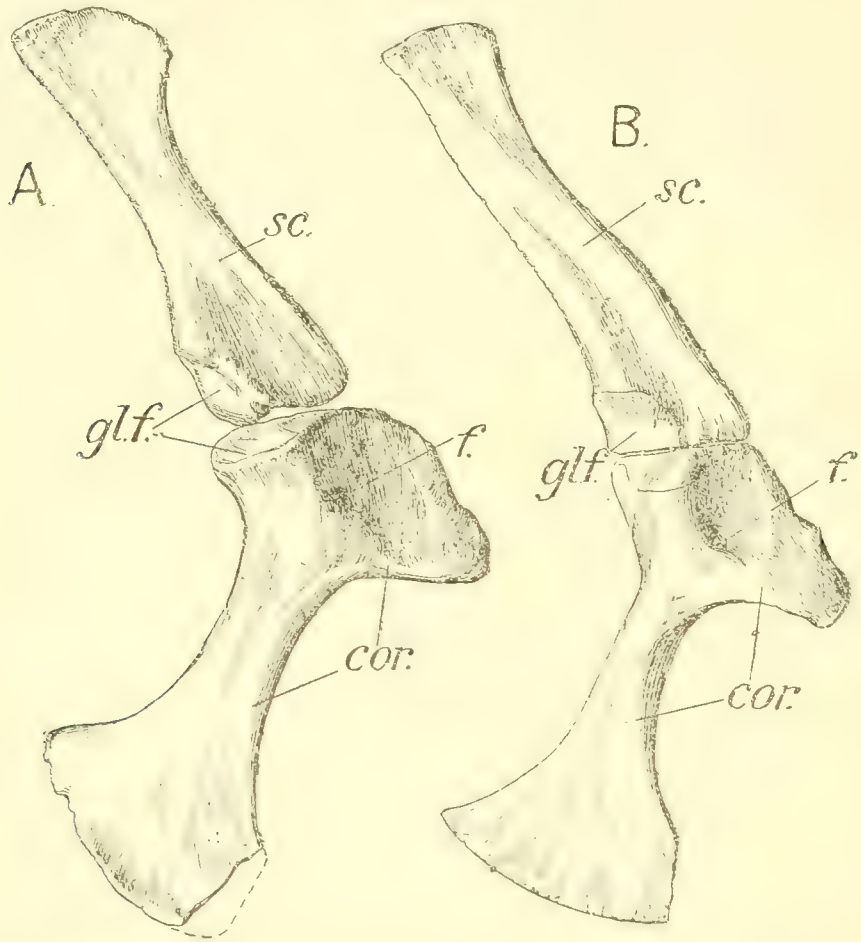
the leg of the **Y** is long and fairly stout; the arms of the **Y** terminate above in an oblique convex facet, in front of and behind which there is a small prominence. Further back the lower arm of the **Y** is shorter and more compressed laterally (text-fig. 40, C). In the posterior chevrons (text-fig. 40, D, E) also the ventral arm is greatly compressed and at the same time elongated, so that it extends considerably both in front of and behind the supporting arms, thus giving the bone, as seen from the side, the form of an axe-head: this form of chevron seems to have continued backwards to within a few vertebræ of the end of the tail.

Shoulder-girdle and Fore Limb (text-figs. 41–42).—The shoulder-girdle (text-fig. 41) does not differ in any important character from that of the recent Crocodiles. It

consists, so far as is known, of scapulæ and coracoids only, no trace of any clavicular arch having been found. The scapula and coracoid take about equal shares in the formation of the glenoid fossa for the humerus. As in the vertebræ, the slenderness or otherwise of the skull is reflected in this part of the skeleton, the coracoid and scapula of *St. leedsi*, for example, being more slender than in *St. durobrivensis*.

The *scapula* (*sc.*) is a bar of bone compressed from within outwards. At its upper

Text-fig. 41.



Right side of shoulder-girdle of: A, *Steneosaurus durobrivensis* (R. 3701, $\frac{2}{3}$ nat. size); B, *Steneosaurus leedsi* (R. 3806, $\frac{2}{3}$ nat. size).

cor., coracoid; *f.*, coracoid foramen; *gl.f.*, glenoid fossa; *sc.*, scapula.

end it is more or less expanded and in life was probably fringed with a suprascapular cartilage. At its lower end it widens out and is thickened, bearing a large oblique facet, forming the upper part of the glenoid cavity (*gl.f.*), and a terminal, elongated, triangular surface for union with the coracoid: this latter surface is prolonged forwards to the anterior angle of the bone.

The *coracoid* (*cor.*) is likewise a bar of bone compressed from within outwards; it is much expanded at both ends. The lower (ventral) end is thin and its edge convex; it appears to have united with a cartilage. The anterior angle of the distal expansion is truncated. The shaft of the bone is narrow, most markedly so in *St. leedsi*. At its upper end it bends rather sharply inwards, passing into the dorsal upper expansion, which is thus inclined at an obtuse angle to the ventral portion. The upper expansion is greatly thickened at its postero-external angle, where it bears the oblique articular surface forming the lower half of the glenoid cavity (*gl.f.*) and terminates in the elongated roughened facet for union with the scapula. In front of this it is produced forwards into a triangular plate terminating in a blunt angle; this expansion is perforated at its base by the coracoid foramen (*f.*), which opens below and in front of the lower angle of the glenoid surface. The edge of this expanded portion was probably fringed with cartilage in life.

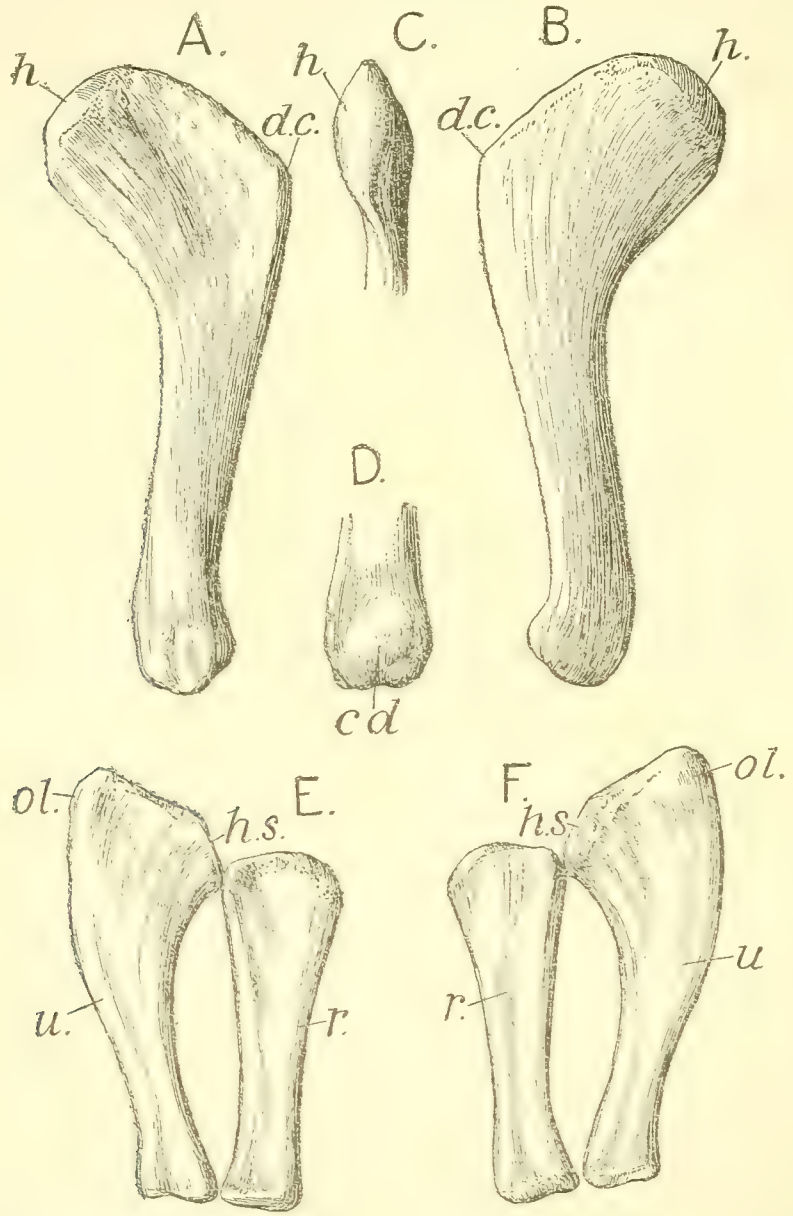
The *fore limb* (text-fig. 42), though much smaller than the hind limb, is not reduced to nearly so great a degree as in the more strictly aquatic *Metriorhynchus*, but to a somewhat greater extent than in the earlier (Liassic) *Mystriosaurus* and in the next described genus *Mycterosuchus* (see p. 139). Moreover, although no well-preserved fore foot is found in the collection, there seems to be no doubt that it was not modified to form the paddle-like structure found in *Metriorhynchus*.

The *humerus* (text-fig. 42, A–D), apart from its relatively smaller size, differs considerably from the same bone in the recent Crocodiles. The upper end is much expanded and is bent backwards to a considerable extent, so that its articular head (*h*). looks much more backwards than is the case in the humerus of recent Crocodiles; the articular surface (text-fig. 42, C) is elongated, oval, strongly convex, especially from above downwards. From the lower angle of the head a sharp ridge runs down on to the shaft, while from the upper angle a slightly convex, thin, roughened border extends to the deltoid crest (*d.c.*), which is not very prominent; there is a shallow bicipital fossa. The upper portion of the shaft is somewhat compressed in the same direction as the proximal expansion, but the distal portion of the shaft, together with the lower articular end, is slightly flattened almost at right angles to this, so that the articular surface looks forwards instead of nearly downwards, as in recent Crocodiles. The anterior face of the bone, above the condylar surface, is gently concave from side to side, the concavity being bounded by a well-marked ridge on the ulnar side. The condyles (*cd.*) are not separated from one another by a distinct groove; or rather it would, perhaps, be more correct to say that only the radial condyle is developed; this is convex anteriorly and passes below into a nearly flat surface occupying the distal end of the bone. The posterior face of the distal articular region is raised into a median ridge and marked by a series of longitudinal rugosities.

The *radius* (text-fig. 42, E, F, *r.*) is a nearly straight rod of bone compressed throughout its length, especially at its upper end, where it widens out to some extent.

On the ulnar side of the upper end there is a small rounded facet, probably for union with the ulna and, perhaps, in part also for articulation with the humerus. The distal end terminates in an oval facet, concave in the middle, but with convex borders.

Text-fig. 42.



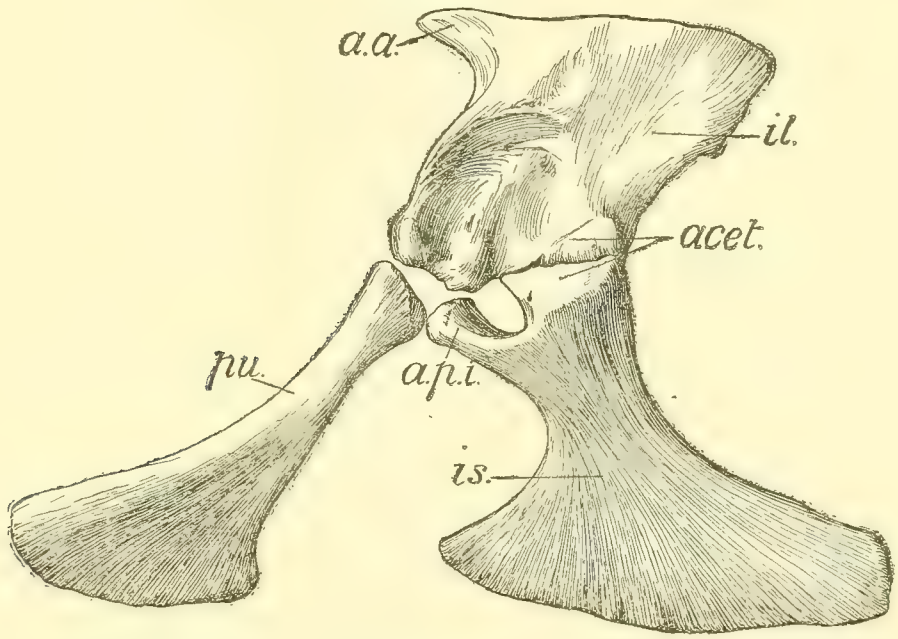
Bones of fore limb of *Steneosaurus durobrivensis*. Left humerus: A, from front; B, from behind; C, proximal end; D, distal end. Left radius and ulna: E, from inner side; F, from outer side. (R. 3701, $\frac{2}{3}$ nat. size.)

cd., condyle of humerus; *d.c.*, deltoid crest; *h.*, head of humerus; *h.s.*, surface for articulation with humerus; *ol.*, olecranon; *r.*, radius; *u.*, ulna.

The *ulna* (text-fig. 42, E, F, *u.*) is greatly expanded at the proximal end, the expansion forming a prominent olecranon angle (*ol.*). The facet for the humerus (*h.s.*) is not almost terminal, as in the recent Crocodiles, but lies nearly parallel with the long axis of the bone. From the olecranon angle the posterior border of the bone is at first gently convex, then towards the distal end it becomes concave; the anterior border from the humeral facet to the distal end is concave. The distal articulation consists of a larger preaxial and a smaller postaxial convexity connected by a ridge; the preaxial projects below the postaxial portion.

The bones of the fore foot are not well known.

Text-fig. 43.



Outer side of the left half of the pelvic girdle of *Steneosaurus leedsi*. (R. 3806, ½ nat. size.)
a.a., anterior angle of ilium; *acet.*, acetabulum; *a.p.i.*, anterior process of ischium; *il.*, ilium; *is.*, ischium; *pu.*, pubis.

Pelvic Girdle and Hind Limb (Pl. VII. figs. 7, 8; text-figs. 43–47).—The pelvis (text-figs. 43, 44) is formed by the usual three pairs of bones—the ilia, ischia, and pubes.

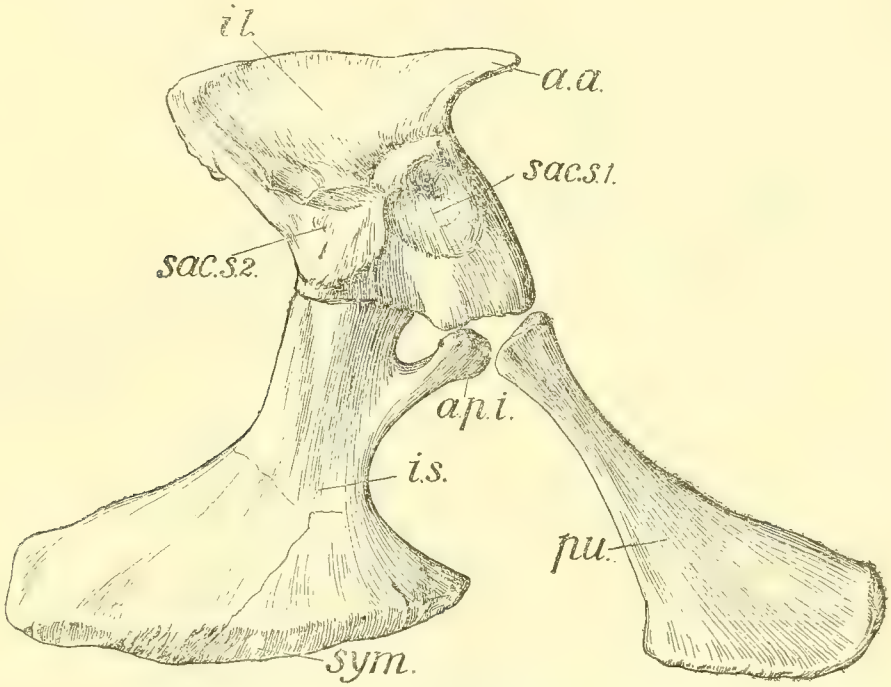
The *ilium* (*il.*) in its general form much resembles that of the recent Crocodiles. The upper border is sharp and nearly straight; anteriorly it ends in the point of the prominent anterior angle (*a.a.*), which is much more strongly developed than in recent types. The ventral face of this prominence is strongly concave and passes below by a sharp curve into the wide convex anterior border of the body of the bone, which terminates ventrally in a broad roughened prominence. On the outer face of the bone

the anterior border forms a prominent ridge, which is continued backwards as the upper rim of the concavity which occupies most of the outer face of the ilium. The roughened surface of the thickened antero-ventral angle is continued on to the ventral border, where it narrows and is deeply notched. The portion of the surface behind the notch, no doubt, was connected with the upper surface of the pubic process of the ischium; but its anterior portion, which is relatively much larger than in the modern Crocodiles, probably, in part at least, supported the upper end of the pubis, which in these Crocodiles does not appear to have united with the lower surface of the pubic process of the ischium, as in recent forms. At least, there is no facet for such a union, and the form of the antero-ventral portion of the ilium makes it very probable that it was largely concerned in supporting the pubis. Thus, in the Steneosaurs at least, although the pubis (*pu.*) is excluded from the acetabulum (*acet.*), its relation to the other pelvic bones is more normal than in modern Crocodiles, and there does not seem any reason to regard this bone in the Crocodilia as other than a true pubis, which has been displaced by the development of the pubic process of the ischium. The facet on the ilium for union with the main body of the ischium is separated from the facet for the pubic process of that bone by a short interval; in form it is roughly crescentic, the concavity being external and the anterior limb of the crescent much narrower than the posterior, which forms a strong ventral prominence. Behind this the posterior border of the bone is at first concave, then convex, passing at a sharp angle into the superior border. Above the ischial surface there is a smooth acetabular facet (*acet.*) which passes above into a well-marked depression, which forms the deepest part of the general concavity of the outer face of the bone. The inner (sacral) face (text-fig. 44) is smooth and gently convex from above downwards to about the level of the lower end of the anterior process. Below this it is greatly roughened by the two complex surfaces for union with the outer ends of the sacral ribs (*sac.s.* 1, *sac.s.* 2). Of these surfaces the anterior one is roughly kidney-shaped, with a short strong ridge projecting downwards and forwards from its upper edge. The posterior surface is rather less rounded, and from near its upper end a prominent ridge runs upwards and backwards to the posterior angle of the bone; this ridge fits into a corresponding groove in the outer end of the backwardly directed flange of the second sacral rib. Beneath the surface for the sacral ribs the bone is nearly smooth and gently convex.

The *ischium* (Pl. VII. figs. 7, 7 *a*; *is.*, text-figs. 43–44) is of the usual Crocodilian form. Ventrally it is expanded into a broad triangular plate, the lower edge of which bears a roughened sutural surface for union with its fellow of the opposite side (*sym.*). The anterior angle is usually very acute, the posterior one is truncated. Above this expanded portion the bone narrows to a neck, the width of which varies considerably in the different species. Above this again is the bifurcated and thickened head, the posterior portion of which is much the larger and bears at its upper end a large smooth facet looking upwards and outwards (in the natural position of the bone), and forming the

lower part of the acetabulum (*acet.*). There is also a smaller roughened surface looking nearly directly upwards for union with the ilium, and corresponding in form with the ischial facet of that bone. The anterior face of the posterior portion is flat or concave. The small anterior branch or pubic process (*a.p.i.*) is directed upwards and forwards; its posterior face is concave in all directions, the anterior convex. At its extremity this process bears a triangular facet for union with the surface on the anterior part of the ilium (Pl. VII. figs. 7, 7 *a*, *il.s.*) to which reference has been made above. At the end of the process and connected with the surface for the ilium, and nearly at right angles with it, is a small facet for union with the upper end of the

Text-fig. 44.



Inner side of the left half of the pelvic girdle of *Steneosaurus leedsi*. (R. 3806, ½ nat. size.)

a.a., anterior angle of ilium; *a.p.i.*, anterior process of ischium; *il.*, ilium; *is.*, ischium; *pu.*, pubis; *sac.s.* 1 & *sac.s.* 2, surfaces for union with the first and second sacral ribs; *sym.*, symphysis.

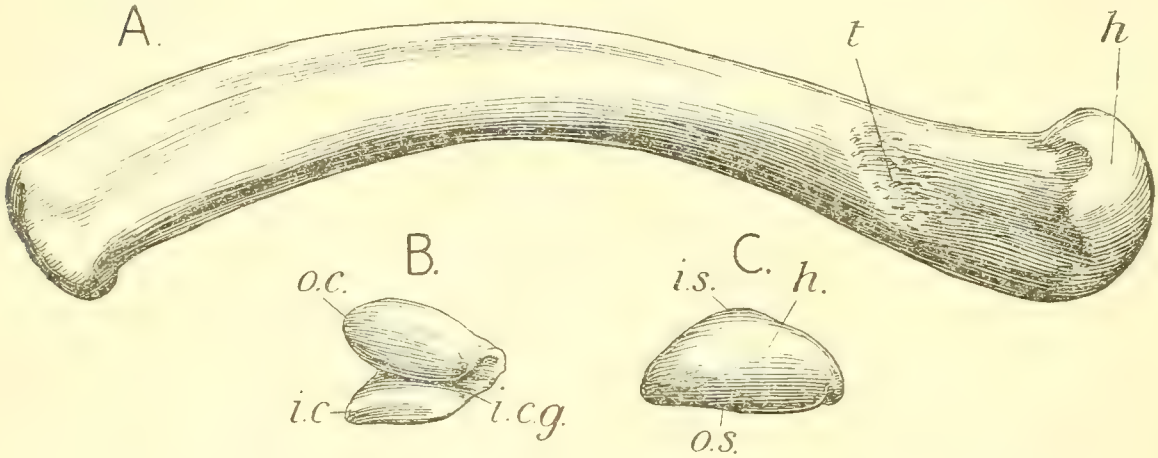
pubis (*pu.s.*); there is no trace of a facet for that bone on the ventral face of the process, such as is found in the recent Crocodiles, and it seems impossible that the pubis articulated only with the ischium, as it does in them.

The *pubis* (*pu.*, Pl. VII. fig. 8; text-figs. 43–44), compared with the ischium, is a slender bone: at its lower end it is expanded into a spatulate blade, the ventral convex edge of which was fringed with cartilage and is directed towards the middle line, but it is not clear whether it reached its fellow on the opposite side. Above the distal expansion the bone narrows to a slender neck, oval in section, while at the upper end

it again slightly enlarges and bears an elongated oval facet, which was probably cartilage-covered in life. This facet seems to have united with the ilium, while posteriorly there was a slight union with the anterior process of the ischium. Probably much cartilage persisted at this point, so that the bones were not in actual contact. In any case there is no evidence that the pubis articulated only with the anterior process of the ischium.

The *femur* (text-fig. 45) is by far the largest of the limb-bones; it is relatively slender and greatly elongated, forming a very open **S**-shaped curve. The head (*h.*) is closely similar to that of the femur in recent Crocodiles, though, perhaps, a little more massive. It is strongly convex, the convex surface being truncated on its outer side (*o.s.*) by the flat outer face of the bone; on the inner (acetabular) side there is a strong rounded prominence (*i.s.*). The flattened outer face of the upper end of the bone is

Text-fig. 45.



Right femur of *Steneosaurus leedsi*: A, inner (preaxial) view; B, distal end; C, proximal end. (R. 3806, ½ nat. size.)

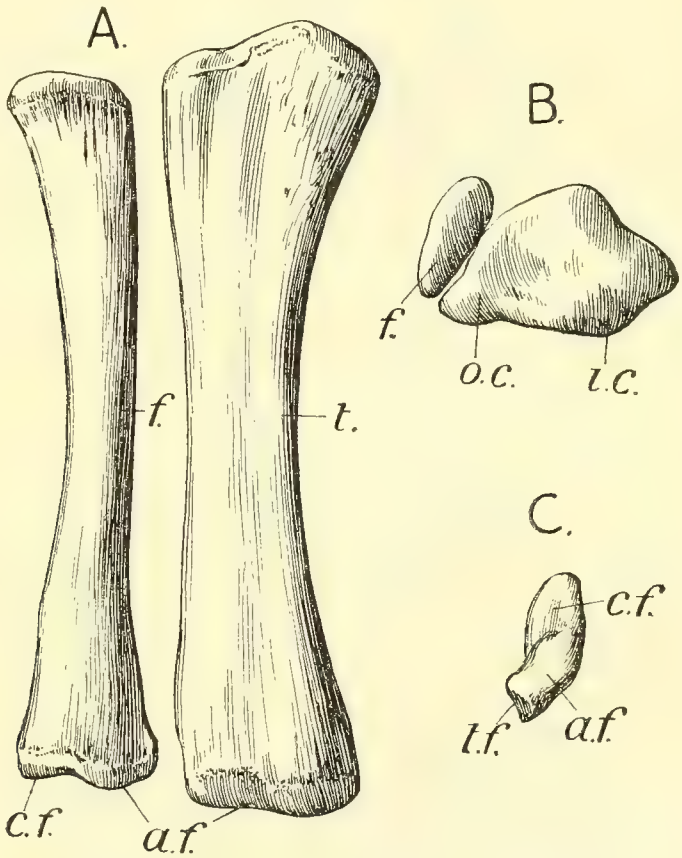
h., head; *i.c.*, inner condyle; *i.c.g.*, intercondylar groove; *i.s.*, inner side of head; *o.c.*, outer condyle; *o.s.*, outer side of head; *t.*, trochanterial surface.

marked by a series of longitudinal rugosities; the inner face beneath the head is also roughened and is concave. A rugose surface on the inner face of the shaft is all that represents the lesser trochanter (*t.*), which, in modern Crocodiles, forms a strong prominence. Beyond this, for a short distance, the shaft becomes more slender and is oval in section; beyond this, again, it is strongly compressed, its upper edge forming a sharp keel, while below it remains rounded. The distal end in nearly all specimens is much crushed, the central cavity of the bone in this region having been large and the walls relatively thin. The condyles form strong convexities separated by an intercondylar groove (*i.c.g.*), which is very deep posteriorly (ventrally). The outer (fibular) condyle (*o.c.*) is considerably larger than the inner (*i.c.*). The whole articular surface

seems to have been covered with a thick pad of cartilage and the condyles are often imperfectly ossified.

The *tibia* (text-fig. 46) was a comparatively thin-walled bone, all the specimens being much crushed, especially in the region of the shaft. The length is about half that of the femur—that is to say, considerably less in proportion than in the recent Crocodiles, in which the length of the tibia to that of the femur is roughly as three to four. The proximal end is massive and wide: it is occupied by the broad articular surface

Text-fig. 46.



Right tibia and fibula of *Steneosaurus leedsi*: A, from front; B, proximal end; C, distal end of fibula. (R. 3806, $\frac{2}{3}$ nat. size.)

a.f., astragalar facets; *c.f.*, calcaneal facet; *f.*, fibula; *i.c.*, inner condyle; *o.c.*, outer condyle; *t.*, tibia; *t.f.*, tibial facet.

for the femur, which projects considerably posteriorly and internally; this articular surface forms an almost continuous gentle convexity, the division into an inner and outer surface for the femoral condyles being scarcely marked. At the outer (fibular) side of the proximal end there is a flange which probably united with the fibula; at its upper end there is a convex articular surface (*o.c.*) looking upwards and

forwards; this, with the proximal articular surface of the fibula (*f.*) no doubt articulated with the outer condyle of the femur.

Beneath the proximal articulation the bone narrows to the middle of the shaft, which, even in the uncrushed state, seems to have been somewhat compressed antero-posteriorly; its inner border is concave in a longitudinal direction, the outer nearly straight. Distally, the bone again widens out and bears the distal articulation for the astragalus (*a.f.*): this surface is narrow and strongly convex from before backwards; it is not quite at right angles to the long axis of the bone, but slopes down to the preaxial border, forming a rounded projecting angle, best marked in large and fully ossified specimens.

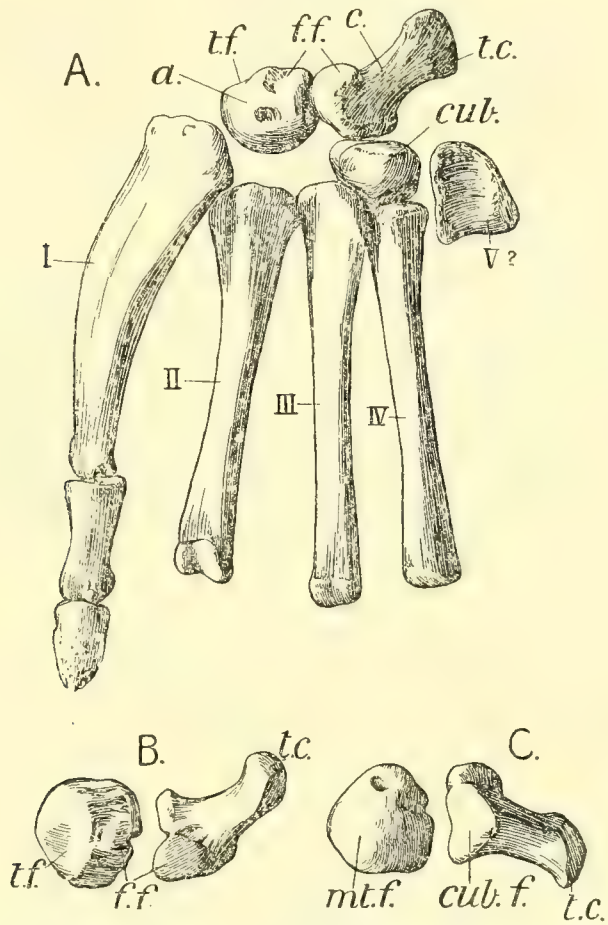
The *fibula* (*f.*) is a much more slender rod of bone than the tibia: it is strongly compressed; its outer face is rounded, the inner nearly flat. At its proximal end it expands and terminates in an elongated convex surface for articulation with the outer portion of the outer condyle of the femur. Distally (text-fig. 46, C) it is expanded to a rather greater degree; its distal extremity, which is about at right angles to the long axis of the shaft, bears two articular surfaces, one on the tibial side forming a strong convexity and probably articulating with the astragalus (*a.f.*); the other, separated from the last by an oblique groove, is a slightly concave surface occupying the outer half of the bone and, no doubt, articulating with the calcaneum (*c.f.*).

The *tarsal* bones (text-fig. 47), unfortunately, have never been found embedded in matrix so as to show their natural relations to one another, to the tibia and fibula on the one hand and to the metatarsals on the other; consequently it is difficult to make out their arrangement, a difficulty greatly increased by the circumstances that in the living animal probably much cartilage persisted in this region, and that they differ considerably in form from the tarsals of recent Crocodiles. This is especially true of the *astragalus* (*a.*, text-fig. 47), which is much narrower than in the recent forms, and has scarcely any trace of the prominent process on the postaxial side which unites with the fibular side of the tibia and bears on its outer side a facet for the fibula. The proximal surface is occupied by a tibial facet (*t.f.*), which is concave in the middle, but possesses rounded borders; on the postaxial surface there is an oblique, gently concave facet (*f.f.*), looking obliquely outwards, for union with the astragalar facet of the fibula; this corresponds to the fibular facet referred to above, as being borne on the postaxial process in recent Crocodiles. The inner (preaxial) face is gently convex, with a slight median depression. The distal surface is evenly convex in its preaxial two-thirds; postaxially it bears a deep pit, probably for a ligament, and behind this there is a deep groove separating the outer convex portion from a narrow oblique facet for union with the calcaneum; a roughened area looking upwards and backwards separates the distal and tibial surfaces posteriorly.

The *calcaneum* (*c.*, text-fig. 47) is much more similar to the corresponding bone in

the recent Crocodiles than is the case with the astragalus. It consists of a body which bears on its outer side a strongly convex surface for the fibula (*f.f.*); this is separated by a deep notch from the facet for the astragalus, which looks forwards and inwards. Distally there is a nearly flat surface (*cub.f.*) for articulation with the distal tarsal (cuboid). Posteriorly the bone is produced into a *tuber calcis* (*t.c.*), the neck of which is narrowed, while distally it expands and bears a large roughened surface looking outwards and backwards.

Text-fig. 47.



Left hind foot of *Steneosaurus leedsi*: A, dorsal surface of foot; B, proximal surface of astragalus and calcaneum; C, distal surface of astragalus and calcaneum. (R. 3806, ½ nat. size.)

a., astragalus; *c.*, calcaneum; *cub.*, cuboid; *cub.f.*, facet for cuboid; *f.f.*, facets for fibula; *mt.f.*, facet for metatarsal; *t.c.*, tuber calcis; *t.f.*, facet for tibia; I–V, metatarsals.

Another small bone belonging to the hind foot seems to be the postaxial tarsal of the distal row (*cuboid*). On its proximal surface there is a facet for union with the calcaneum, while distally there is a convex surface divided by a low antero-posterior ridge, on either side of which there is a pit for a ligament. Posteriorly, the bone

is produced backwards into two pointed processes separated by a concave surface; the postaxial process is the more prominent.

The first *metatarsal* (I, text-fig. 47) is much the stoutest; it is much expanded and thickened at its upper end, where it bears a large articular surface for the astragalus, concave externally and convex internally. The shaft is compressed and strongly curved outwards; at its upper end, on the outer border, there is a slight rugose prominence; distally it narrows and terminates in an obliquely grooved articular surface for the first phalange. The remaining metatarsals are straight and more slender, the third being the largest; at their proximal ends they bear a somewhat convex articular head, from which a small flange projects outwards and overlaps the front of the upper end of the next metatarsal. Distally, the second metatarsal bears a grooved articular surface for the phalange, but in the third and fourth the distal articulation is simply convex from above downwards; the sides immediately above the distal articular surface are concave, at least in the second and third. The fifth metatarsal seems to be represented by the small irregularly shaped bone shown in text-fig. 47 A, V ?.

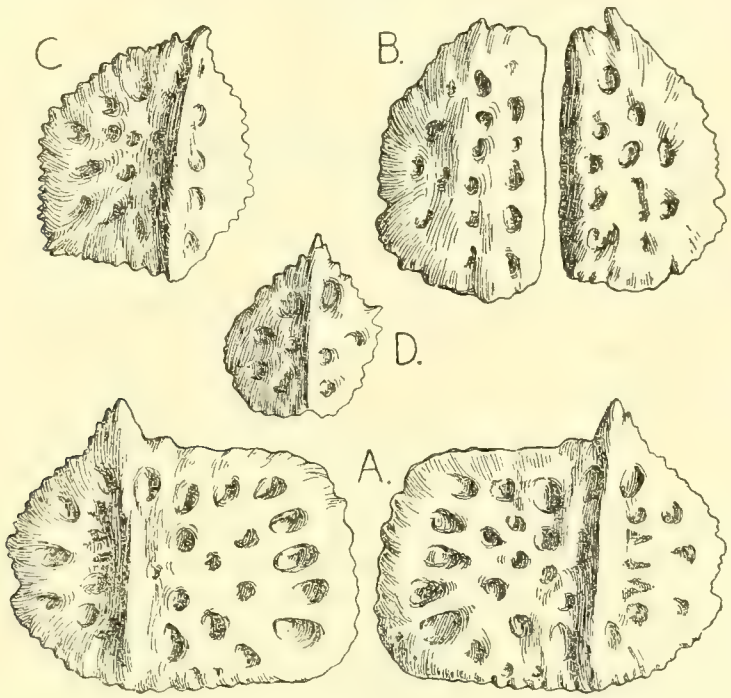
The exact arrangement of the *phalanges* is not known. The stoutest of those preserved probably belong to the first digit, which no doubt terminated in a well-developed ungual phalange, some specimens of which are preserved. At its proximal end the ungual phalange bears a deeply concave articular surface. The dorsal surface is strongly convex from side to side, the ventral face only slightly so. Distally, the bone is compressed from above and is much roughened, having evidently been covered with a horny nail in life. Whether the terminal phalanges of the other digits were similar is not known; probably they were not, since not more than one such claw has been found with any foot.

Dermal Armour (Pl. V. figs. 6–10; Pl. VI. figs. 4, 5; Pl. VII. fig. 6; text-figs. 48, 49).—The dermal armour consists of a great number of bony scutes varying much in shape and size, according to the regions of the body in which they occur. Unfortunately, the scutes are always found scattered, so that their exact arrangement cannot be determined. Probably it was much as in the allied *Mystriosaurus*, in which there is a pair of rows of scutes meeting, or nearly meeting, in the middle dorsal line, probably a lateral row on each side of the tail, and a ventral plastron, the arrangement of the scutes in which is not certain.

In *Steneosaurus* the scutes, presumably from the dorsal region (text-fig. 48, A), are roughly quadrate in outline, their outer surface bearing a sculpture of deep pits, the form and arrangement of which vary in the different species, while the inner surface is smooth. The inner (median) edge of the scute is straight and united in suture, or at least was in contact with its fellow of the opposite side. The outer edge is convex. There is a longitudinal ridge considerably nearer the outer than the inner border of the scute, and terminating anteriorly in a tooth-like peg fitting under the posterior border of the scute in front, which also overlaps the smooth bevelled anterior border of its successor.

In some cases the ridge is obscure, particularly in some scutes that may have come from the nuchal region (text-fig. 48, B); these are considerably longer than wide, and their straight inner edge is somewhat serrated, but perhaps was separated by a narrow space

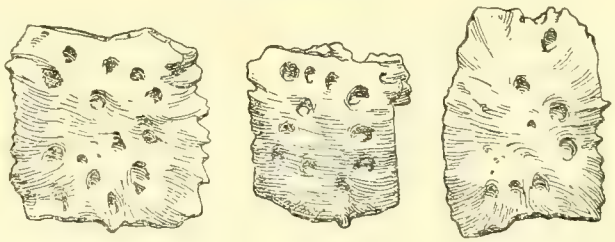
Text-fig. 48.



Dorsal scutes of *Steneosaurus leedsi*: A, from back; B, (?) from neck; C & D, from tail. (R. 3806, $\frac{2}{3}$ nat. size.)

from the opposite scute. Other scutes of smaller size (text-figs. 48, C, D) have a very prominent ridge and have both their inner and outer border strongly curved, so that clearly they did not meet in the middle line; at the same time, the anterior angle

Text-fig. 49.



Ventral scutes of *Steneosaurus leedsi*. (R. 3806, $\frac{2}{3}$ nat. size.)

forms a strong peg for union with the scute in front; these probably formed one or more rows on the tail.

Besides these, there occur scutes in which no ridge is developed (text-fig. 49); these probably formed the ventral armour. They are usually more or less quadrate in

outline; some of their edges show clearly that they united in suture with the adjoining plates, while others are bevelled off as if to allow of the overlap of the adjoining plate: their actual arrangement is quite uncertain.

With a few skeletons some irregular rod-like, occasionally bifurcating, and apparently imperfectly ossified bones occur, and in some cases may fuse with one another: these are perhaps ventral ribs.

Steneosaurus leedsi, Andrews.

[Plate V.; text-figs. 34, A, B, 35, A, B, 36, 38, D, E, F, 40, 41, B, 43–47, 48, 49.]

1896. "*Steneosaurus roissyi*, Deslongchamps," Bigot, Bull. Soc. géol. de Normandie, vol. xvii. p. 23, pl. ii. fig. 1.

1909. *Steneosaurus leedsi*, Andrews, Ann. Mag. Nat. Hist. [8] vol. iii. p. 300, pl. viii. fig. 1.

1909. *Stenosaurus teleosauroides*, Auer, Palæontographica, vol. lv. p. 266.

Type Specimen.—A nearly complete skull and mandible (R. 3320) described and figured in Ann. Mag. Nat. Hist. [8] vol. iii. (1909) p. 300, pl. viii. fig. 1 (see also Pl. V.).

In 1896 Professor Bigot described a Steneosaur with a long and slender snout, from the Callovian of Calvados. This he referred to Deslongchamps' *Steneosaurus roissyi*, a name applied to some portions of a mandible from the Oxford Clay of Vaches Noires. Mr. Leeds, however, has pointed out to me that these fragments are clearly portions of a jaw of *Metriorhynchus*. Professor Bigot's specimen is almost certainly referable to *St. leedsi*, described by me in March 1909 from a skull (R. 3320) in the Leeds Collection.

This species is especially characterised by the great length and slenderness of the rostral portion of the skull and mandible. In a skull (Pl. V. figs. 1–3) with a total length of 81 cm., the length in front of the orbit is 59 cm., or about 73 per cent. of the whole; in *St. hulkei* the proportion is under 60 per cent., and in *St. durobrivensis* about 61 per cent. The frontals terminate anteriorly in an acute angle. The anterior angle of the nasals is about opposite the twenty-first maxillary tooth, and they are thus separated by a long interval from the facial processes of the premaxillæ, which extend back to the level of the third maxillary tooth. There are 45–46 teeth on each side of the upper jaw, four being borne by each of the premaxillæ, the posterior two being enlarged. The teeth are slender and sharp-pointed; they are slightly compressed at the extreme tip and the enamel is marked by a series of fine longitudinal ridges.

In the mandible (Pl. V. fig. 3) the symphysial portion is very long and slender, occupying about 58 per cent. of the total length. There are 43–44 teeth on either side of the jaw: of these about thirty-three are in the symphysial portion; the splenials extend into the symphysis to about the level of the twenty-fourth tooth.

In the account of the skeleton in the genus, reference has been made to the fact

that in the vertebræ and to some extent in the bones of the limb-girdles and limbs the slenderness characteristic of the head is again shown. The description of the skeleton, given above, is in great part founded on a nearly complete skeleton of this species (R. 3806), and several figures of it have been given.

The dermal armour (Pl. V. figs. 6–10; text-figs. 48–49), as usual, consists of two rows of keeled dorsal scutes in contact in the middle line; the keel is prolonged forwards into a spine, which is overlapped by the scute in front. There are also numbers of keelless scutes which probably belong to the ventral surface, but the arrangement of these is not known. In the dorsal scutes the sculpture consists of deep and numerous pits.

R. 3320. Nearly complete skull and mandible. Type specimen described and figured in Ann. Mag. Nat. Hist. [8] vol. iii. (1909) p. 300, pl. viii. fig. 1, also Pl. V. figs. 1–3. The skull wants one or two centimetres of the tip of the snout, and the cranial portion is, as usual, much crushed from above downwards. There are 45–46 teeth on either side of the upper jaw and 43–44 in the lower.

The dimensions (in centimetres) of this specimen are :—

Skull: total length (occipital condyle to tip of snout)	81·0
length in front of orbit	59·0
„ between outer angles of quadrates	18·0
„ of temporal fossæ on inner side	12·0
width of temporal fossæ	7·3
„ frontals between the orbits	3·5
„ skull opposite the anterior rim of the orbit	10·5
„ snout at anterior end of nasals	4·3
width behind premaxillary expansion	2·9
width of premaxillary expansion	3·8
Mandible: total length	89·0
length of symphysial region	52·0
width at hinder end of symphysis	7·3
„ narrowest point behind anterior expansion	2·2

R. 3806. Nearly complete skeleton, including skull, mandible, atlas, axis (text-fig. 34, A, B), and other cervicals (text-fig. 35, A, B), dorsals (text-fig. 36), sacrals and caudals (text-fig. 38, D, E, F), numerous cervical and dorsal ribs, chevrons (text-fig. 40), scapulæ and coracoids (text-fig. 41, B), humeri, radii, ulnæ, ilia, ischia, and pubes (text-figs. 43, 44), femora (text-fig. 45); tibiæ and fibulæ (text-fig. 46) and bones of the hind foot (text-fig. 47); numerous scutes (Pl. V. figs. 6–10; text-figs. 48, 49) and some portions of ventral ribs. This specimen is probably the most nearly complete skeleton of a Mesozoic Crocodile known.

The dimensions (in centimetres) of this specimen are :—

Skull: total length	85·3
length in front of orbit	61·3
width between outer angles of quadrates	20·4
length of temporal fossæ (inner side)	14·2

Skull: width of temporal fossæ	8·2
„ frontals between orbits	4·2
„ snout opposite the anterior border of the orbits	12·5
„ snout at anterior angle of nasals	5·9
width behind premaxillary expansion	3·8
width of premaxillary expansion	4·7
Mandible: total length	96·0
length of symphysial portion	50·8
width at hinder end of symphysis	8·7
„ narrowest point behind anterior expansion	3·2

Vertebræ	Atlas and axis.	Third cervical.	Sixth cervical.	Eighth cervical.	Anterior dorsal.	Middle dorsal.	Posterior dorsal.	Anterior caudal.	Middle caudal.	Posterior caudals.	
Length of centrum in mid-ventral line	8·2	5·3	5·2	5·3	5·3	5·3	5·5	4·9	4·9	4·2	3·8
Width of posterior face of centrum	3·2	3·4	3·6	..	3·8	3·8	4·0	3·5	2·8	2·4	1·2
Height of posterior face of centrum	3·5	3·9	3·7	4·1	4·0	..	3·6	3·6	2·8	2·2	1·7
Height to top of neural spine	6·4	8·7	8·9	8·9	8·7	8·8	8·1	8·5	7·8	7·0	4·0 app.

Shoulder-girdle:	
Scapula (text-fig. 41, B): length	10·2
width at articular end	2·8
width of shaft at narrowest point	1·4
„ upper end	2·2
Coracoid (text-fig. 41, B): length	10·0
width of articular end	5·3
„ shaft at narrowest	1·3
„ lower end	5·0
Fore limb:	
Humerus: length	13·0
width of proximal expansion (exaggerated by crushing)	5·2
width of distal articulation	2·1
Ulna: length	8·9
width of upper end	3·7
„ lower end	1·8
Radius: length	6·7
Pelvis (text-figs. 43, 44):	
Ilium: length of dorsal border	9·4
height from acetabular edge to dorsal border	6·9
length from antero-inferior to postero-superior angle	11·5
Ischium: length of symphysial border	12·2
width from articular end to posterior angle	12·9

Ischium: width of neck at narrowest	2·8
greatest width of proximal end	5·3
Pubis: greatest length	13·0
width of lower expansion	6·7
„ shaft at narrowest	1·1
„ upper end	2·0
Hind limb:	
Femur (text-fig. 45):	
length in straight line	30·2
greatest width of proximal end	5·3
long diameter of the middle of the shaft	2·9
short diameter of the middle of the shaft	2·1
Tibia (text-fig. 46): length	15·3
width of proximal end	4·4
„ middle of shaft	2·2
„ distal end	3·3
Fibula (text-fig. 46): length	14·3
First metatarsal (text-fig. 47)	9·7
Second „	10·5
Third „	11·4
Fourth „	10·2

R. 2619. Imperfect skeleton, including parts of the skull, a nearly complete mandible, atlas, axis, and eight other cervical vertebræ, thirteen dorsals, two sacrals, and twenty-eight caudals, some dorsal ribs; portions of scapula and coracoid, left humerus and part of right; ilia, portions of ischia, pubes, right femur and part of left, tibiæ, some bones of hind foot, numerous broken scutes.

Some dimensions (in centimetres) of this specimen are :—

Mandible: length	79·0
length of symphysis	43·1
width at hinder end of symphysis	7·3
width at narrowest point behind the anterior expansion	2·6
width of anterior expansion	3·9

Vertebræ	Atlas and axis.	Middle cervical.	Last cervical.	Middle dorsal.	Anterior caudal.	Middle caudal.	Posterior caudal.
Length of centrum in mid-ventral line	6·7	4·3	4·4	4·8	4·1	3·9	3·0
Width of posterior face of centrum	2·8	3·4	3·3	3·1	2·8	2·3	1·3
Height of posterior face of centrum	2·8	3·3	3·2	3·5	3·1	2·3	1·6
Height to top of neural spine	5·7	8·0	7·8	7·6	7·8	6·6	..

Humerus: length	10·3
width of proximal expansion	3·8
„ distal end	1·3

Pelvis:		
Ilium:	length of dorsal border . . . . . (approx.)	7·7
	height from acetabular edge to dorsal border . . .	5·3
	length from antero-inferior to postero-superior border . . . . . (approx.)	9·7
Pubis:	greatest length	10·0
	width of lower expansion . . . . . (approx.)	4·7
	,, shaft at narrowest	1·0
	,, upper end	1·9
Hind limb:		
Femur:	length	25·0
	long diameter of middle of shaft	2·3
	short diameter of middle of shaft	1·7
Tibia:	length	11·6
	width of upper end	3·2
	,, lower end	2·8

Steneosaurus hulkei, n. sp.

Type Specimen.—An imperfect skeleton, including the skull (wanting the tip of the snout), an imperfect mandible, atlas, axis, and seven other cervicals, fourteen dorsals, two sacrals, seven caudals, a number of dorsal ribs (mostly imperfect), sacral ribs, ilia, ischia, pubes; right femur, tibia, part of fibula, numerous bones of the hind feet; many scutes (R. 2074, Leeds Coll. 2).

This specimen was in part described by Hulke in a paper entitled "Contribution to the Skeletal Anatomy of the Mesosuchia, based on Fossil Remains from the Clays near Peterborough" (Proc. Zool. Soc. 1888, p. 417). He there described the vertebral column, pelvic girdle, femur and tibia, and the dermal armour, giving figures of the axis (pl. xviii. fig. 6), a cervical vertebra (text-fig. 3), a dorsal (text-fig. 4), a caudal (text-fig. 5), and a sacral with the sacral ribs (text-fig. 6). He also figures the left ilium (pl. xix. figs. 3, 4), the ischium (pl. xix. fig. 5), and the pubis (pl. xix. fig. 6).

This specimen has been usually regarded as representing the *St. edwardsi* of Deslongchamps, but a detailed examination shows that it differs in several respects from that form, and the name *Steneosaurus hulkei* is now suggested for it in honour of the late Mr. J. W. Hulke, who contributed so much to our knowledge of the Mesozoic Reptilia.

In this species the snout is comparatively short and the nasals are separated from the premaxillæ by a shorter interval than in *St. durobrivensis*; their anterior angle is at the level of the thirteenth maxillary tooth; the anterior angle of the palatines is opposite the nineteenth maxillary tooth. The anterior angle of the frontals is blunt and far behind the anterior angle of the prefrontals, a character which distinguishes

the species from *St. edwardsi* and approximates it to *St. durobrivensis*. The symphysis of the mandible is comparatively short, about 40 per cent. of the total length; its posterior end is opposite the twenty-first tooth. The splenials run into the symphysis to the level of the thirteenth tooth; in the posterior half of their symphysial region they are marked off from the dentaries by a deep groove. The teeth are relatively large. The skeleton, on the whole, is closely similar to that of *St. durobrivensis*; in the vertebræ, however, particularly in the dorsal region, the neural spines are rather lower. The scutes also are different, the depressions being shallow, separated by wider smooth areas of bone, and, in many cases, much elongated in a transverse direction.

It is a notable circumstance that none of the species of *Steneosaurus* from Peterborough agree exactly with the species described by Deslongchamps from the north of France; this is probably due to a slight difference of geological horizon. At the same time some of the differences now taken to be specific may be age-characters, for nothing is known definitely as to whether changes in the proportionate length of the snout or in the character and number of the teeth may take place in the course of growth.

R. 2074 (Leeds Coll. 2). Skull, imperfect mandible, atlas, axis, and seven other cervical vertebræ, fourteen dorsals, two sacrals, and seven caudals; a number of dorsal ribs, sacral ribs; ilia, ischia, pubes; right femur, tibia, part of fibula, numerous bones of the hind feet, and many scutes. Type specimen; the axis, a middle cervical, a dorsal, a caudal, a sacral with the sacral ribs, left ilium, ischium, and pubes figured by Hulke, *loc. cit. supra*.

Some dimensions (in centimetres) of this specimen are:—

Skull: total length	(approx.)	60·0
length in front of the orbit	(approx.)	35·0
width at outer angles of quadrates		22·0
length of temporal fossæ (inner side)		15·3
width of temporal fossæ (in middle)		8·0
„ frontals between orbits		4·6
„ snout at anterior end of nasals		5·4
width behind the premaxillary expansion		4·7
„ of premaxillary expansion		5·5

The measures of width are probably somewhat too great, owing to the flattening that the skeleton has undergone.

Mandible: approximate length		72·0
length of symphysial region		28·9
width at hinder end of symphysis	(approx.)	8·0
„ narrowest point behind the anterior expansion		3·8

Vertebræ	Atlas (odontoid).	Axis *.	Middle * cervical.	Last cervical.	Dorsal.	First * sacral.	Middle caudal.
Length of centrum in mid-ventral line	2·0	4·1	4·1	3·7	4·5	3·9	4·0
Width of posterior face of centrum	2·6	2·8	3·6	3·6	3·4	3·1	2·8
Height of posterior face of centrum	2·9	3·2	3·4	3·4	3·3	2·7	3·3
Height to top of neural spine	..	6·9	9·0	8·5	6·8	..	8·2

The width between the outer ends of the anterior pair of sacral ribs is about 13·5 cm.

Pelvis:		
Ilium *:	length of dorsal border (with spine)	7·8
	„ from dorsal border to acetabular edge . . .	5·8
	„ from antero-inferior to postero-superior angle	8·8
Ischium *:	length of symphysial border	10·2
	width from articular surface to posterior angle . .	10·1
	„ of neck at narrowest	3·3
	greatest width of proximal end	4·9
Pubis *:	length	10·8
	width of lower expansion . . . . . (approx.)	4·0
	„ neck at narrowest	0·8
	„ upper end	2·1
Hind limb:		
Femur:	length in straight line	24·8
	greatest width of proximal end	4·2
	long diameter of the middle of the shaft	2·5
	short diameter of the middle of the shaft	1·7
	width of condyles	2·8
Tibia:	length	11·3
	width of upper end	2·9
	„ shaft at narrowest	1·7
	„ lower end	2·9

Steneosaurus durobrivensis, Andrews.

[Plate VI.; text-figs. 31, 32, 33, 34, C, D, 35, C, D, 37, 38, A, B, C, 39, 41, A, 42.]

1909. *Steneosaurus durobrivensis*, Andrews, Ann. Mag. Nat. Hist. [8] vol. iii. p. 304, pl. viii. fig. 2.
1909. ? *Steneosaurus larteti*, var. *kokeni*, Auer, Palæontographica, vol. lv. p. 224.

Type Specimen.—A nearly complete skeleton, including the skull (figured in Ann. Mag. Nat. Hist. [8] vol. iii. (1909) pl. viii. fig. 2; also Pl. VI. figs. 1, 2), mandible, teeth, atlas, axis (text-fig. 34, C, D), and eight other cervical vertebræ (text-fig. 35, C, D),

* Figured by Hulke (*loc. cit. supra*).

twelve dorsals (text-fig. 37), two lumbars, two sacrals (Pl. VI. fig. 6), and thirty-eight caudals (text-figs. 38, A, B, C), cervical ribs (text-fig. 39), dorsal ribs, chevrons, scapulæ, and coracoids (text-fig. 41, A), humeri, radii, and ulnæ (text-fig. 42), pubes, ischia, ilia, femora, tibiæ, fibulæ, and many bones of hind foot; numerous scutes (Pl. VI. figs. 4, 5) (R. 3701).

In March, 1909, the present writer described this species, basing the description upon the skull referred to above. Almost simultaneously, Auer published (*loc. cit. supra*) an account of a closely similar specimen in the collection of Tübingen University, and referred it to a new variety of *Steneosaurus larteti* of Deslongchamps. As it seems certain that this species is distinct from *St. larteti*, and as, moreover, the greater part of the available specimens are in the British Museum, the name *Steneosaurus durobrivensis* is here employed.

In this species the rostrum (Pl. VI. figs. 1, 2) is of moderate length only, the preorbital region being about 61 per cent. of the whole, while in *St. leedsi* it is about 73 per cent. The temporal fossæ are very large and about twice as long as wide; the orbits are proportionately smaller than in *St. leedsi*. The frontals terminate anteriorly in a very obtuse angle a little in front of the level of the anterior rim of the orbits. In the type specimen the bone is coated with a pyritous incrustation concealing the sculpture, which, judging from another specimen (R. 2865), consists of irregular pits on the frontals and prefrontals, and numerous more or less longitudinal grooves of varying length on the surface of the rostrum. In the upper jaw there are about thirty-four teeth on each side, of which thirty are borne on the maxilla; the anterior point of the nasals is about opposite the sixteenth maxillary tooth, while the anterior angle of the palatines is about opposite the twenty-second, so far as can be made out. A number of detached teeth (Pl. V. fig. 5; Pl. VI. fig. 3) said to be associated with the type skeleton are very sharply pointed, having the crowns covered with finely ridged enamel on their lower part, while the summit is smooth, somewhat compressed, and with two well-marked carinæ on opposite sides; there are also some teeth with blunter points having the enamel-sculpture extending to the tips and very slightly marked carinæ. Teeth of a similar character to these last are seen just showing their tips in the lower jaw of the type. It is doubtful whether both these forms of teeth belong to this species, differing in different parts of the jaw.

In the mandible there are about thirty-one teeth on each side; the posterior end of the symphysis is opposite the twenty-fifth, the anterior angle of the splenials opposite the seventeenth. The symphysial region of the mandible occupies about 44 per cent. of its total length.

As has been noted above, in correlation with the shortness of the head, the vertebræ and the bones of the limb-girdles are relatively shorter than in the long and slender skulled *St. leedsi*. The scutes seem to have larger and shallower pits than in *St. leedsi*, and these do not show the tendency to elongation and arrangement in lines running

out from the central ridge so marked in *St. hulkei*; but the variation of the form of the scutes in different parts of the series and in different individuals makes comparison in this respect unsatisfactory.

This species is distinguished from *St. edwardsi* * in several respects: thus in that form (1) the frontals terminate in front in an acute angle at the level of the anterior points of the prefrontals; (2) the premaxillæ extend further back and are not quite so widely separated from the nasals; (3) the form of the maxillo-premaxillary suture on the palate is different, the two not interlocking in the manner seen in *St. durobrivensis*. In *St. heberti* † there are 39–40 teeth in the upper jaw instead of 33–34. The hinder end of the symphysis appears to be opposite the twenty-seventh or, in one specimen, the thirtieth tooth. In *St. intermedius* there are thirty-eight or thirty-nine teeth in the upper jaw and thirty-seven or thirty-eight in the lower, the hinder border of the symphysis being opposite the thirty-second. In this species also the symphysis forms about 52 per cent. of the total length of the mandible, while in *St. durobrivensis* the proportion is about 44 per cent. In *St. larteti* the anterior border of the frontals and the maxillo-premaxillary suture differ in form from those of the present species; in *St. larteti* also the anterior angle of the nasals seems from Deslongchamps' figure to come about opposite the alveolus of the eighteenth maxillary tooth.

R. 3701. Nearly complete skull and skeleton. The parts preserved are skull (Pl. VI. figs. 1, 2), mandible, teeth; atlas, axis (text-figs. 34, C, D), and eight other cervical vertebræ (text-figs. 35, C, D), twelve dorsals (text-fig. 37), two lumbars, two sacrals (Pl. VI. figs. 6, 6 *a*), thirty-eight caudals (text-fig. 38, A, B, C); cervical and dorsal ribs (text-fig. 39); chevrons; scapulæ, coracoids (text-fig. 41, A); humeri, radii, and ulnæ (text-fig. 42), pubes, ischia, ilia; femora, tibiæ, fibulæ, and many bones of the hind feet; scutes (Pl. VI. figs. 4, 5). Type specimen described *loc. cit. supra.*

The dimensions (in centimetres) of this skeleton are:—

Skull (Pl. VI. figs. 1, 2):	
Total length	74·0
Length in front of orbit	45·0
Width between outer angles of quadrate	24·0
Length of temporal fossæ (inner side)	18·0
Width of temporal fossæ (inner side)	8·8
,, frontals between orbits	5·4
,, middle of snout	6·4
Width behind premaxillary expansion	4·8
Width of premaxillary expansion	5·7

* Deslongchamps, Bull. Soc. Linn. Normandie, sér. 2, vol. i. (1868) p. 155, as *Teleosaurus*; see also Deslongchamps, Notes Paléontologiques, p. 239.

† Morel de Glasville, Bull. Soc. Géol. France, sér. 3, vol. iv. (1876) p. 342; also vol. viii. (1880) p. 318.

Mandible:

Total length	85·0
Length of symphysial region	37·5
Width at hinder end of symphysis	10·2
„ narrowest point behind anterior expansion	3·8

Vertebræ	Atlas and axis.	Third cervical.	Middle cervical.	Posterior cervical.	Anterior dorsal.	Middle dorsal.	Lumbar.
Length of centrum in mid-ventral line	8·6	5·0	4·4	4·7	5·1	5·3	4·9
Width of posterior face	3·7	3·8	4·2	4·4	4 (app.)	4·3	4·5
Height of posterior face	4·0	4·0	4·3	4·5	4·5	4·7	4·0
„ to top of neural spine	7·9	9·0	12·2	11·3	10·9	9·4	10·1
Width between the outer ends of the transverse processes	..	..	..	..	13·3	15·2	15·2

	Sacrals. First.	Sacrals. Second.	Anterior caudals.		Middle caudals.		Posterior caudals.	
Length of centrum in mid-ventral line	4·8	4·7	4·4	4·5	4·5	4·2	4·0	3·6
Width of posterior face	3·8	4·7	3·8	3·6	3·4	3·3	2·0	1·3
Height of posterior face	4 (app.)	4·3	4·5	4·5	3·9	3·6	2·5	2·0
„ to top of neural spine	10·6	11·1	12·0	12·2	11·0	10·8	6·1	5·0 (app.)
Width between the outer ends of sacral and caudal ribs	16·5	15·5	13·4	11·7 (app.)	9 (app.)	..	..	..

The anterior face of the first sacral is 4·5 cm. wide and 3·9 cm. high.

Shoulder-girdle (text-fig. 41, A):

Scapula: greatest length	9·1
width at articular end	2·6
„ middle of shaft	1·4
„ upper end	2·8
Coracoid: greatest length	10·9
width of articular end	5·8
„ shaft	1·6
„ lower end (approx.)	5·2

Fore limb (text-fig. 42):

Humerus: length	12·2
width of upper end at deltoid crest	4·8
„ shaft at narrowest point	1·2
„ lower end	2·1
Radius: length	7·1
Ulna: length	8·9

Pelvis:

Ilium: length of dorsal border	9·5
height from acetabular edge to dorsal border	7·1
length from antero-inferior to postero-superior angle	10·8

Ischium: length of symphysial border . . . . (approx.)		14·5
width from articular end to posterior angle . . .		13·0
„ of neck at narrowest		3·8
greatest width of proximal end		5·7
Pubis: greatest length		12·9
width of lower expansion		6·2
„ shaft at narrowest point		1·1
„ upper end		2·3
Hind limb:		
Femur: length in straight line		31·4
greatest width of proximal end		5·0
long diameter of the middle of the shaft		3·0
short diameter of the middle of the shaft		2·3
Tibia: length		14·0
width of proximal end		3·8
„ middle of shaft		2·3
„ distal end		3·5
Fibula: length		13·1
First metatarsal: length		9·3

R. 2865 (Leeds Coll. 28). Imperfect skeleton. The parts preserved are:—Skull; atlas, axis, and seven other cervical vertebræ, fourteen dorsals, two sacrals, and twenty-three caudals; cervical and dorsal ribs; chevrons; ischia, one pubis, femora, tibiæ, and fibula, numerous bones of foot and many scutes.

This skeleton is that of a larger and presumably older individual than the type specimen. The skull differs in some details: *e.g.*, the rostrum appears to be relatively a little longer. It approximates in form to the specimen figured by Auer as *St. larteti*, var. *kokeni*. The diagrammatic text-figures nos. 31–33 are founded mainly on the skull of this specimen.

Some dimensions (in centimetres) of this specimen are:—

Skull:		
Total length from tip of snout to occipital condyle		93·5
Length in front of orbit		58·9
Width between the outer angles		
„ of the quadrates . . . . . (approx.)		31·2
Length of temporal fossæ (inner side)		22·5
Width of temporal fossæ (anterior end)		9·8
„ frontals between orbits		7·1
* „ snout at anterior end of nasals		8·2
„ snout behind the premaxillary expansion		5·5
* „ premaxillary expansion (crushed)		7·5

* Somewhat exaggerated by crushing.

Vertebræ*	Atlas and axis.	Middle cervical.	Posterior cervical.	Middle dorsal.	Posterior sacral.	Anterior caudal.	Posterior caudal.
Length in mid-ventral line	10·5	7·0	5·4	5·5	5·5	5·1	5·5
Width of posterior face of centrum	4·4	5·3	5·8	5·4	5·7	5·0	4·0
Height of posterior face of centrum	5·2	5·5	5·7	6·2	5·5	5·8	4·6
Height to top of neural spine	..	15·3	14·5	13·3	12·3	14·3	13·7
Width between outer ends of transverse processes, and sacral or caudal ribs	..	..	..	19·3	21·6	16·6	..

Ischium: length of symphysial border	(approx.)	16·0
width of neck at narrowest point		5·2
,, upper end		7·5
Pubis: greatest length		16·6
width of distal expansion		7·9
,, neck at narrowest		2·0
,, upper end		2·5
Femur: length in straight line		38·5
greatest width of proximal end		7·4
Tibia: length		17·6

R. 2075 (Leeds Coll. 3). Imperfect skeleton of an individual rather larger than the type specimen. The parts preserved are portions of skull and mandible, atlas and axis, five other cervicals, about seventeen dorsals, one sacral and twenty-three caudals, some scutes.

The two following specimens, in which the skull is badly preserved, are referred provisionally to the present species:—

R. 2076 (Leeds Coll. 4). An imperfect skeleton of an individual rather larger than the type specimen. The parts preserved are portions of the skull and mandible, the centra of the atlas and four other cervical vertebræ, six dorsals, two sacrals, and eight caudals (the neural arches in the cervical and dorsal regions are nearly all separated from the centra); cervical and dorsal ribs, chevrons, ilia, femora, a tibia and fibula, bones of hind foot, numerous scutes.

The dimensions (in centimetres) of some of the bones are:—

Vertebral centra	Atlas.	Middle cervical.	Anterior sacral.	Anterior caudals.	
Length in mid-ventral line	..	6·4	5·3	5·9	5·5
Width of posterior face	4·3	5·3	4·7	4·1	3·7
Height of posterior face	4·7	5·4	4·2	4·7	4·1

* The vertebræ are so much crushed that only approximate measurements can be made.

Ilium :	length of dorsal border	10·8
	height from acetabular edge to dorsal border	7·9
	length from antero-inferior to postero-superior border	13·0
Femur :	length in straight line	35·5
	greatest width at proximal end	6·3
	long diameter of middle of shaft	4·1
	short diameter of middle of shaft	2·8
Tibia :	length	17·1
	width of proximal end	4·9
	,, distal end	4·8
Fibula :	length	15·9

R. 2073 (Leeds Coll. 1). Imperfect skull and mandible, seven cervical vertebræ and fifteen dorsals, ilia, ischia, femora, tibiæ (one imperfect), fibula, and some bones of the hind foot.

The dimensions (in centimetres) of some of the bones are :—

Ilium :	length of dorsal border	(approx.)	10·5
	height from acetabular to dorsal border		7·9
	length from antero-inferior to postero-superior angle		13·2
Femur :	length in straight line		34·3
	greatest width of head		6·0
Tibia :	length		16·0

Steneosaurus obtusidens, Andrews.

[Plate VII.; text-fig. 50.]

1909. *Steneosaurus obtusidens*, Andrews, Ann. Mag. Nat. Hist. [8] vol. iii. p. 306, pl. ix. fig. 2.

Type Specimen.—A considerable portion of a skeleton of a very large individual. The parts preserved are skull and mandible (figured and described, *loc. cit. supra*, pl. ix. fig. 2, also Pl. VII. fig. 1), numerous teeth (Pl. VII. figs. 2–4), atlas, axis, and five other cervical vertebræ, eleven dorsals, two sacrals (text-fig. 50), nineteen caudals (Pl. VII. fig. 5), numerous cervical and dorsal ribs, chevrons, one scapula, parts of the humerus, ulna, ilia, ischia (Pl. VII. fig. 7), part of one pubis, right femur and part of left, tibia, fibula, astragalus, calcaneum and other bones of the hind foot, and numerous scutes (Pl. VII. fig. 6), mostly broken. (R. 3168.)

This species is distinguished mainly by the form of the teeth (Pl. VII. figs. 2–4), which are blunt and rounded at the tips; the enamel bears a sculpture of fine ridges, parallel to one another in the lower part of the crown, but more irregularly arranged on the summit; on both the anterior and the posterior faces there is one more strongly marked ridge running from base to summit of the crown. It should be noted that some of the replacing teeth in the type skull of *St. durobrivensis* are of somewhat similar form, and although other differences between that species and the present one

exist, the possibility that the specimens upon which the latter is based may be very old and large individuals of *St. durobrivensis* cannot be entirely ignored.

The type specimen is a very large and presumably old individual, the skull of which, in its general proportions, is similar to that of *Steneosaurus durobrivensis*, and if it were not for the peculiarity of the teeth, might almost have been referred to that species; but since, so far as I am aware, there is no evidence of considerable change in tooth-form during the life of these animals it is better to separate the present species, especially as this distinction is supported by some other characters. In the skull (Pl. VII. fig. 1) the rostrum is very thick and massive, perhaps more so than in the other species. The orbits are large and oval; the frontal terminates anteriorly in an obtuse angle about on a level with the anterior border of the orbits: its surface is ornamented by a number of obscure ridges radiating from the centre. There is a small slit-like antorbital foramen about 7 cm. in front of the orbit. The rostrum has its upper surface strongly convex from side to side, and at its anterior end seems to have curved a little upwards; in front of the orbits it narrows very gradually to a point about 16 cm. behind its anterior end, where it is only 7·3 cm. wide; in front of this the premaxillary region is expanded. The total number of teeth in the upper jaw cannot be made out. In this skull the length of the preorbital region is about 51 per cent. of the whole; in *St. leedsi* it is about 73 per cent. and in *St. durobrivensis* about the same as in the present species, in which, however, the rostrum seems to narrow rather more gradually.

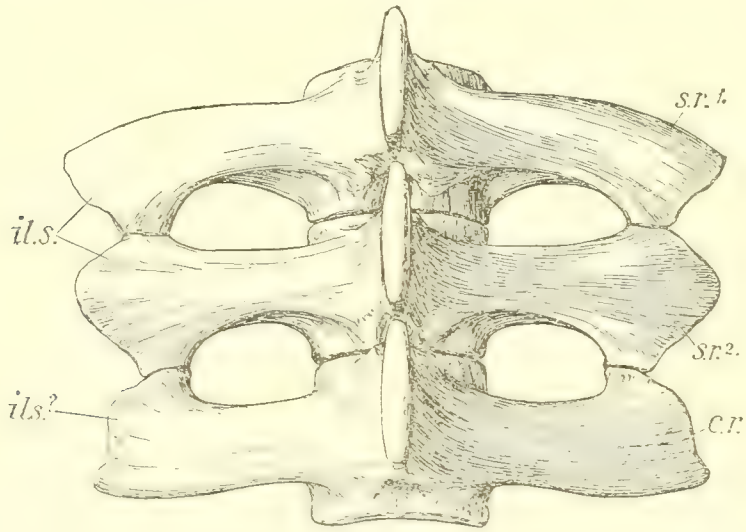
The mandible is very massively constructed. The symphysial region, which extends back to about the level of the twenty-fourth tooth, occupies about 42 per cent. of the total length, is flattened ventrally, and has a considerable anterior expansion, greatest at the fourth tooth. In *St. leedsi* the symphysis occupies about 58 per cent. of the total length of the mandible, in *St. hulkei* about 40 per cent., and in *St. durobrivensis* 44 per cent., these two species in this respect being very similar to the present one.

The lower teeth are about 28 in number on each side. The first two are small, then follow two large teeth closely crowded together, behind these again there is a small tooth followed by an increase in size till near the hinder end of the series. One peculiarity in the dentition of the type specimen, is that about half the teeth in the lower jaw bite into deep pit-like sockets in the maxilla, the walls of these sockets forming slight prominences along the outer alveolar border of the upper jaw. It is, however, uncertain whether this remarkable character is normal, and it seems that the condition may have been produced by great pressure which forced the points of the lower teeth into the maxillæ while the bone was in the semi-plastic state which many of the specimens in the Oxford Clay seem to have passed through.

The structure and proportions of the cervical, dorsal, and caudal vertebræ seem to be very similar to those of the corresponding vertebræ in *St. durobrivensis*, but in the

sacral region of the type specimen (the only one in which this part of the skeleton is preserved) a remarkable condition is found, there being apparently three sacrals (text-fig. 50). The explanation of this appearance seems to be, that the ribs of the first caudal have greatly enlarged and resemble sacral ribs, taking part in the support of the ilium. The two true sacrals are similar to those of *St. durobrivensis*, except that the outer end of the ribs of the second, instead of having a facet on its anterior face only, for union with the end of the rib of the first sacral, has also a facet on its hinder face for union with the massive rib of the first caudal; the postero-dorsal flange of the second sacral ribs also seems to have been lost, though a similar ridge may have been present on the first caudal rib. This is a massive structure like the ribs of the true sacrals; it is trihedral in section and much expanded at its outer end, where it bears two irregularly roughened surfaces, one,

Text-fig. 50.



Sacral and first caudal vertebræ (restored) of *Steneosaurus obtusidens*, from above (R. 3168, $\frac{1}{3}$ nat. size).
c.r., caudal rib; *il.s.*, iliac surface of sacral ribs; *il.s.?*, doubtful iliac surface of caudal rib; *s.r.*1, *s.r.*2, first and second sacral ribs.

the largest, apparently for union with the posterior part of the ilium, the other looking forwards for union with the corresponding facet on the posterior side of the outer end of the second true sacral: as above noted, the postero-superior angle may have been produced into a flange such as is seen on the posterior side of the second sacral rib in *St. durobrivensis* (Pl. VI. fig. 6) and in *Mycterosuchus* (text-fig. 52). The ilium in this specimen has a much roughened surface behind that for the second sacral rib, probably for union with the outer end of the enlarged caudal rib, but in another still larger specimen referred to this species there is no trace of this surface, although those for the two true sacrals are well defined. From this it appears likely that the condition in the type specimen may be an individual peculiarity.

In the rest of the skeleton the similarity to that of *St. durobrivensis* is so great that special description is unnecessary. In the case of the coracoid the ventral end is more expanded than in that species, and the bone is very like that of *Mycterosuchus* (text-fig. 54), but this expansion is probably merely the result of more extensive ossification consequent upon advanced age.

The dorsal scutes (Pl. VII. fig. 6) differ considerably from those of the other species. The pits are mostly shallow and elongated; they are arranged in lines radiating in most cases from the middle of the keel, and sometimes almost running together to form shallow grooves.

R. 3168. Skull (Pl. VII. fig. 1) and mandible, teeth (Pl. VII. figs. 2–4), atlas, axis, and five other cervical vertebræ; eleven dorsals, two (? three) sacrals (text-fig. 50), nineteen caudals (Pl. VII. fig. 5), numerous cervical and dorsal ribs, chevrons, one scapula, an imperfect humerus, an ulna, ilia, ischia (Pl. VII. fig. 7), one pubis, femora (one imperfect), incomplete tibiæ and fibulæ, bones of the hind foot, portions of ventral ribs, and numerous scutes (Pl. VII. fig. 6). Type specimen, the skull and mandible of which are described and figured in Ann. Mag. Nat. Hist. [8] vol. iii. (1909) p. 306, pl. ix. fig. 2. The skull, though much broken, is less flattened than usual; the vertebræ are nearly all crushed and distorted.

The dimensions (in centimetres) of this specimen are :—

Skull (Pl. VII. fig. 1):	
Total length	116·0
Length in front of orbit	71·0
Width between outer angles of quadrates	37·5
Length of temporal fossa (inner side)	33·0
Width of temporal fossa	(?) 14·0
„ frontals between orbits	8·5
„ snout opposite anterior end of nasals. (approx.)	9·0
„ snout behind premaxillary expansion	7·3
„ premaxillary expansion	9·5
Mandible:	
Total length	137·0
Length of symphysial region	58 0
Width at hinder end of symphysis	14·0
„ narrowest point behind anterior expansion	6·2

Vertebræ	Atlas and axis.	Middle cervical.	Dorsals.		Sacrals. 1st.	Sacrals. 2nd.	First caudal.	Anterior caudals.		Posterior caudal.
Length of centrum in mid-ventral line	12·0	7·2	6·5	7·0	..	5·3	5·9	6·7	6·8	5·4
Width of posterior face	5·8	7·4	7·6	7·1	..	7·3	7·5	5·0	4 9	4·2
Height of posterior face	..	7·2	7·2	8·2	5·8	6·0	7·0	5 5	5·8	3·8
Height to top of neural spine	..	..	15·7	..	..	14·5app.	..	16·1	14·8	10·0

The width between the outer ends of the ribs in the first sacral is 27·4 cm., in the second 24·7 cm., and in the first caudal 25·0 cm.

Scapula:	length	16·7
	width of articular end	5·1
	„ middle of shaft	2·2
	„ upper end	5·0
Ilium:	length of dorsal border	16·1
	height from acetabular border to dorsal edge	11·3
	length from antero-inferior to postero-superior angle	18·2
Ischium:	length of symphysial border	20·2
	width from articular end to posterior angle	20·1
	width of neck at narrowest	5·5
	greatest width of proximal end	8·8
Femur:	length in straight line	45·6
	width of upper end	7·9
	long diameter of middle of shaft	4·3
	short diameter of middle of shaft	3·5
	greatest width at condyles	5·6
Tibia:	approximate length	21·3
	width of upper end	6·0

R. 3169. Portions of the skeleton of a large individual probably belonging to this species. The parts preserved are tracheal rings, left coracoid, right scapula, radius, ulna, right ilium, pubis (Pl. VII. fig. 8), femora, tibiæ, bones of hind foot, scutes. In this specimen a few of the ossified tracheal rings are in a remarkably good state of preservation.

The dimensions (in centimetres) of this specimen are :—

Tracheal ring:	long diameter	3·2
	short diameter	2·7
	greatest thickness	0·5
Coracoid:	greatest length	16·1
	width of shaft at narrowest	2·4
	length of the scapular border	4·0
	approximate width of lower end	8·5
Scapula:	greatest length	15·0
	width at upper end	5·5
	width of shaft at narrowest	2·3
Ulna:	length	11·9
	width of upper expansion (approx.)	5·5
Ilium:	length of dorsal border	12·2
	height from acetabular to dorsal border	9·8
	length from antero-inferior to postero-superior border	16·1
Femur:	length in straight line	41·7
	width of head	6·4
	long diameter of middle of shaft	4·3

Femur:	short diameter of middle of shaft	4·0
	width of condyles (approx.)	5·3
Tibia:	length	19·7
	width of upper end	5·7
	„ lower end	4·8
Front metatarsal:	length	12·0

R. 3898. Left ilium, ischium, and femur of a very large individual, probably of this species. The dimensions (in centimetres) of these bones are :—

Ilium:	length of dorsal border	19·0
	height from acetabular to dorsal border	12·5
	length from antero-inferior to postero-superior angle	22·9
Ischium:	length of symphysial border (approx.)	25·5
	width from acetabular surface to posterior angle	23·5
	width of neck	6·8
	greatest width of the proximal end	12·0
Femur:	length in a straight line	53·0
	greatest width of proximal end	9·5
	long diameter of middle of shaft	5·9
	short diameter of middle of shaft (approx.)	4·0

This is the largest Steneosaur recorded from this horizon.

Genus **MYCTEROSUCHUS**, nov.

Large Mesosuchian Crocodiles in which the snout is greatly elongated and sharply marked off from the cranial region of the skull, which narrows very rapidly immediately in front of the orbits. The alveolar borders are straight and the teeth slender, though not excessively so; they were probably not directed outwards as in *Teleosaurus*. The temporal fossæ are relatively smaller and especially shorter than in the typical Steneosaurs. The upper surface of the skull exhibits a strong rugose sculpture, especially on the frontals. In the mandible the symphysis is long, but is less than two-thirds of the total length. The fore limb is less reduced than in *Steneosaurus*, and in the humerus both distal condyles are well developed. The tail is very long and the caudal centra are strongly compressed laterally: their neural spines are broad and high, and in the middle and posterior regions deeply notched both anteriorly and posteriorly. The dorsal armour was heavy, the scutes being much more massive than in *Steneosaurus*.

This genus has been established for the reception of the only known species, *Mycterosuchus nasutus*, from the Oxford Clay of Peterborough, a form which differs considerably from any of the species of *Steneosaurus*, and in the sudden narrowing of the snout has some similarity with *Teleosaurus*, from which, however, it is distinguished by (1) the straight alveolar borders with downwardly directed teeth, (2) the relatively larger size of the superior temporal fossæ, and (3) the relatively larger head.

Mycterosuchus nasutus, Andrews.

[Plate VIII.; text-figs. 51–54.]

1909. *Steneosaurus nasutus,* Andrews, Ann. Mag. Nat. Hist. [8] vol. iii. p. 302, pl. ix. fig. 1.

Type Specimen.—A considerable part of a skeleton, including the skull (Pl. VIII. fig. 1), mandible (Pl. VIII. fig. 2), atlas, axis, and nine other cervical vertebræ, two or three crushed dorsals, forty-two caudals (Pl. VIII. figs. 4–9), left coracoid and scapula (text-fig. 54, C), left humerus (text-fig. 54 A, B) and ulna, left and part of right femur, right tibia and fibula, astragalus, calcaneum, metatarsals, and other foot-bones, also numerous scutes (Pl. VIII. figs. 4, 10). The skull was figured in Ann. Mag. Nat. Hist. [8] vol. iii. (1909) pl. ix. fig. 1. (R. 2617.)

The *skull* (Pl. VIII. fig. 1) in the type specimen has been much compressed vertically and the snout is somewhat curved round to the right. In some respects it approaches the *Teleosaurus*-type, particularly in the rapid preorbital narrowing of the skull. The orbits seem to have looked more directly forwards than in *Steneosaurus.* The frontals, prefrontals, outer face of the squamosals, and the parietals, all have their surface sculptured by strongly-marked pits and rugosities, which occur even on the summit of the high sagittal crest; the surface of the snout is also sculptured, but here the rugosities are less marked and run, in the main, in a longitudinal direction. The premaxillary expansion (*pmx.*) was considerable and probably bore four teeth on each side, of which the two hindmost are enlarged and set closely together; each of the maxillæ bears about thirty-eight teeth, which are nearly equal in size throughout the series. The crowns of the teeth (Pl. VIII. fig. 3) are slender and sharply pointed; the enamel is marked by a series of very fine longitudinal ridges, one of which, on the outer side, is rather more strongly marked and continuous than the others.

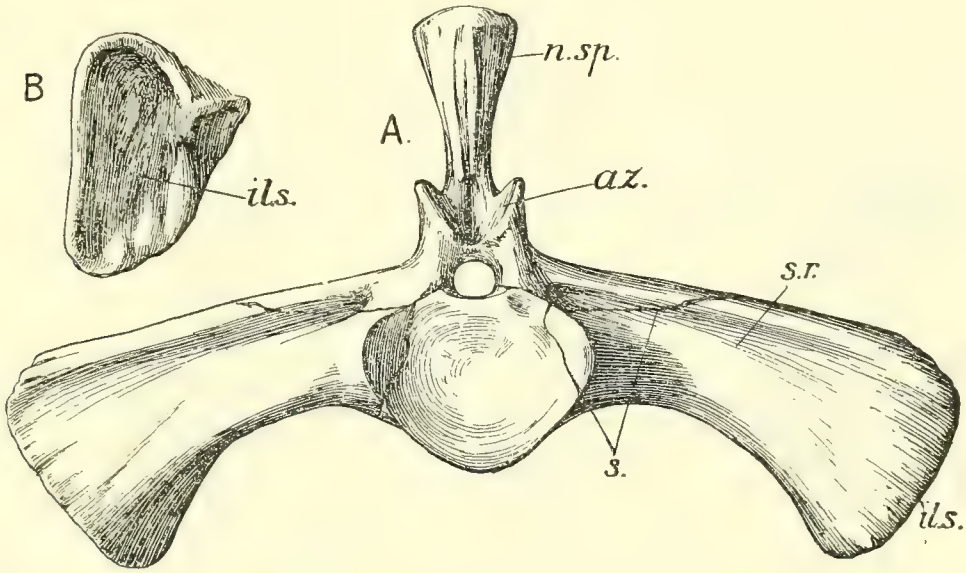
The *mandible* (Pl. VIII. fig. 2) is slender and has been much compressed vertically. The upper surface of the symphysial region seems to have been somewhat convex from side to side, while the ventral surface is marked by an ornamentation of irregular longitudinal ridges; there is a slight expansion at the anterior end, and the third and fourth teeth are enlarged. The splenial (*spl.*) extends into the symphysis as far as the level of the twenty-second tooth, and the hinder end of the symphysis is opposite the thirty-seventh tooth. There are about forty-two teeth on each side.

Speaking generally, the vertebræ are similar to those of *Steneosaurus*, but there are some differences, especially in the caudal region (Pl. VIII. figs. 4–9).

The *atlas* and *axis* are not so long as might be expected from the great elongation of the skull. The neural spine of the axis, instead of extending back nearly to the level of the hinder ends of the posterior zygapophyses and rising gradually to its hinder end as in *Steneosaurus*, is a low rounded crest, the highest point being near the middle of its length, behind which it slopes downwards and disappears between the

bases of the posterior zygapophyses. The remainder of the cervicals, though perhaps slightly longer in proportion to their other dimensions than those of *St. durobrivensis*, are otherwise similar to them. In the type specimen the dorsal vertebræ are lost or very badly preserved, but in another specimen (R. 3892) they are in good preservation. They are here found to be closely similar to those of *St. durobrivensis*, except that the neural spines are considerably thickened at their summit, terminating in a smooth, flat or slightly convex surface, while beneath this on their flat sides there are well-marked vertical ridges: this character is especially marked in the sacral region (as shown in text-figs. 51–53), and seems to be correlated with the support of a heavier armour of scutes than is found in *Steneosaurus*. Text-fig. 51, A, shows that the inner ends of the sacral ribs form a quite considerable portion of the concave anterior surface

Text-fig. 51.



First sacral vertebra of *Mycterosuchus nasutus*: A, from front: B, outer end of sacral rib. (R. 3892, ½ nat. size.)

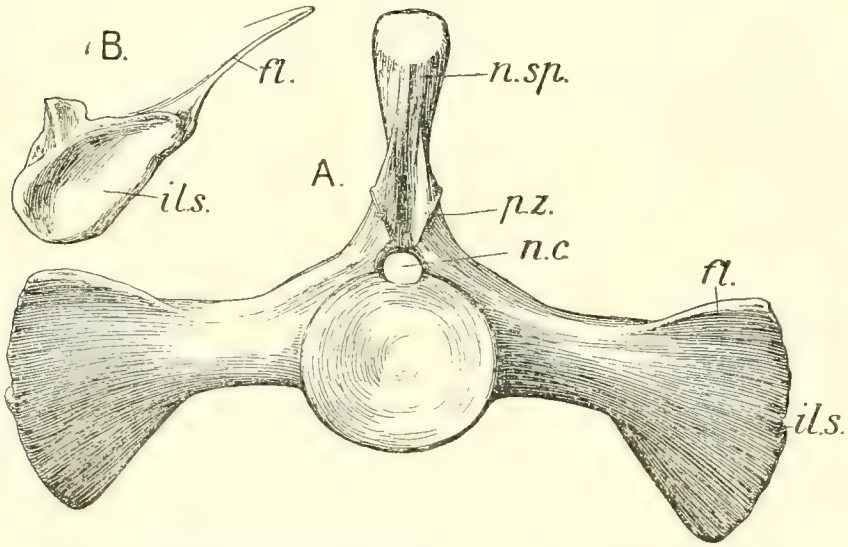
a.z., anterior zygapophysis; *il.s.*, surface for ilium; *n.sp.*, neural spine; *s.*, suture between sacral rib and the vertebra; *s.r.*, sacral rib.

for union with the centrum of the lumbar; the extension outwards of the base of the neural arch along the dorsal edge of the sacral rib is also seen. In the figure of the second sacral (text-fig. 52) the thickening of the upper end of the neural spine is again shown, as also is the peculiar form of the outer end of the sacral rib, the postero-superior angle of which is produced backwards and upwards into a well-developed flange (*fl.*, text-fig. 52, B), the outer edge of which must have fitted into a corresponding depression on the inner face of the ilium. The caudal vertebræ (Pl. VIII. figs. 4–9) differ to a considerable degree from those of *Steneosaurus*. In the anterior caudals the

articular ends of the centra are oval in outline and somewhat deeply concave; the caudal ribs are strongly developed, but did not help to support the ilium. In the first caudal no chevron-facets are present; these first appear on the second, where, in the type specimen, they are asymmetrically arranged, that on one side being, as usual, on the posterior ventral edge of the centrum, while that on the other is further forwards on the ventral surface: in this vertebra and the next the posterior portion of the centrum is deflected downwards, the tail at this point having apparently curved down from the pelvic region. The neural spines are inclined a little forwards.

In the rest of the tail (Pl. VIII. figs. 4–9) the centrum is more or less compressed laterally, especially in its middle portion; the upper and lower borders of the articular faces are flattened, so that in end view the outline of the centrum is somewhat quadrate

Text-fig. 52.



Second sacral vertebra of *Mycterosuchus nasutus*: A, from behind; B, outer end of sacral rib. (R. 3892, ½ nat. size.)

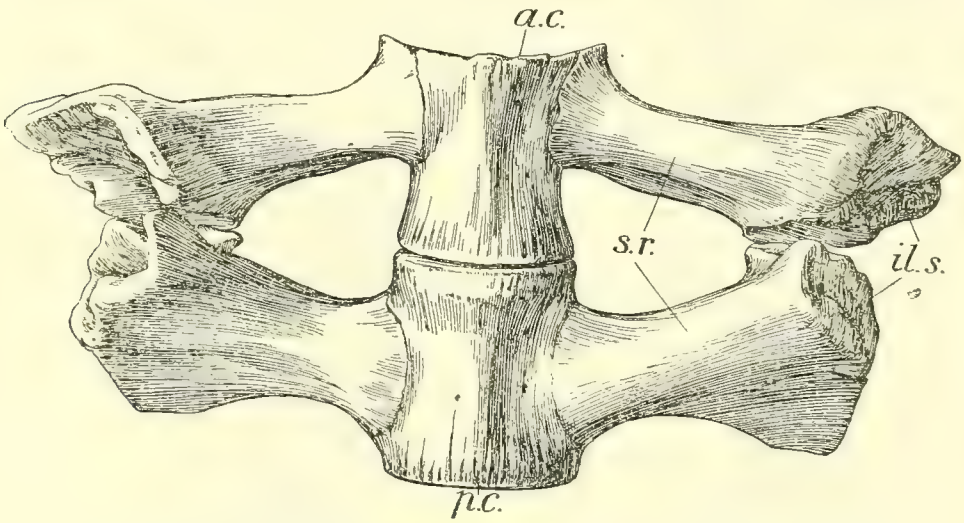
fl., flange on outer end of sacral rib; *il.s.*, surface for ilium; *n.c.*, neural canal; *n.sp.*, neural spine; *p.z.*, posterior zygapophysis.

(Pl. VIII. figs. 5 *a*, 6 *a*), the sides being convex; the chevron-facets are borne at the hinder end of a pair of ridges which run nearly the whole length of the ventral surface of the centrum and are separated by a narrow flat or concave band of bone.

The neural spines are peculiar, and differ considerably from those of the Steneosaurs described above. In the most anterior caudals, as above noted, the spine slopes a little forwards and is thickened at its upper end. Further back in the series (at about the sixth) it becomes upright, and behind this slopes backwards. Here it is a broad thin plate of bone extending nearly the whole length of the arch. At about

the twelfth vertebra, or the first in which the caudal ribs are wanting, the upper portion of the spine is narrowed by a broad notch on its anterior edge (Pl. VIII. fig. 5), dividing it into the main spine behind and a narrow pointed process in front, projecting nearly vertically upwards. Still further back a posterior notch appears: at first this merely forms a kind of bay in the posterior border of the spine, but becoming larger in the more posterior vertebræ, it separates off from the main spine a posterior prominence similar to that in front (Pl. VIII. fig. 6). These anterior and posterior processes of the neural spine are continued nearly to the end of the tail (Pl. VIII. figs. 7–8), and in the posterior vertebræ have a deceptive resemblance to zygapophysial processes, though an examination of their mode of origin shows that they are not so, but merely portions of the neural spine. In the posterior vertebræ

Text-fig. 53.



Sacral vertebræ of *Mycterosuchus nasutus*, from below. (R. 3892, ½ nat. size.)
a.c., anterior end of centra; *il.s.*, surface for ilium; *p.c.*, posterior surface of centrum; *s.r.*, sacral ribs.

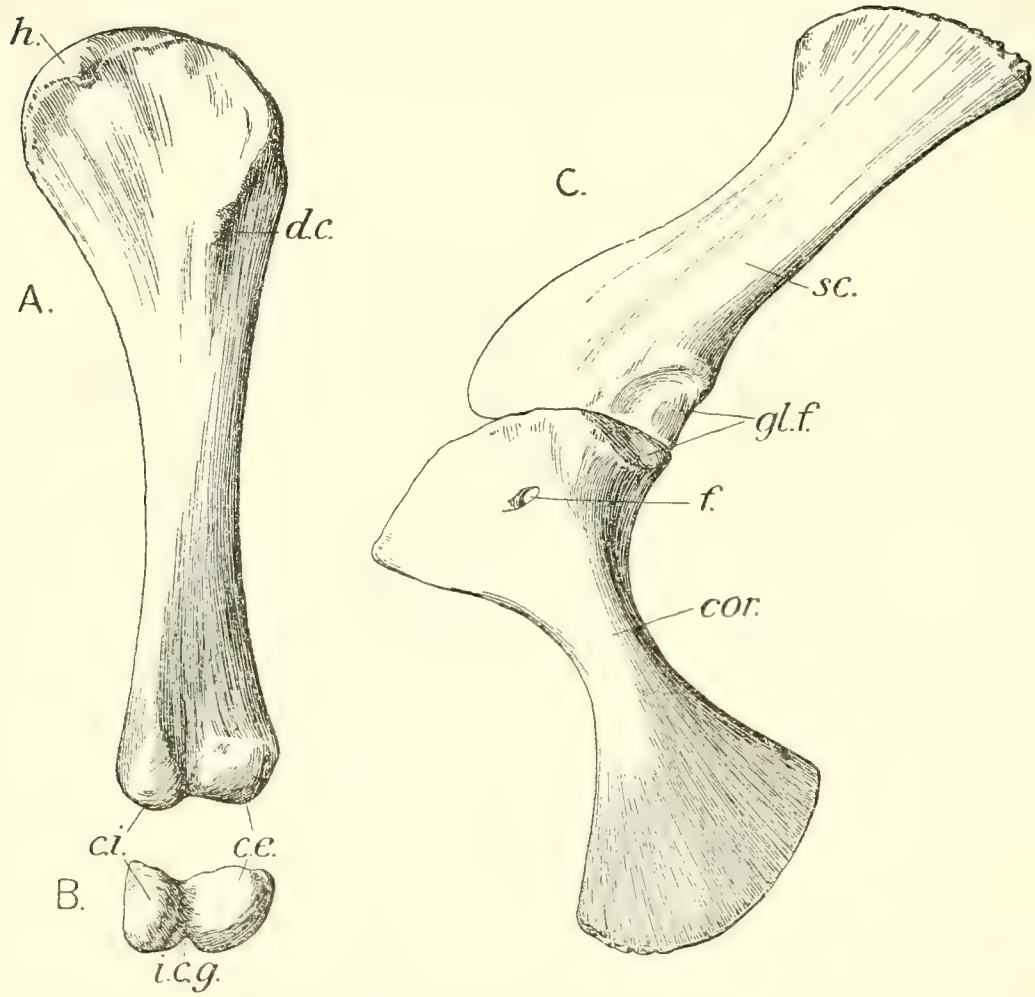
the main part of the neural spine shifts further and further back on the arch, and at the same time becomes smaller.

The *shoulder-girdle* (text-fig. 54, C), in correlation with the relatively large size of the fore limb, is strongly developed, both the coracoid and scapula being much expanded at their extremities.

The *humerus* (text-fig. 54, A, B) is large compared with that of *Steneosaurus* and differs from it in several other respects. Thus the upper end seems to be less bent backwards, and consequently its articular surface is more nearly terminal. At the distal end both condyles are well developed, though the radial one (*c.c.*) is the

larger; the two are separated by a well-marked oblique groove (*i.c.g.*) running from front to back of the bone. The plane of the distal condyles makes an angle with that of the proximal expansion, but is not turned almost at right angles with it as in *Steneosaurus*. There is a well-marked deltoid prominence (*d.c.*). The humerus in this genus is longer than the tibia and more than half as long as the femur: in *Steneosaurus* the reverse is the case. The *radius* and *ulna*, though similar to those of

Text-fig. 54.



Left humerus and left half of shoulder-girdle of *Mycterosuchus nasutus*: A, humerus from front; B, distal end of humerus; C, outer side of coracoid and scapula. (R. 2617, ½ nat. size.)

c.e., radial condyle; *c.i.*, ulnar condyle; *cor.*, coracoid; *d.c.*, deltoid crest; *f.*, coracoid foramen; *gl.f.*, glenoid fossa; *h.*, head of humerus; *i.c.g.*, intercondylar groove; *sc.*, scapula.

Steneosaurus in form, are likewise proportionately larger. The difference of proportion between the fore and hind limb may be expressed by saying, that if the combined

length of the femur and tibia be taken as 100, then the combined length of the humerus and radius will be represented in *Mycterosuchus nasutus* by about 54, but in *Steneosaurus leedsi* and *Steneosaurus durobrivensis* by about 43.

The *pelvis* is not known, and the bones of the hind limb, so far as preserved, do not appear to differ much in structure from those of *Steneosaurus*. The *tibia* is just half the length of the femur, while in *Steneosaurus* it is rather less.

The *dermal scutes* (Pl. VIII. figs. 4, 10) are proportionately thicker and heavier than in *Steneosaurus*. In the dorsal region the keel does not appear to have been well developed; the sculpture consists of a number of large, deep, and closely-set pits.

R. 2617 (Leeds Coll. 1). The greater part of the skeleton of a large individual, including nearly complete but crushed skull and mandible (Pl. VIII. figs. 1, 2), atlas, axis, and nine other cervical vertebræ, two or three crushed dorsals, forty-two caudals (Pl. VIII. figs. 4–9), left coracoid and scapula (text-fig. 54, C), left humerus (text-fig. 54, A, B) and ulna, left and part of right femur, right tibia and fibula, astragalus, calcaneum, metatarsals and other foot-bones. Numerous scutes are preserved, in many cases adherent to the sides of the neural spines. Type specimen, the skull and mandible being described and the skull figured in Ann. Mag. Nat. Hist. [8] vol. iii. (1909) p. 302. pl. ix. fig. 1 (the registered no. is there wrongly given as R. 3577).

The dimensions (in centimetres) of this specimen are :—

Skull (Pl. VIII. fig. 1):	
Total length	100·0
Length in front of orbits	73·0
Width between the outer angles of the quadrates	25·0
Length of temporal fossæ (inner side)	14·0
Width of temporal fossæ	10·5
„ of frontals between orbits	6·0
„ of skull at anterior border of orbits	16·5
„ at anterior angle of nasals	6·3
„ behind premaxillary expansion	4·2
„ of premaxillary expansion	7·3
Mandible (Pl. VIII. fig. 2):	
Total length	110·0
Length of symphysial portion	62·0
Width at hinder end of symphysis	11·6
„ behind anterior expansion	4·2

Owing to the crushing undergone by the skull and mandible, many of the above dimensions are only to be taken as approximate.

Vertebræ	Atlas & axis.	3rd cervical.	9th cervical.	Caudals. 2nd.	8th.	13th.	20th.	26th.	30th.	34th.	40th.	41st.
Length in mid-ventral line	8·5	6·4	6·8	6·7	6·9	6·2	5·7	5·3	4·9	4·3	3·4	3·1
Width of posterior face	4·5	..	5·5	..	3·8	3·3	2·7	2·0	1·6	1·6	·9	..
Height of posterior face	4·7	..	5·3	..	3·7	3·2	2·7	2·3	1·8	1·3	1·0	..
„ to top of spine	9·2	14·1	14·2	..	9·7 (app.)	9·8	8·8	6·7	5·4	..	..	..

The numbers of the caudals in the series are only approximate, at least three are wanting from the anterior region.

Shoulder-girdle (text-fig. 54, C):	
Scapula: length	13·5
width of articular end	6·1
„ shaft	3·0
„ upper expansion	5·9
Coracoid: length (approx.)	15·0
width of articular end	8·2
„ lower end (approx.)	7·6
Humerus (text-fig. 54, A, B): length	21·1
width of proximal end	7·0
„ shaft at narrowest	2·3
„ lower end	4·3
Ulna: length	14·3
width of upper end	4·9
„ lower end	2·2
Radius: length	11·5
width of upper end	3·6
„ lower end	2·9
Femur: length	40·0
Tibia: length	20·0
width of upper end	5·5
„ lower end (approx.)	5·0
Fibula: length	17·8
width of upper end	3·3
„ middle of shaft	1·6
„ lower end	3·9

R. 3892 (Leeds Coll. 9). A great part of the vertebral column of a large individual. The vertebræ preserved are six cervicals (the atlas and axis are wanting), fourteen dorsals, one lumbar, two sacrals (text-figs. 51–53), and twenty-one caudals. Most of the vertebræ, though somewhat distorted, are well preserved, and in most the neural arches and spines are present.

Some approximate dimensions (in centimetres) of some of these vertebræ are :—

	Caudals.		Dorsals.		First sacral.	Second sacral.	First caudal.	Anterior caudal.	Middle caudals.		Posterior caudal.
Length in mid-ventral line . . .	5·9	6·2	6·5	6·8	5·8	5·9	5·1	6·8	6·0	5·8	5·3
Width of posterior face of centrum .	4·8	5·4	5·8	5·4	5·0	5·5	5·2	4·2	3·8	3·4	2·8
Height of posterior face of centrum .	5·0	5·1	5·3	5·5	3·9	4·6	4·5	3·9	3·3	3·1	2·5
Height to top of neural spine . .	11·0	14·1	12·8	13·1	12·3	11·5 app.	..	11·3	9·9	9·5	..

Family GEOSAURIDÆ.

Mesosuchia which are modified for a strictly aquatic life. Nasals large, taking a considerable share in the formation of the rostrum; they may or may not extend forwards to the premaxillæ. Prefrontals very large and overhanging the orbits, which look forwards and outwards. Premaxillæ with no terminal expansion. Teeth usually somewhat compressed and carinate. Vertebræ with slightly concave ends. Fore limb greatly reduced and paddle-like. Hind limb large. Tail long, with the distal segment sharply bent down and supporting a large dorsal fin. No dermal skeleton is known; a sclerotic ring was present in the eye.

This family corresponds to the group Thalattosuchia of E. Fraas *.

Genus **METRIORHYNCHUS**, H. v. Meyer (emend. E. E. Deslongchamps).

[Isis, 1830, pt. v. p. 518, and Palæologica (1832), p. 106; emend. E. E. Deslongchamps in Notes Paléontologiques, p. 132 (Caen, 1867).]

1890. *Suchodus*, Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. p. 288.

Exhibiting the characters of the family, but distinguished from the later *Geosaurus* by (1) the absence of the serration of the carinæ of the teeth, the enamel of which is, as a rule, raised into a varying number of fine longitudinal ridges; (2) the smaller degree of reduction of the humerus; (3) the greater length of the tibia and fibula in comparison with the femur. *Dacosaurus*, from Kimmeridgian beds, is very similar and should perhaps be referred to this genus.

Oxford Clay. The later forms are probably all referable to *Geosaurus* or *Dacosaurus*.

This genus was founded by H. v. Meyer for Cuvier's "Second Gavial of Honfleur" †,

* "Die Meer-Crocodilier (Thalattosuchia) des oberen Jura," Palæontographica, vol. xlix. (1902), p. 1.

† Ossements Fossiles, ed. 2, vol. v. pt. 2 (1824), p. 143.

described from a skull consisting partly of a skull of *Metriorhynchus* and partly of one of *Steneosaurus*, a circumstance which has led to much confusion in the use of these names. In 1867 the genus was defined in detail by E. E. Deslongchamps, the species regarded by him as typical being *Metriorhynchus superciliosum*, Blainv., sp.

E. Fraas, in his paper on the Thalattosuchia *, distributes the different species of *Metriorhynchus* into three groups as follows:—

1. Forms with very short snout, the nasals reaching the premaxillæ; prefrontals very large; teeth strongly developed.—*M. brachyrhynchus.*
2. Forms with thick-set snout, but the nasals separated from the premaxillæ by a considerable interval; prefrontals moderately large; powerful dentition with less than twenty-five teeth in the upper jaw.—*M. hastifer.*
3. Forms with elongated snout, the nasals in spite of their length being separated by a long interval from the premaxillæ; prefrontals smaller and not very prominent; dentition consisting of rather slender teeth, of which there are more than twenty-five on each side of the jaws.—*M. superciliosum*, *M. moreli*, *M. blainvillei.*

These groups, which are probably rightly considered by Fraas to be directly ancestral to the various forms of *Geosaurus* and *Dacosaurus* of higher horizons, hold good in a general way for the species now described, though some of these might be regarded as breaking down the sharp distinctions between them. Moreover, probably some of the new species are more directly in the line of descent of some of the species of *Geosaurus* than those previously known.

In the present volume seven species of *Metriorhynchus* are recognised, of which three are new. The skulls range in form from a long slender type to the stout broad type which has been referred to *Suchodus durobrivensis*, but the transition from the one form to the other is so gradual that it seems best to retain the same generic name for all.

The occurrence of so many species of one genus at one locality and on the same horizon is remarkable, but perhaps this is due to the fact that these reptiles were widely ranging pelagic forms which, as in the case of the smaller Cetacea, may have been represented by many species in one marine area of distribution.

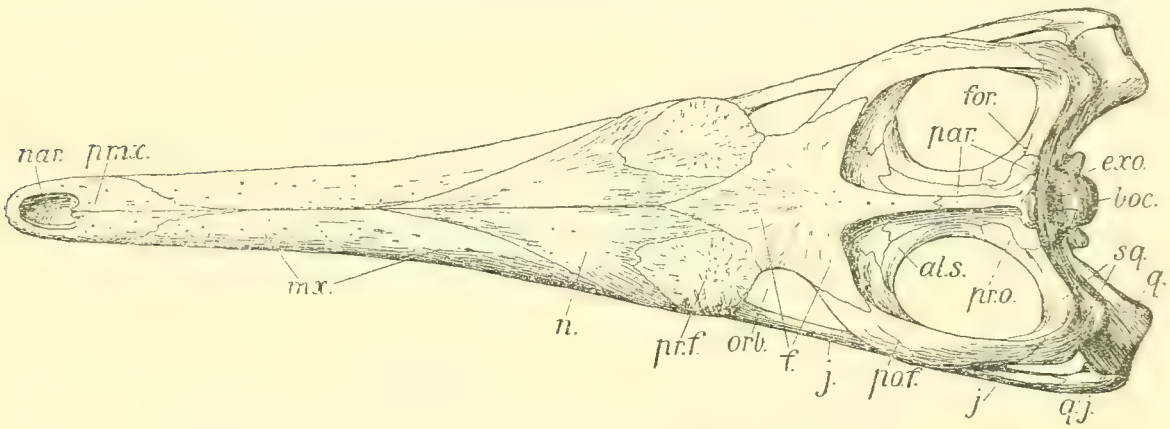
Skull (Pls. IX.–XIII.; text-figs. 55–59).—The following general account of the skull in this genus is founded largely on the two skulls (R. 3699–3700) of *Metriorhynchus brachyrhynchus* (Pl. XII.) in which the palatal region is fairly well preserved, as described by Mr. E. Thurlow Leeds (Quart. Journ. Geol. Soc. vol. lxiv. (1908) p. 345). Other specimens are referred to when they throw light on points not determinable from these specimens. Unfortunately nearly all the skulls in the collection have been greatly crushed, so that in most cases the roof is flattened and driven down,

* Palæontographica, vol. xlix. (1902) p. 1.

the sides being concealed and the thin bones of the palate destroyed. Besides making it difficult to work out the structure of the skull, this crushing also renders the measurements, particularly those of width, very unreliable.

In its general outline (text-fig. 55) the skull seen from above is an elongated isosceles triangle; the height of the triangle (*i. e.* the length of the skull) differs much in its relative proportion to the base (*i. e.* the width between the outer angle of the quadrates) in the various species, the difference in length depending mainly on the degree of development of the rostral (preorbital) region. The premaxillary region is pointed and shows no expansion such as occurs in the Steneosaurs. The posterior (occipital) surface of the skull is triangular in outline and is by no means so depressed as in *Steneosaurus*, but unfortunately in nearly all cases it is greatly deformed by crushing. The large temporal fossæ vary somewhat in form and size in the different

Text-fig. 55.



Semi-diagrammatic view of skull of *Metriorhynchus superciliosum*, from above.

al.s., alisphenoid; *boc.*, basioccipital; *ex.o.*, exoccipital; *f.*, frontal; *for.*, foramen in hinder wall of temporal fossa; *j.*, jugal; *mx.*, maxilla; *n.*, nasal; *nar.*, external nares; *orb.*, orbit; *par.*, parietal; *pmx.*, premaxilla; *po.f.*, postfrontal; *pr.f.*, prefrontal; *pr.o.*, pro-otic; *q.*, quadrate; *q.j.*, quadrato-jugal; *sq.*, squamosal.

species, but may be said to be roughly quadrangular with the angles rounded off to a varying extent.

The *premaxillæ* (*pmx.*) form the anterior extremity of the pointed snout. Above, they surround the external narial aperture, which is usually an elongated heart-shaped opening, the indentation on its posterior border being formed by a pair of processes of the premaxillæ projecting forwards. In *Geosaurus*, according to Fraas *, these processes completely divide the nasal opening in the middle line, but this is not

* Palæontographica, vol. xlix. (1902) p. 43.

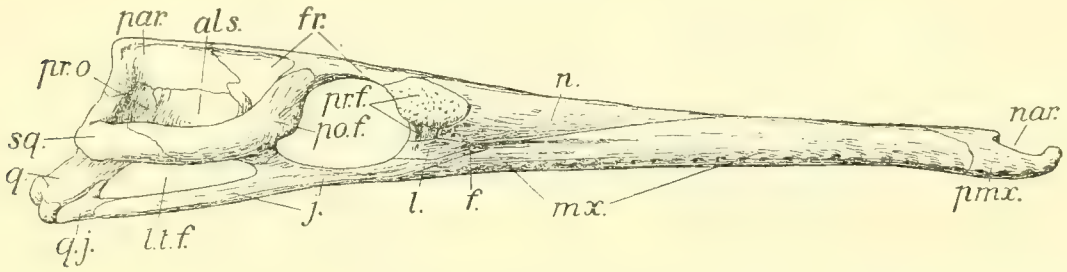
seen in the specimen of *Geosaurus gracilis* figured in the frontispiece. In *Metriorhynchus* these processes vary much in length, in some cases being very short, while, according to Mr. Leeds, in some skulls of *M. superciliosum* they may extend two-thirds of the length of the nasal opening; they are often broken away and are not always completely shown in the figures. At the sides of the nares the premaxillæ form a thickened rounded border, low in the middle but rising anteriorly and forming in the middle line a well-marked prominence. An incisive foramen on the floor of the nasal opening has not been observed. Behind the nasal opening the premaxillæ are produced backwards into pointed facial processes which are thrust between the maxillæ. These processes may actually meet the anterior angles of the nasals, thus shutting out the maxillæ from the median dorsal line, or they may be separated from them by an interval varying in the different species, and to some degree even in the individuals of one species. Beneath the nares the sides of the premaxillæ are rounded from above downwards; ventrally they are nearly flat and meet in the middle line for a short distance anteriorly, behind which they are produced back into pointed palatine processes underlying the pointed anterior ends of the palatine plates of the maxillæ, which are thrust like a wedge between them as far forwards as the level of the interval between the second and third dental alveoli. Each premaxilla bears three alveoli, which are separated from one another by equal intervals; the anterior tooth is a little smaller than the others. Between the last tooth in the premaxilla and the first in the maxilla there is usually a diastema of considerable length; this region is a little concave from before backwards, and is crossed towards its hinder end by the maxillo-premaxillary suture.

The *maxillæ* (*mx.*) are very large bones forming a great part of the rostrum. They may meet in the middle dorsal line for some distance, or may be excluded from it by the junction of the premaxillæ and the nasals. Their greatest length is along the alveolar border, which extends from the premaxillæ to the jugal behind. The number and the distance between the dental alveoli vary considerably in the different species; thus in *M. læve* there are considerably over thirty teeth in each maxilla, the alveoli being set very close together, while, on the other hand, in *M. brachyrhynchus* there are only about eighteen, separated by intervals equal to at least half the diameter of the alveoli themselves. Anteriorly the palatal plates of the maxillæ are thrust wedge-like between the premaxillæ. From this anterior angle they meet in a median suture as far back as the anterior angle of the palatines, which are interposed between them, increasing gradually in width from before backwards. The palatal surface of the maxilla immediately within the alveolar border is raised into a ridge which forms the outer border of a longitudinal groove which gradually increases in depth from before backwards. Posteriorly the grooves thus formed run into the notches between the median and lateral points of the anterior ends of the palatines. In this region the grooves become narrow and deep, and appear to have foramina opening into their roof. At first they

curve towards one another till they nearly meet in the middle line; they then diverge again and die away at about the level of the hinder end of the dental series; at their posterior end they may be represented by a row of foramina only. In *M. moreli* and *M. brachyrhynchus* they terminate a little in front of the anterior angle of the palatal vacuity. Along their median symphysis the palatine surface of the maxillæ is raised into a slight ridge, which in that region separates the grooves just described. Where the maxillæ are separated by the palatines, their palatal surface is gently concave from side to side and continues to be so as far as the palatine vacuities. The posterior prolongations of these bones form the outer border of the anterior portion of the openings just referred to and terminate about opposite their middle point; the alveoli are continued almost to the tip of these prolongations, the upper side of which is overlapped by the anterior end of the jugals which shut out the maxillæ from any share in the formation of the orbit.

The facial surface of the maxilla is strongly convex from side to side, and a section of the upper surface of the snout, in the region where the maxillæ meet in the middle

Text-fig. 56.



Skull of *Metriorhynchus superciliosum* from right side, the palatine portions of the skull being omitted.

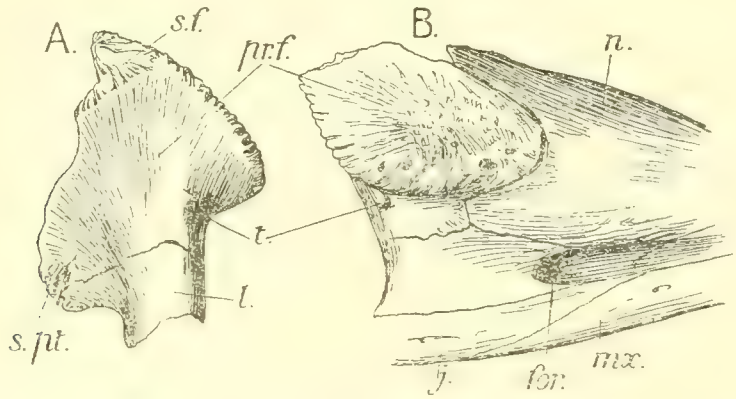
al.s., alisphenoid; *f.*, lachrymal foramen; *fr.*, frontal; *j.*, jugal; *l.*, lachrymal; *l.t.f.*, lateral temporal fossa; *mx.*, maxilla; *n.*, nasals; *nar.*, external nares; *par.*, parietal; *pmx.*, premaxilla; *po.f.*, postfrontal; *pr.f.*, prefrontal; *pr.o.*, pro-otic; *q.*, quadrate; *q.j.*, quadrato-jugal; *sq.*, squamosal.

dorsal line, makes a curve rather greater than a semicircle. This strong convexity of the snout is continued in the region of the nasals, but it is only in one or two specimens that this can be seen, for in nearly all cases the vertical crushing to which the skulls have been subjected completely distorts their form and obscures the relations of the bones to one another, especially in the neighbourhood of the orbits. The anterior parts of the facial portions of the maxillæ receive between them the facial processes of the premaxillæ, with which they unite in a suture of varying form. Behind this they may or may not meet in the mid-dorsal line to an extent differing in the different species, and even to some degree in different individuals of the same species. Posteriorly they are separated by the wedge-like nasals, and narrow gradually to their posterior end, which is occupied by a deep groove nearly parallel with the alveolar border and continued back to the deep notch on the anterior side of the lachrymal (*l.*),

with which bone the maxilla has at most a very short union, being separated from it to a large extent by the anterior end of the jugal.

The *nasals* (*n.*) are very large elements which take a great share in the formation of the upper surface of the rostrum. They meet in suture in the middle line, and in the uncrushed condition were strongly convex from side to side (text-figs. 56, 57); in some species (e. g. *M. superciliosum*) their posterior portion is considerably inflated. Anteriorly they narrow to a point and are thrust between the maxillæ to a varying degree, sometimes, as already noted, reaching the premaxillæ. At their posterior end they are separated from one another by the wedge-shaped end of the frontal, between which and the prefrontals they send back a process of varying form and length. Beneath the prefrontal they also send back a process, so that the anterior end of the prefrontal is fixed in a deep bay or notch on their hinder end. The lower border of the ventral prolongation unites below with the lachrymal in a straight suture. The

Text-fig. 57.



Portion of skull in front of the orbit in *Metriorhynchus* (?) *moreli*: A, front wall of orbit; B, side of skull in front of orbit. (R. 3900, ½ nat. size.)

for., lachrymal foramen; *j.*, jugal; *l.*, lachrymal; *mx.*, maxilla; *n.*, nasal; *pr.f.*, prefrontal; *s.f.*, suture for frontal; *s.pt.*, suture for union with palatine; *t.*, tubercle in groove in prefrontal.

surface of the nasals is sculptured to a degree varying in the different species: usually the sculpture in this region consists of longitudinal ridges which run into one another irregularly.

The *prefrontal* (*pr.f.*) is a large and solidly constructed bone which in nearly all specimens is so crushed as to appear merely as a flat plate overhanging the orbit. Actually it consists of two parts (text-fig. 57): (1) an upper portion which overhangs the orbit and has its dorsal surface sculptured in most species, and (2) a downwardly deflected region which helps to form the anterior wall of the orbit and bears a broad groove running forwards on to the face from the orbit. The inner border of the upper portion unites posteriorly with the frontal, anteriorly with the nasal; its anterior end,

as above described, being received into a deep bay in the hinder end of that bone. The outer free edge overhangs the orbit and varies in form in the different species; its posterior border usually bears a number of small irregular notches, while its outer border is thickened and passes down into the smooth ventral region. This latter unites below with a process of the nasal in front and with the lachrymal behind. The groove above mentioned as running from the orbit on to the face is partially blocked at the edge of the orbit by a small pointed process (text-fig. 57, *t.*), the function of which is not known. Behind this point the bone is curved sharply inwards to form the upper part of the anterior wall of the orbit, the ventral part being joined by the lachrymal. The ventral angle of the inner end of the prefrontal, together with the lachrymal, is produced downwards into a short process terminating in a sutural surface probably for union with the palatine (Pl. XIII. fig. 2, *pal.f.*).

The *lachrymal* (*l.*) is a solidly constructed bone which appears on the side of the face in front of the orbit, of which it forms the antero-ventral portion of the border and the lower part of the anterior wall (text-fig. 57). In front it unites with the nasal above and the jugal below; its anterior border bears a deep notch, at the bottom of which is a small foramen (*for.*). From this notch the deep groove on the maxilla runs forwards as described above, but it is not certain whether the maxilla has any direct union with the lachrymal, though probably such a junction does exist for a short distance at the hinder end of the groove. At the margin of the orbit the bone is curved sharply inwards to form the front wall of that cavity. Above, it joins the prefrontal, as above described, and its ventral inner angle is produced downwards with that bone and helps to form the sutural surface for union with the palatine (Pl. XIII. fig. 2). Below, its straight ventral border joins the jugal in a broad sutural surface.

The *frontals* (*fr.*) are represented by a single bone which never shows traces of a median suture. It consists of a broad interorbital region with a median and a pair of lateral posterior processes. The interorbital portion terminates anteriorly in a wedge-shaped process thrust between the posterior ends of the nasals; behind this it joins the postero-internal border of the prefrontals, behind which again it forms the posterior portion of the upper border of the orbit. The form and relations of the nasals, frontals, and prefrontals to one another are of great importance in separating the various species, as will be seen below. The lateral processes run outwards, downwards, and backwards, overlapping the anterior end of the postfrontals (*po.f.*) and terminating in a point. The median process forms the anterior half of the ridge between the temporal fossæ, joining the parietal crest behind in a complex suture; the width of the upper surface of this median process differs in the different species, and it may, or may not, bear sculpture. In the angle between the postorbital process of the frontal and the median process a thin plate of bone, constituted by the lower edge of the frontal and the posterior edge of the postfrontal, forms a floor to the antero-internal portion of the supratemporal fossa (text-fig. 55).

The united *parietals* (*par.*) form the posterior portion of the crest between the temporal fossæ, and anteriorly they are overlapped to a considerable extent by the frontals; the portion of the sagittal ridge formed by the parietals is usually much narrower than the frontal portion, and may have a groove along its summit. Posteriorly, the bone widens out and its dorsal surface usually forms a small triangular area. The occipital surface is nearly vertical with a strong median ridge. The lower edges unite with the nearly transverse upper border of the supraoccipital, except for a short distance on either side, where a pair of foramina separate the bones. Laterally, the parietals slope away and are prolonged outwards into a pair of processes which overlie the upper surface of the inner arm of the squamosals (*sq.*) and extend some distance down into the temporal fossæ.

In the cranial region the parietals unite in front with the alisphenoid (*al.s.*) and behind with the pro-otic (*pr.o.*), which is separated from the alisphenoid by a nearly vertical suture. At the point of union of the squamosal, parietal, and pro-otic there is a foramen from which a groove runs out on the posterior wall of the temporal fossa, terminating in another foramen between the squamosal and probably the quadrate; these foramina probably transmitted a blood-vessel.

The *alisphenoid* (*al.s.*, text-figs. 55, 56), as already noted, unites above with the parietal, the suture with which is slightly convex upwards. At its anterior end the alisphenoid seems to be continued as a narrow strip along the edge of that part of the parietal which in the crushed skulls seems to help in forming the floor of the anterior part of the temporal fossa; in the natural condition this portion of the parietal and alisphenoid would probably slope more downwards and outwards, forming the upper part of the side walls of the cranium. Posteriorly, the alisphenoid joins the pro-otic (*pr.o.*) in a straight suture, running nearly vertically downwards to the foramen for the fifth nerve, the upper edge of which is formed by a notch on the lower border of the alisphenoid and pro-otic at their junction with one another; this foramen may have been closed below by the inner extension of the quadrate.

The bone which is here regarded as the *pro-otic* (text-fig. 55, *pr.o.*) unites above with the parietal and posteriorly forms the lower border of the vascular foramen, the upper edge of which is formed by the squamosal and parietal; behind the foramen there is a short union with the squamosal. Its lower border at its junction with the alisphenoid is notched by the foramen for the fifth nerve, as described above; behind this it unites with the inner extension of the quadrate (*q.*).

The *squamosal* (*sq.*) is an **L**-shaped bone consisting of a stout anterior process uniting with the postfrontal (postorbital) and an inwardly directed process uniting below with the quadrate and exoccipital and overlapped at its inner end by the lateral process of the parietal; below, it forms part of the border of the vascular foramen mentioned, and has a short union with the pro-otic. The inner faces of the two arms of the

squamosal pass into one another by a sharp curve, which forms the postero-external angle of the supratemporal fossa.

The *postfrontal* (*po.f.*) forms the greater part of the postorbital bar, separating the orbit from the supratemporal fossa and forming an incomplete postorbital wall. At its upper end it is overlapped by the lateral process of the frontal in a V-shaped suture, and in this region its posterior edge helps to form a floor to the front part of the supratemporal fossa, as described above, uniting with the corresponding plate of the frontal and apparently also with the anterior prolongation of the alisphenoid. The outer face of the anterior part of the bone in many species is sculptured like the prefrontal. Posteriorly it is smooth, and overlaps the zygomatic process of the squamosal in a long oblique suture. Immediately behind the orbital part of its border it is produced down into an angular process which unites with a corresponding process on the upper edge of the jugal, thus closing the lateral temporal fossa in front.

The *quadrate* (*q.*) is a massive bone very firmly fixed among the adjacent elements. It consists of an articular region which is directed downwards, outwards, and backwards and terminates in the condylar surface for the mandible. This surface consists of two convexities, separated by a deep groove running obliquely inwards and forwards from about the middle of the posterior border. The outer edge immediately above the outer condyle bears an elongated oval surface for union with the posterior end of the quadrato-jugal. Above this the outer edge is prolonged obliquely forwards and upwards to the squamosal, along the lower edge of which it extends forwards so as to form a short union with the postfrontal. It also sends back along the ventral face of the squamosal a process which makes an acute angle with the ascending process; the angle forms the anterior border of the external auditory opening. The body of the quadrate is prolonged inwards towards the cranial surface of the skull, uniting with the squamosal and epiotic above and probably with the pterygoid at its inner end. It seems to have formed the lower edge of the aperture for the fifth nerve. On its hinder face it is extensively overlapped by the lateral wings of the exoccipital.

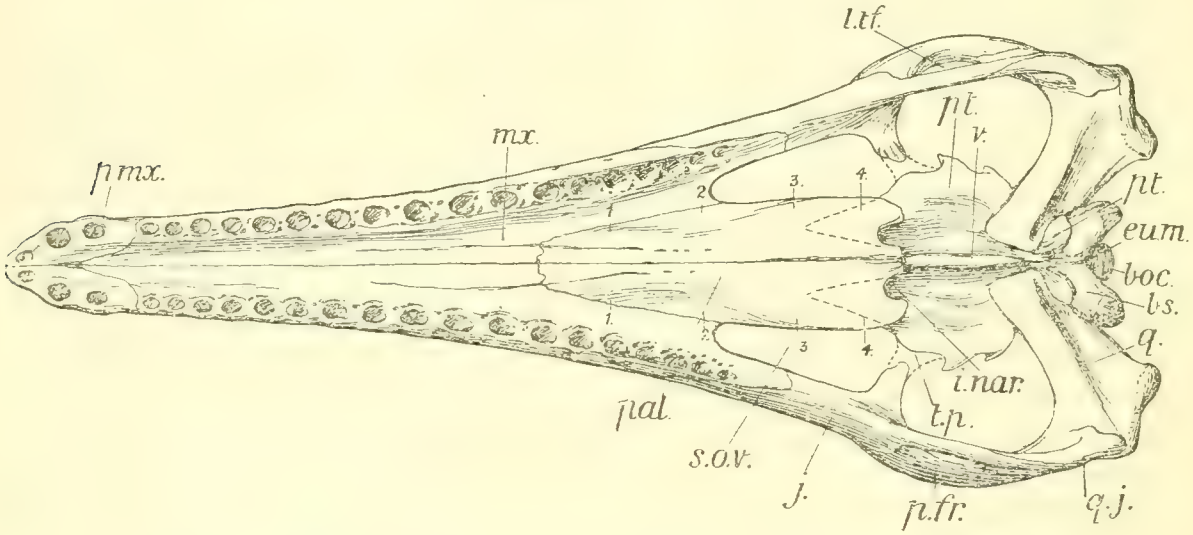
The *quadrato-jugal* (*q.j.*) is a small bone which unites with the outer edge of the lower end of the quadrate by means of an expansion bearing an oval sutural surface. From this a short process runs forwards and is overlapped by the hinder end of the jugal; it forms the postero-inferior angle of the lateral temporal fossa.

The *jugal* (*j.*) is a long slender bone. At its anterior end it terminates in a point which is thrust between the hinder end of the maxilla below and the lachrymal above, the union with the latter being a strong straight suture. Behind this it forms the suborbital bar, which is triangular in section and sometimes sculptured on its outer face. On its inner face in this region there is a narrow palatal plate which terminates posteriorly in a strong inwardly directed process ending in a sutural surface, with which no doubt the transpalatine unites, though unfortunately all the specimens are

incomplete in this region. Behind the orbit the bone is widened by the presence of a prominence on its upper border, by means of which it unites with the postfrontal. Behind this it becomes round and narrows, terminating posteriorly in a point which overlaps the anterior end of the quadrato-jugal, thus enclosing the lateral temporal fossa below.

The palatine region of the skull (Pl. XII. fig. 2; text-fig. 58) is in nearly all cases more or less completely destroyed by the crushing to which it has been subjected. In two specimens, however, of *M. brachyrhynchus* (Leeds Coll. 164–165, R. 3699–3700), this part of the skull is fairly well preserved and has been described in detail by Mr. E. Thurlow Leeds (Quart. Journ. Geol. Soc. vol. lxiv. (1908) p. 345), upon whose work the following account is for the most part founded, the same two skulls being described.

Text-fig. 58.



Semi-diagrammatic figure of the palatal surface of the skull of *Metriorhynchus brachyrhynchus*; partly after E. Thurlow Leeds. (About $\frac{1}{5}$ nat. size.)

boc., basioccipital; *bs.*, basisphenoid; *eu.m.*, median eustachian opening; *i.nar.*, internal narial opening; *j.*, jugal; *l.t.f.*, lateral temporal fossa; *mx.*, maxilla; *pal.*, palatine; *p.fr.*, postfrontal; *pmx.*, premaxilla; *pt.*, pterygoid; *q.*, quadrate; *q.j.*, quadrato-jugal; *s.o.v.*, suborbital vacuity; *t.p.*, transpalatine (restored); *v.*, vomer (parasphenoid); 1, 2, 3, 4, these figures mark the levels at which are taken the sections shown with the corresponding numbers in the next figure (text-fig. 59).

Other specimens in which the palate is fairly preserved are the skull of a large individual referred to *M. superciliosum* (R. 3016) and that of a young specimen of *M. durobrivense* (R. 2618) in which the vomer (parasphenoid) is particularly well shown.

The *palatines* (*pal.*) unite in front with the maxillæ in a suture which may be nearly transverse (*M. brachyrhynchus*), but usually forms a median point meeting its fellow in the middle line, and a lateral process projecting beyond the last, from which it is separated by a notch which marks the course of the deep groove described above

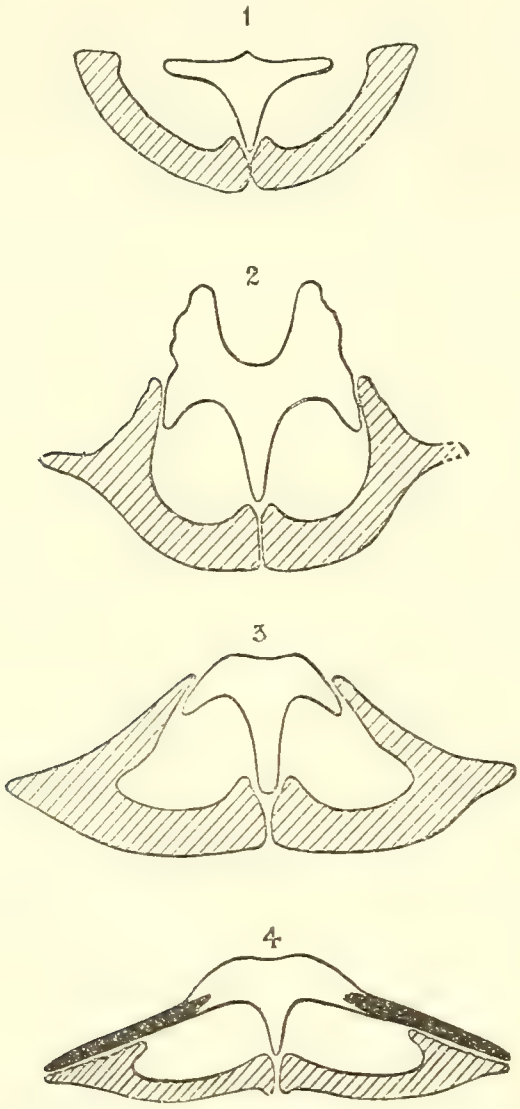
as running from the maxilla on to the palatine. Behind this the palatine unites for some distance with the maxilla, then, separating from it, forms the inner border of the suborbital vacuity. It widens out a little towards its posterior end, which terminates in an outer longer process and a shorter median one which unites in the middle line with its fellow of the opposite side, projecting backwards from the ventral border of the narial opening, which is thus divided into right and left halves. In specimens figured by Deslongchamps* the ventral border of the narial opening is shown as pointed anteriorly, the palatines being separated posteriorly by a notch: this is not the case with the specimens here described. Anteriorly the upper surface of each palatine is deeply grooved for the floor of the narial canal, which is separated from its fellow of the opposite side by the vertical plate of the vomer (text-fig. 59, 1). A little further back there rises from the upper edge of the palatine a dorsal plate (text-fig. 59, 2, 3) sloping up to the vomer, which it overlaps, completing the nasal canals superiorly; the dorsal plate is concave from side to side. At about the middle of the palatine the narial canals seem to have curved inwards and the dorsal plate of the palatine is thickened and united above with the downwardly directed process of the prefrontal and lachrymal. As Mr. Leeds has pointed out, the ventral process of the prefrontal in modern Crocodiles unites with the palatine and pterygoid at the anterior end of the latter and considerably behind the small vomer.

The bone described by Mr. Leeds as the *vomer* (*v.*) is a large median element without, as he pointed out, any trace of division into two lateral halves, a circumstance which, taken together with the fact that it extends back to and unites with the ventral face of the basisphenoid, makes it very probable that this element should rather be regarded as a parasphenoid, the bones which are called vomers in the recent crocodiles being absent, or at least not yet certainly recognised. At its anterior end the bone is T-shaped in section, the vertical arm resting on the line of union of the palatines (text-fig. 59, 1) and forming a median wall between the nasal canals; the upper surface is grooved, the lateral arms of the T curving upwards to an increasing extent as they are followed backwards, till opposite about the middle point of the palatines they enclose a deep channel, and at the same time are considerably thickened (text-fig. 59, 2). The upper edges of the dorsal plates of the palatines rest against the outer part of the lower edge of these thickened arms of the T, which further back still, curve downwards, the median groove disappearing (text-fig. 59, 3). Posteriorly the dorsal plates of the palatines diverge from the vomer (text-fig. 59, 4), the roof of the narial canal being completed by the anterior ends of the pterygoids. Behind this the vomer narrows and is prolonged backwards between the pterygoids on the roof of the narial opening, where it forms a median ridge. A similar ridge occurs on the roof of the narial opening in a skull of *Mystriosaurus* from the Lias of Whitby, but it is not clear

* Notes Paléontologiques, pl. xx.

whether this is formed by a median parasphenoid element or by the elevation of the pterygoids along a median line of symphysis. Mr. Leeds points out that Deslongchamps figures a similar ridge in *Pelagosaurus*, but it does not seem to be present in *Steneosaurus*. At its hinder end the vomer (parasphenoid) is concealed ventrally

Text-fig. 59.



Sections across the nasal canals of *Metriorhynchus brachyrhynchus* at the various levels marked 1–4 on text-fig. 58. The vomer (parasphenoid) is left blank, the palatines are shaded, and the pterygoids are shown in black. (R. 3700, nat. size.) (After E. Thurlow Leeds, Quart. Journ. Geol. Soc. vol. lxiv. (1908) p. 354, fig. 2.)

by the overlap of the pterygoids meeting in the middle line (text-fig. 58), while dorsally it seems to have fused with the lower face of the basisphenoid, which

terminates abruptly in front. The whole form and relations of this bone seem to show that it is actually the parasphenoid (vomer of Broom), while the paired elements usually called vomers in reptiles (pre-vomers of Broom) are either absent or small.

The *pterygoids* (*pt.*, text-fig. 58) are usually greatly crushed, so that their relations to the surrounding bones are rarely clear. Posteriorly they unite in the middle line beneath the basisphenoid (and ? parasphenoid), their posterior border forming a curved ridge which runs up on the side of the basis cranii to the point at the base of the lateral processes of the basioccipital where they join the downward processes of the exoccipitals. Laterally this posterior portion of the pterygoid seems to be overlapped by the inner prolongation of the quadrate, which extends inwards nearly to the middle line. In front of their median union the pterygoids are separated in the middle line by the vomer (parasphenoid), which, as above noted, forms a median ridge along the concave roof of the nasal fossa. In the region of this fossa the bones widen out considerably, and their ventral surfaces form shallow concave pterygoid fossæ; their outer border is convex with two or three tooth-like projections directed forwards, while towards the hinder end of this border there is a surface for a squamous suture with the transpalatine (*t.p.*), which seems to have been very small, but in no case is preserved. In front of the level of the ventral border of the internal narial openings the pterygoids run off into thin triangular processes, which overlap the vomer and the palatines, forming the roof to the posterior part of the nasal canals (text-fig. 59, 4). Anteriorly they terminate in points at about the level of the middle of the suborbital vacuity.

In its general form the occipital surface (Pl. XIII. fig. 3) in the uncrushed skull is a triangle, of which the base (width between the outer angles of the quadrates) is rather more than twice the height (from lower border of the occipital condyle to the summit of the parietal crest); but in nearly all cases the crushing undergone has completely destroyed this form, the foramen magnum, as a rule, being almost completely obliterated.

The *basioccipital* (*boc.*) forms the whole of the occipital condyle, except a small portion of the upper outer border, which is borne on the exoccipitals. The upper surface of the condyle between the exoccipitals is flat or gently concave, but the remainder is nearly evenly rounded, its transverse diameter being slightly longer than the vertical; there is a pit in the middle of the convexity. Ventrally the condyle is sharply delimited by a short neck. In front of this the sides of the bone are produced downwards and outwards into the large lateral tuberosities which are separated by a deep fossa, at the anterior end of which is the median eustachian opening (*eu.m.*). This is bounded in front by the hinder edge of the basisphenoid (*bs.*), which no doubt it penetrated. The outer sides of the lateral tuberosities are formed by a thin downwardly directed process of the exoccipitals; their extremities are much roughened.

The *exoccipitals* (*ex.o.*) are large and complicated bones. They meet above the foramen magnum, from which they thus exclude the supraoccipital. Below they unite with the basioccipital, forming a small part of the rim of the occipital condyle and the outer face of the downwardly directed lateral processes. External to these there is a notch from which a short groove runs upwards and inwards, terminating in the large carotid foramen, which is thus more on the hinder face of the bone than in *Steneosaurus*; it is probable that this foramen also transmitted the vagus group of nerves. External to the notch the lateral wing of the exoccipital unites closely with the hinder face of the quadrate. Above this is a deep groove passing at its outer end into a foramen and marking off the prominent paroccipital ridge, the upper edge of which joins the parietal and squamosal, forming the hinder face of the post-temporal bar. The outer end of the paroccipital bar is very prominent and terminates in a roughened surface.

The *supraoccipital* (*s.oc.*) is a small bone, which, as above noted, is completely excluded from the foramen magnum by the exoccipitals. Its suture with the parietals is nearly straight and is interrupted at its outer ends by a pair of foramina which run in between the two bones. From these openings the lateral sutures with the exoccipitals run downwards and inwards to the short and nearly straight inferior border of the bone.

The foramina in the occipital region are probably as follows:—(1) the carotid opening referred to above, through which the vagus group of nerves probably also passed (Pl. XIII. fig. 3, *car.* & X?); (2) a small opening near the lower part of the border of the foramen magnum, presumably for the hypoglossal (XII) nerve; (3) a large foramen at the bottom of the groove separating the paroccipital process of the exoccipital from the part uniting with the quadrate, probably for the facial (VII) nerve—its anterior edge may be formed by the quadrate. There are also two or three small openings in the exoccipital external to, but about on the same level with, the hypoglossal opening, but their nature is unknown.

The *basisphenoid* (*bs.*, text-fig. 58) unites posteriorly with the basioccipital; on the ventral surface its posterior border forms a thin sharp ridge constituting the anterior wall of the fossa, at the bottom of which is the median eustachian opening. Laterally it unites with the anterior face of the ventro-lateral processes of the basioccipital. In the mid-ventral line there is a strong cristiform ridge, upon the anterior end of which converge two curved ridges which mark the line of union with the posterior ends of the pterygoids. These bones unite with one another beneath the basisphenoid for some distance, but seem to have been separated in front by the posterior end of the vomer (parasphenoid), which unites with the anterior portion of the ventral face of the basisphenoid, and this bone terminates abruptly in front in a vertical surface.

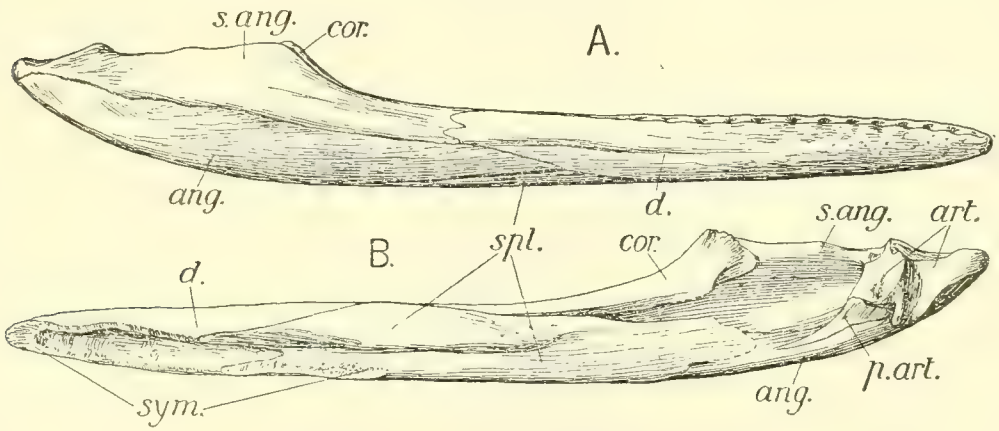
The *sclerotic plates*, which are known to have been present in members of this family, are very rarely found, only two or three plates, belonging to two individuals,

being preserved. The plates unite with one another in a complex interlocking suture; they are thickest on their inner edge, which, like the outer, is irregularly serrated; the number of plates in each eye is not known.

Mandible (Pl. XI. fig. 3; text-fig. 60).—The mandible in *Metriorhynchus* is very similar in its general structure to that of *Steneosaurus*, but is distinguished from it by the want of any expansion of the anterior end and by the absence of any lateral vacuity.

The *dentaries* (*d.*) are very large elements. Anteriorly they unite in a symphysis (*sym.*) to an extent which varies in the different species; in the hinder part of the symphysis they are separated by the wedge-like anterior ends of the splenials (*spl.*), which are thrust between them to a varying extent. The ventral surface of the symphysis is evenly convex from side to side, and is usually more or less sculptured by numerous grooves and pits; one groove with vascular pits at intervals, running a little below

Text-fig. 60.



Mandible of *Metriorhynchus cultridens*: A, from outer side; B, from inner side. (R. 3804, $\frac{1}{6}$ nat. size.)
ang., angular; *art.*, articular; *cor.*, coronoid; *d.*, dentary; *p.art.*, prearticular; *s.ang.*, surangular; *spl.*, splenial; *sym.*, symphysis.

the alveolar border, is particularly well marked, especially on the hinder part of the dentary, behind which it is continued along the line of suture between the angular and surangular elements. The oral (upper) surface is smooth and slopes down to the middle line from the ridge which forms the inner border of the row of alveoli. The number and arrangement of these vary greatly in the different species. Posteriorly, as already noted, the inner face of the dentary is overlapped by the outer side of the splenial, while externally it tapers away, lying in a depression in the anterior ends of the angular and surangular. For a short distance along its upper edge it is in some cases overlapped by the anterior end of the coronoid.

The *splenials* (*spl.*) form a median symphysis with one another in front; behind this their inner face is strongly convex from above downwards, and they are much thickened.

Towards their posterior end they thin away, but the exact form of this end is not known. On the outer surface they unite with the dentary, and at their posterior end are overlapped by the anterior prolongations of the surangular and angular (*ang.*). They extend beneath the latter for some distance anteriorly, forming the ventral border of the ramus. On their upper edge they bear a narrow groove which lodges the slender anterior prolongation of the coronoid (*cor.*); the outer margin of this groove is formed mainly by the upper edge of the surangular, but sometimes for a short distance in front the dentary shares in its formation.

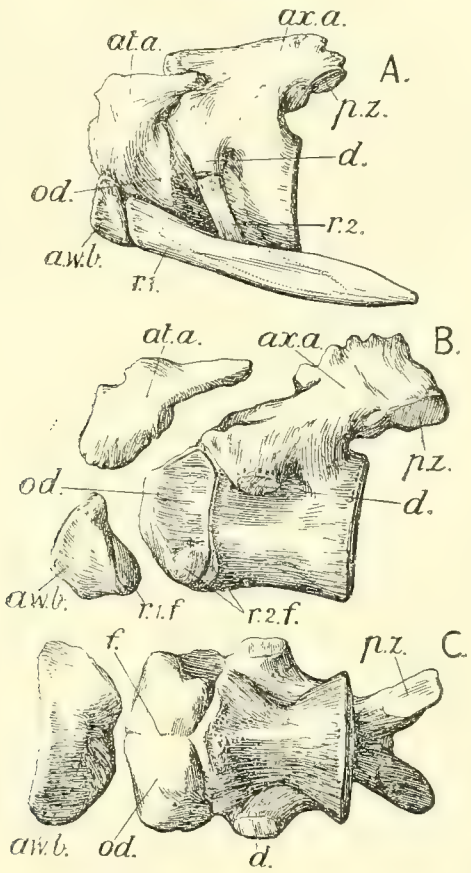
The *angular* (*ang.*) and *surangular* (*s.ang.*), which form the greater part of the ramus, unite with one another on the outer side of the jaw in an overlapping suture, which is not interrupted by any lateral vacuity. Anteriorly, as already noted, they are overlapped externally by the hinder end of the dentary, and on the inner side unite with the splenial, with which they enclose a large dental canal. At its hinder end the angular is prolonged backwards to the end of the postarticular process, and its upper edge unites with the articular to about the level of the hinder border of the articular surface, in front of which the two are separated by a small intercalated bone, apparently a *prearticular* (*p.art.*, dermo-articular of Kingsley), which, so far as I am aware, has not been previously recorded in Crocodiles. This element is confined to the inner face of the jaw; it unites above and on its outer side with the edge of the inner lobe of that part of the articular which bears the surface for the quadrate; thence it sends downwards and forwards, along a deep groove on the inner face of the angular, a slender process which in no specimen is complete anteriorly, but which probably reached the posterior end of the splenial. Posteriorly the bone appears as a short pointed process between the articular and angular.

The *surangular* (*s.ang.*) extends backwards nearly to the end of the postarticular process, uniting closely with the articular above. In front of this its upper border is thickened and rounded, running nearly horizontally forwards to the coronoid angle, where it curves sharply down, the bone narrowing gradually to its anterior end. On the inner edge of its upper border in this region lies the peculiar *coronoid* (*cor.*). This bone, which forms the summit of the coronoid angle, where it is considerably expanded, passes anteriorly into a long slender process along the upper border of the jaw, resting in a groove between the upper edges of the splenial and surangular; anteriorly it may reach the dentary and for a short distance border upon the inner side of the tooth-sockets. From the coronoid angle to its hinder extremity the inner surface of the bone bears a roughened surface for muscle-attachment. In recent Crocodiles the coronoid helps to form the coronoid angle and in that region resembles the same bone in *Metriorhynchus*; but beyond this the resemblance ceases, for, instead of being prolonged forwards in the manner above described, it spreads downwards, overlapping the inner face of the splenial in front,

while below it joins a process of the angular, forming with that bone the inner border of the widely open dental canal.

The *articular* (*art.*) is a massive bone. The surface for the quadrate consists of two concavities separated by a low oblique ridge: on the outer side the articular surface is completed by a thickening of the surangular; on the inner side, a little behind the articular surface, the border is produced inwards into a prominent process terminating

Text-fig. 61.



Atlas and axis of *Metriorhynchus*: A, atlas and axis of (?) *M. superciliosum*, with ribs, from left side (Leeds Coll., ½ nat. size); B, atlas and axis of *M. cultridens*, from left side; C, ditto from below (R. 3804, ½ nat. size).

at.a., arch of atlas; *a.w.b.*, anterior wedge-bone; *ax.a.*, arch of axis; *d.*, diapophysis; *f.*, median furrow in odontoid; *od.*, odontoid; *p.z.*, posterior zygapophysis; *r.*1., rib of atlas; *r.*2., rib of axis; *r.*1.*f.*, facet for first rib; *r.*2.*f.*, facet for second rib.

in a rugose surface. Behind this the bone narrows to the postarticular angle; in this region the upper surface is gently concave on each side of a low longitudinal convexity.

On the inner side the articular is supported by the angular and by the prearticular, which covers its inner face; externally it unites with the surangular.

Vertebral Column (text-figs. 61–66).—In general structure the atlas and axis of *Metriorhynchus* (text-fig. 61) are very similar to those of *Steneosaurus*, but differ in certain points to be noted below. These vertebræ have been described in detail by several writers (Hulke *, Jaekel †, Arthaber ‡, and others).

The first subvertebral wedge-bone (*a.w.b.*) (hypocentrum of atlas) forms the lower portion of the cup for the occipital condyle, extending up to about the middle of the sides, where its upper angles articulate with the lower ends of the bases of the neural arch. Posteriorly it unites with the obliquely truncated lower border of the odontoid (*od.*, centrum of atlas). The lateral borders are truncated by a pair of elongated facets, looking outwards, downwards, and backwards, for union with the head of the first rib. The two halves of the neural arch (*at.a.*) do not seem to have united in the middle line, and in no specimen is a proatlas preserved, although that structure was no doubt present. Each half of the arch is produced backwards into a prominent posterior zygapophysis for union with the arch of the axis. Ventrally the enlarged bases of the arch unite with a broad surface of the odontoid, extending backwards to the anterior edge of the axis. Anteriorly they form the superior lateral portions of the atlantal cup. On the sides of these basal portions of the neural arch of the atlas there are, in a few cases, well-marked diapophysial prominences. This is especially well shown in an atlas and axis (R. 2054) figured by Hulke (Proc. Zool. Soc. 1888, pl. xviii. fig. 1). At the same time the proximal end of the first rib shows no trace of division into head and tubercle. Perhaps, as in the case of the rib of the axis in *Steneosaurus*, the tubercle was represented by a ligament joining the diapophysis. The partial persistence of the diapophysis in the atlas probably indicates that the rib was originally double-headed.

The *odontoid* (*od.*), which in adults is fused with the axis, presents some peculiar features. On its ventral side it is divided by a median groove into two lateral prominences; the groove (*f.*) is continued up the anterior face of the bone to about its middle point. Probably this groove represents the suture described by Jaekel (*loc. cit.*) as occurring in the odontoid of *M. jaekeli* (? *M. superciliosum*), and may indicate that the odontoid was originally a paired structure—that is to say, according to the view here adopted, is formed by the union of the pleurocentra of the first vertebra. Anteriorly the odontoid forms the middle and upper part of the atlantal cup; above it is gently concave from side to side, forming the floor of the neural canal. Laterally it is largely

* Proc. Zool. Soc. 1888, p. 418.

† Zeitschr. deutsch. geol. Gesellsch. vol. lvi. (1904) p. 109.

‡ Beitr. Paläont. Oesterr.-Ung. vol. xix. (1906) p. 295; in this paper a summary of the various views as to the nature of these vertebræ is given.

hidden by the overlap of the bases of the neural arch and by the anterior wedge-bone. At its postero-inferior angle there is a rounded prominence which, with a corresponding projection on the centrum of the axis, bears the articular surface for the head of the second rib. Posteriorly it ends in a nearly flat vertical surface which, in the adult, fuses with the centrum of the axis.

The atlas of *Geosaurus*, as described and figured by Fraas *, differs in a remarkable degree from that of *Metriorhynchus*, the anterior subvertebral wedge-bone having apparently lost its wedge-shape and forming, as it were, the lower half of a short centrum bearing on its sides facets for the first pair of ribs, the odontoid being much reduced. The specimens, however, are described as being unsatisfactorily preserved in this region, so probably the differences are more apparent than real.

The centrum of the *axis* (text-fig. 61) resembles that of the succeeding cervicals in its general form, but differs in fusing with the odontoid in front and in bearing at its antero-ventral angle a prominence which helps to form the surface for the head of its rib. In its middle portion the centrum is somewhat constricted, and its ventral surface bears a rounded ridge which is much roughened at its ends. The posterior face is gently concave and nearly circular in outline, there being only a slight flattening beneath the neural canal. The neural arch (*ax.a.*) is large, and above bears an elongated neural spine which slopes up gradually from its anterior end, the summit being, as a rule, much roughened. Anteriorly, on the sides of the arch are the zygapophysial facets for union with the zygapophyses of the atlas. The posterior zygapophyses (*p.z.*) are of the normal form; they are oval in outline and project considerably beyond the centrum. The pedicles of the arch unite with the whole length of the centrum, and anteriorly may even extend a little on to the odontoid. Near the base of the sides of the arch is a pair of prominent diapophyses (*d.*) for the tubercle of the rib, which is here bifurcated. In *Steneosaurus* this diapophysis is scarcely at all developed, and the only indication of the forking of the rib is a slight prominence on its upper edge (text-fig. 39 B, p. 103).

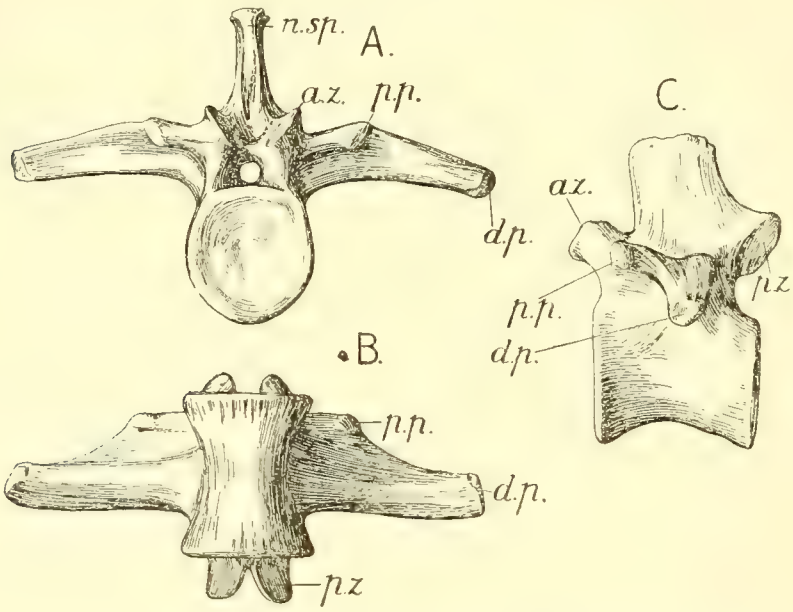
In none of the skeletons examined are there more than five cervical vertebræ behind the atlas and axis, regarding as cervicals the vertebræ in which the parapophysis is borne entirely on the centrum. If this rule be adopted, then in the *Metriorhynchus* skeleton described by Arthaber †, the two vertebræ which he calls the first and second dorsals would be cervicals, making seven in all behind the axis. It seems very unlikely that this is correct, and some vertebræ belonging to another individual have probably been included. Nevertheless, it may be pointed out that in *Steneosaurus* there were at least seven postaxial cervicals, and it is possible that, as Fraas has suggested, the shortening of the neck in *Metriorhynchus* is one of the consequences of its more extreme adaptation to a purely pelagic life.

* Palæontographica, vol. xlix. (1902) p. 49, pl. vii. fig. 5.

† Beitr. Paläont. Oesterr.-Ung. vol. xix. (1906) p. 294.

In the postaxial cervicals the articular ends of the centra are moderately deeply concave, and in uncrushed specimens their vertical diameter is a little greater than the transverse; beneath the neural canal the upper border is flattened. The sides of the centrum are concave both from before backwards and from above downwards; the anterior and posterior borders are usually raised into a series of fine rugosities. The ventral face is concave longitudinally and between the bases of the parapophyses from side to side also, but behind these it is convex. The parapophyses, except in the last, are situated near the front of the centrum and very low down, so that a line joining the lower borders of the opposite parapophyses will pass beneath the centrum. The parapophyses are very short—shorter, indeed, than in *Steneosaurus*—and at their outer

Text-fig. 62.



Dorsal vertebra of *Metriorhynchus moreli*: A, from front; B, from below; C, from left side. (R. 2054, ½ nat. size.)

a.z., anterior zygapophysis; *d.p.*, diapophysial process; *n.sp.*, neural spine; *p.p.*, parapophysial process; *p.z.*, posterior zygapophysis.

end they bear an articular surface, elongated in a horizontal direction. In the last cervical the parapophysis passes up on to the side of the centrum, forming a strong prominence immediately beneath the neuro-central suture. In the next vertebra, here spoken of as the first dorsal, the parapophysis passes wholly or partly on to the neural arch, but still arises quite separately from the diapophysis.

The pedicles of the neural arch in the cervical vertebræ unite with the whole length of the centrum. Just above the neuro-central suture and about midway between the anterior and posterior ends they bear the prominent diapophyses, which increase in

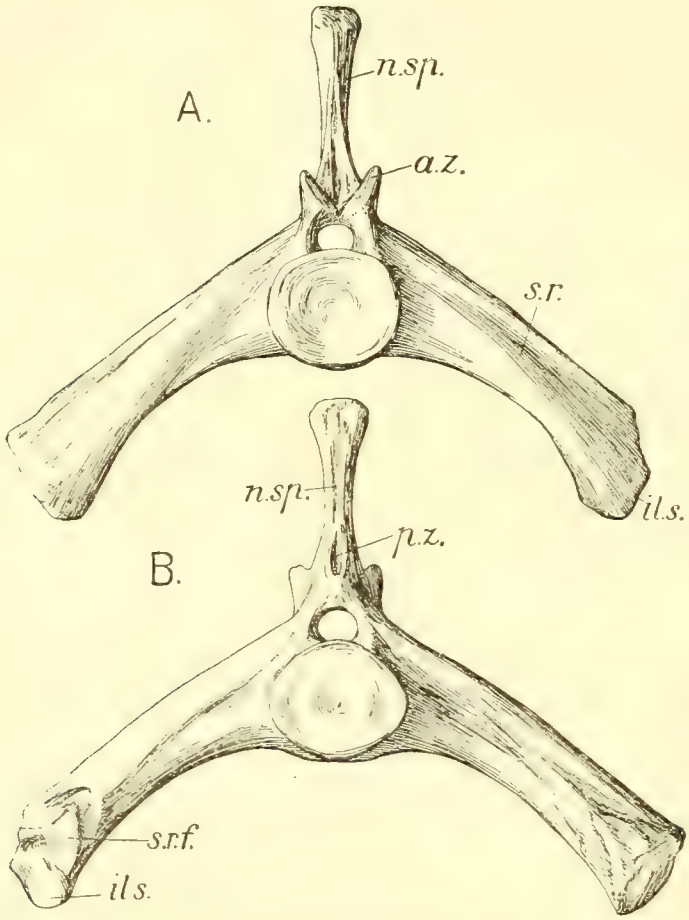
length as they pass back in the series ; they are compressed from above downwards, terminate in an oval facet, and are directed downwards to a varying degree. The zygapophyses are large, with flat oval surfaces. The neural spines increase in length from before backwards ; they are nearly vertical and are somewhat thickened at the upper end, especially towards the posterior side.

The exact number of dorsal (text-fig. 62) and caudal (text-figs. 65, 66) vertebræ is doubtful, there being much uncertainty as to the completeness of the specimens preserved. The greatest number of rib-bearing dorsals preserved in any skeleton is seventeen, and there were probably one or two lumbars. Fraas, in *Geosaurus*, finds that there were sixteen dorsals and two lumbars, a number which is adopted by Arthaber for *Metriorhynchus*; probably there were sixteen or seventeen rib-bearing dorsals and one or two lumbars. In recent Crocodiles it is usual to regard as the first dorsal the first vertebra of which the rib joins the sternum, but in these fossil forms, in the absence of the sternum, this distinction is not possible ; therefore the first dorsal is considered to be that vertebra in which the parapophysis is wholly or partly borne on the neural arch, although in modern types this does not occur till some distance back in the dorsal series. In fact, it is not possible to distinguish clearly the different regions of the presacral portion of the column. The centrum of the first dorsal (according to the above definition) differs little in form from that of the last cervical, except that the parapophyses have passed up on to the neural arch. Further back in the series the centra become more elongated and cylindrical, and are more constricted in the middle. In uncrushed specimens there is no keel on the mid-ventral line, but in compressed specimens such a ridge is frequently present. The articular ends are gently concave and the vertical diameter is a little greater than the transverse ; there is a slight flattening beneath the neural canal.

The neural arch unites with the centrum by broad pedicles, which, however, in the hinder part of the series at least, do not extend to the posterior end of the centrum. In the first dorsal the pedicle of the arch bears near its antero-ventral angle a blunt parapophysial prominence, above and, for the most part, behind which arises the strong transverse process, the outer end of which bears the surface for the tubercle of the rib. In this vertebra the transverse process is little compressed from above downwards, but further back in the series this compression increases and the process widens, its anterior edge being thin, the posterior thickened and grooved, at least near the base. The parapophysis in a few of the dorsals behind the first may form a distinct rounded process, rising from the anterior border of the base of the transverse process (*e. g.*, in the small many-toothed species, *M. læve*), or it may merely form a step-like prominence on the anterior border of the process. As it is followed backwards in the series, this step does not appear to pass outwards towards the diapophysial surface of the end of the process as in *Steneosaurus*, but, on the other hand, the diapophysial surface, by the shortening of the process, to some extent approaches the parapophysis.

The zygapophyses are very strongly developed and separated from one another in the middle line by a deep fossa; the articular surface of the anterior zygapophysis is slightly convex, the posterior correspondingly concave. The anterior processes project a little beyond the centrum, the posterior rather further, at least in uncrushed specimens. The neural spines slope a little forwards and are much thickened at their upper end, which is roughened and may be longitudinally grooved. It seems possible that some kind of ridge-like dorsal fin was present; on the anterior border of the neural spine

Text-fig. 63.



First sacral vertebra of *Metriorhynchus moreli*: A, from front; B, from behind. (R. 2504, ½ nat. size.) *a.z.*, anterior zygapophysis; *il.s.*, surface for ilium; *n.sp.*, neural spine; *p.z.*, posterior zygapophysis; *s.r.*, sacral rib; *s.r.f.*, facet for rib of second sacral.

is a roughened surface for the attachment of a ligament. The lumbar vertebræ differ only from the dorsals in the absence of rib-facets on the transverse process.

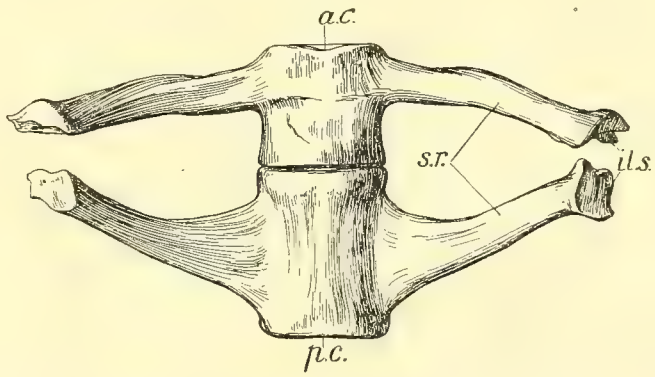
The two sacrals (text-figs. 63, 64) in general form resemble those of *Steneosaurus*. In the first (text fig. 63) the anterior articular surface is gently concave and nearly

circular in outline; a very small portion of its upper lateral borders is formed by the bases of the neural arch. The posterior surface is slightly concave and somewhat oval in outline. Ventrally the centrum is strongly concave from before backwards and convex from side to side, there being a blunt longitudinal ridge. The centrum of the second sacral is very similar.

The neural arch bears a high spine (*n.sp.*) much thickened at the summit; ventrally it unites with facets occupying the anterior two-thirds of the centrum, and also with the upper surface of the inner end of the sacral rib, apparently sending out a process along the dorsal surface of the latter, as in *Steneosaurus* and *Mycterosuchus* (text-fig. 51). The zygapophyses are well developed in both sacrals.

The *sacral ribs* (*s.r.*, text-figs. 63, 64) differ from those of *Steneosaurus* in being more slender and in curving downwards to a greater extent, so that their outer ends are considerably below the level of the ventral face of the vertebral centra. At their inner ends they unite with the bases of the neural arches and the sides of the centra; externally

Text-fig. 64.



Sacral vertebræ of *Metriorhynchus moreli*, from below. (R. 2504, ½ nat. size.)

a.c., anterior face of sacrum; *il.s.*, surface for ilium; *p.c.*, posterior face of sacrum; *s.r.*, sacral ribs.

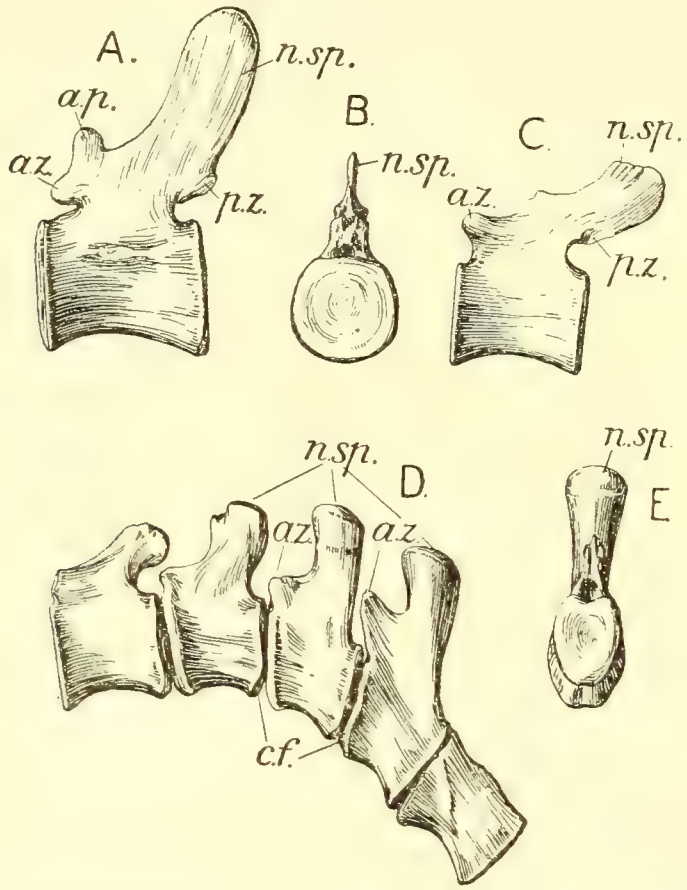
(The centrum of the first sacral vertebra has been shortened through crushing.)

the ends of the two ribs meet in a small triangular surface and, for union with the ilium, bear concave facets, which look outwards and downwards.

The *caudal* series (text-figs. 65, 66) includes a very large number of vertebræ, which differ greatly from one another in different parts of the tail. The greatest number of caudals preserved in any specimen in the Museum is thirty-five. Arthaber mentions that in the different specimens of *Metriorhynchus* from Peterborough, preserved in various Continental museums, the number varies from thirty-three to thirty-six, and that in a specimen in Vienna the flexure of the tail occurs at the twenty-fifth vertebra, while in one at Munich it is at the twenty-sixth. Probably, with the small terminal caudals, the tail consisted of about forty vertebræ in all, the bend occurring at the twenty-fifth or twenty-sixth. *Geosaurus* is described by Fraas as possessing forty-four caudals.

The centra of the anterior caudals (text-fig. 65, A) have gently concave articular ends, which are nearly circular in outline; they are considerably constricted in the middle, and the first thirteen or fourteen, at least, bear caudal ribs, which are strongly compressed from above downwards and diminish in size when followed backwards in the series. The centrum of the first caudal is considerably shorter than that of the second, behind which there is a gradual diminution in length to the end of the tail. In the first two or three caudals no chevrons are present and the ventral faces of the

Text-fig. 65.



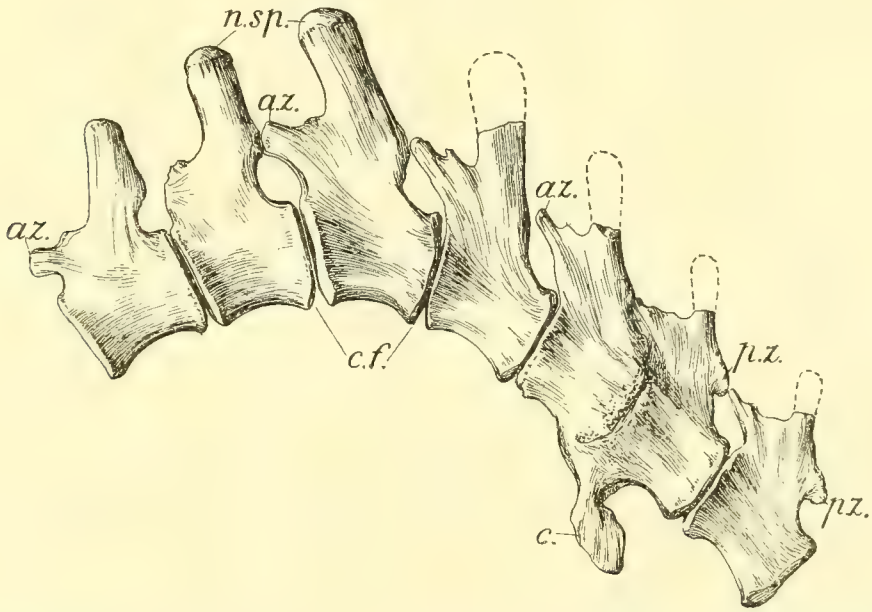
Caudal vertebræ of *Metriorhynchus læve*: A, anterior caudal from left side; B, posterior caudal from front; C, ditto from left side; D, vertebræ at bend of tail from left side; E, first vertebra in deflected part of tail from front. (R. 3014, $\frac{2}{3}$ nat. size.)

a.p., anterior process of neural spine; *a.z.*, anterior zygapophysis; *c.f.*, chevron-facets *n.sp.*, neural spine; *p.z.*, posterior zygapophysis.

centra are evenly convex from side to side; but further back, where the chevrons are present, the ventral face is somewhat flattened, the borders of the flattened area forming a pair of ridges which are obliquely truncated at their hinder ends by the chevron-

facets. In the anterior part of the tail the neural arches are borne on pedicles which extend nearly the whole length of the centrum. The anterior zygapophyses are small and closely embrace the posterior zygapophyses of the preceding vertebra; these are situated at the lower end of the posterior edge of the neural spine. The neural spine (*n.sp.*) varies much in form in different parts of the column. Unfortunately, none of the anterior caudals examined have the neural spines well preserved, so that it is not possible to see whether the notching of their anterior edge, described by Fraas * in the case of *Geosaurus*, begins in the same way; but further back in the column the spines are quite similar to those found in that genus, consisting of a small anterior pointed process (*a.p.*), projecting upwards above the anterior zygapophysis (*a.z.*), and a large backwardly sloping portion (*n.sp.*), which constitutes the main body of the spine.

Text-fig. 66.



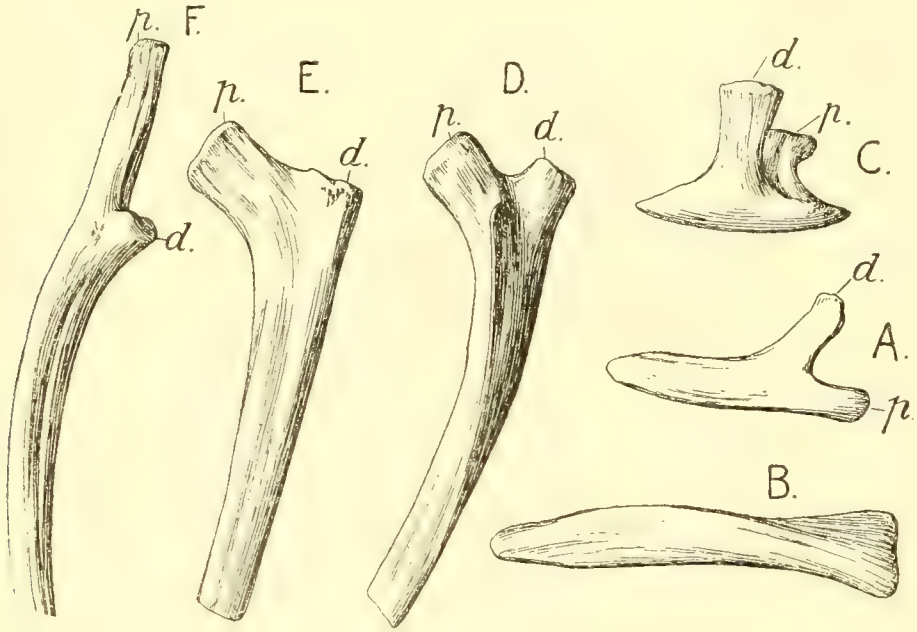
Vertebræ at bend of tail of *Metriorhynchus cultridens*, from left side. (R. 3804, ½ nat. size.)
a.z., anterior zygapophysis; *c.*, chevron; *c.f.*, chevron-facets; *n.sp.*, neural spine; *p.z.*, posterior zygapophysis.

This latter in the anterior part of the tail is strongly compressed from side to side and terminates above in a rounded border; as before noted, the posterior zygapophyses are situated on either side of the lower end of the main part of the spine. As this type of neural spine is followed backwards in the series it becomes gradually smaller and slopes backwards to a greater degree. On the vertebræ immediately in front of the bend (text-figs. 65 D, 66) the neural spine is still directed backwards, but becomes much thickened, and the posterior zygapophyses are greatly reduced or absent. In the next

* Palæontographica, vol. xlix. (1902) p. 52.

vertebra the spine is still thickened, but is nearly vertical: it terminates above in a convex facet, which does not occupy the whole length of its upper end; in this vertebra also the zygapophyses are much reduced. The next vertebra (the first of those in the deflected portion of the tail) has a much higher neural spine, which is directed forwards; in the next the spine is likewise large, much thickened at its upper end, and directed forwards. The anterior zygapophyses are well developed and articulate with the small posterior zygapophyses on the posterior face of the arch in front. Behind this point the neural spines become smaller and smaller, but are still directed forwards. A little in front of the flexure of the tail the centra become strongly compressed from side to side, and at the flexure itself they are considerably longer dorsally than ventrally,

Text-fig. 67.



Ribs of *Metriorhynchus superciliosum*: A, right rib of axis; B, right rib of atlas; C, middle right cervical rib; D & E, anterior dorsal ribs; F, middle dorsal rib. (R. 1530, $\frac{2}{3}$ nat. size.)

d., diapophysial process (tubercle); *p.*, parapophysial process (head).

the flexure being, in fact, produced by the apposition of the centra of this form. Behind the flexure there seem to have been about thirteen vertebræ, the centra of which are all strongly compressed laterally.

Ribs (text fig. 67).—The rib of the atlas (text-fig. 67, B) is a simple bar of bone which widens a little in its posterior third and then narrows posteriorly to a blunt point. At its anterior end it bears a flat, or slightly convex, facet for union with the corresponding surface on the posterior border of the anterior subvertebral wedge-bone;

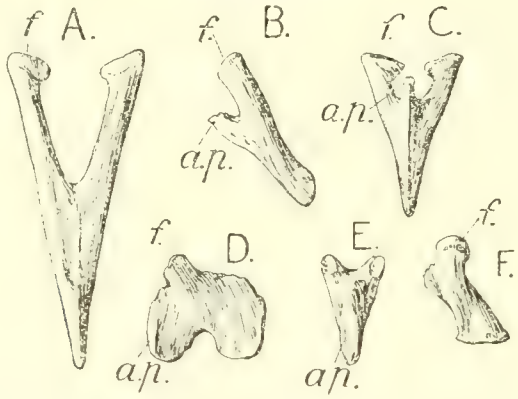
its outer face is convex or flat from above downwards, while the inner is concave and fitted closely against the outer face of the rib of the axis (text-figs. 61, A, and 67, A). Although in some specimens there is a clear trace of a diapophysial prominence at the base of the neural arch of the atlas (see Hulke, Proc. Zool. Soc. 1888, pl. xviii. fig. 1), no atlantal rib has been found in which there is any trace of the bifurcation of the proximal end, though perhaps there may have been a ligamentous connexion with the diapophysis, as there probably was in the case of the rib of the axis of *Steneosaurus* (see above, p. 103, text-fig. 39, B).

The rib of the axis (text-fig. 67, A) is deeply bifurcate, the head articulating with a surface borne partly on the odontoid and partly on the ventro-lateral border of the centrum of the axis (text-fig. 61, A); the upper (tubercular) branch articulates with the well-developed diapophysial process borne on the base of the arch of the axis. The capitular branch and the body of the rib are in the same straight line, and are concealed beneath the atlantal rib, when the bones are in their natural position (text-fig. 61, A); the outer face is gently convex from above downwards, the inner concave. At the posterior end of the inner face there is a facet, the function of which is not clear. The cervical ribs (text-fig. 67, C) behind the axis are very similar to those of *Steneosaurus* in general structure, but differ in having a proportionately longer and more compressed capitular (parapophysial) process, while the tubercular (diapophysial) process is stouter; this at least is the case with *Metriorhynchus superciliosum*. In *M. læve* the cervical ribs are more slightly constructed. In the posterior cervicals and anterior dorsals the anterior limb of the body becomes reduced to a crest, while the posterior portion elongates to form the main part of the rib, which is grooved posteriorly. In this region (text-fig. 67, D, E) the capitular and tubercular branches form a distinct angle with one another, but further back in the dorsal series the tubercular (diapophysial) articulation merely forms a step-like prominence on the posterior face (text-fig. 67, F) of the upper end of the rib, the posterior border of which, between the capitular and tubercular facets, is closely applied to the anterior edge of the transverse process, the line of contact being marked by a rugose surface. The capitular and tubercular facets do not seem to have approached one another towards the hinder end of the series as in the modern Crocodiles and, to some extent, in *Steneosaurus*, but remain widely separated to the last. In the dorsal region the bodies of the ribs are oval to circular in section, and there is a slight ridge on the upper part of the posterior surface running down from the tubercular facet. The sacral ribs have already been referred to (text-figs. 63, 64).

The caudal ribs (transverse processes) are borne on the first thirteen or fourteen vertebræ; they are strongly compressed from above downwards, and decrease rapidly in size from before backwards; they seem to be borne mainly or entirely on the centrum, at a lower level than in *Steneosaurus*.

Chevrons (text-fig. 68).—Of the chevrons no good series is available for description. The anterior chevrons (text-fig. 68, A) are of the ordinary **Y**-shape, the arms being rather shorter than the ventral process; above they terminate in an oblique rounded facet for union with the facets on the hinder ends of the centra of the caudal vertebræ. At the junction of the two arms the bone is compressed from before backwards, but at the lower end the compression is lateral. The exact form and arrangement of the other chevrons cannot be made out from any specimen, but, judging from the skeleton of *Geosaurus* (frontispiece), the condition seems to have been as follows:—As the chevrons are followed backwards towards the bend in the tail they become smaller and the upper arms of the upper **Y** shorten and widen. At the same time they slope considerably backwards, and a forwardly-directed process arises from the angle of the **Y**, giving them the appearance shown in text-fig. 68, B, C. Behind the bend of the tail the ventral part of the chevron is greatly enlarged, strongly compressed laterally, and

Text-fig. 68.



Chevron-bones of *Metriorhynchus superciliosum*: A, anterior chevron from front; B, posterior chevron from left side; C, from front; D, chevron from end of tail, from left side, and (E) front; F, posterior chevron from left side. (R. 1530, $\frac{2}{3}$ nat. size.)

a.p., anterior process; *f.*, facet for union with vertebra.

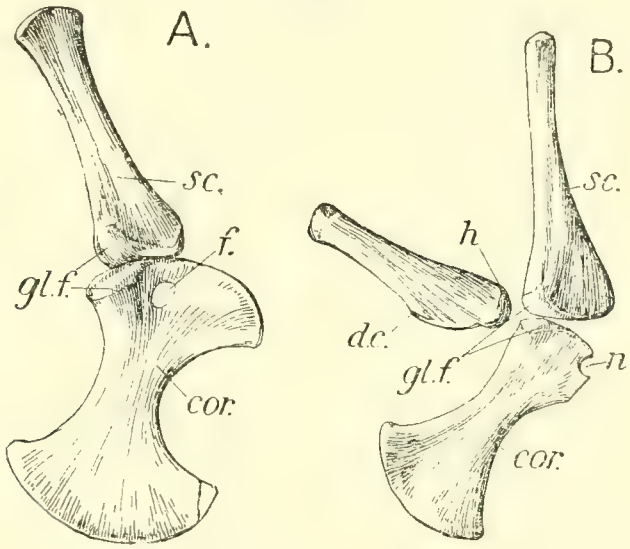
with its ventral border notched in the middle (text-fig. 68, D, E). The anterior and posterior ends of the expanded portion bear oval facets apparently for union with the chevrons in front and behind, so that in this region the chevrons form a closed series, much like a row of strongly compressed centra; this arrangement must have greatly strengthened this fin-bearing region of the tail. Towards the extreme end of the tail the ventral portion of the chevron again becomes rod-like and is thickened towards its extremity which terminates in a flat facet (text-fig. 68, F). In *Geosaurus* the arrangement is very similar (text-fig. A, Introduction), but the expanded chevrons have a convex ventral border without a notch.

Shoulder-girdle (text-figs. 69, 70 B).—The shoulder-girdle and fore limb have both undergone great reduction, the latter having apparently been modified to form a

small paddle-like structure much as in *Geosaurus*. The shoulder-girdle is formed by the scapula and coracoid only.

The *scapula* (*sc.*) is a slender flattened bone, widening out a little at its upper end, which terminates in a smooth convex surface. At the lower end the expansion is greater and the posterior side much thickened, the thickened portion bearing two surfaces. Of these, one is roughened and triangular in outline for union with the coracoid; this extends nearly the whole width of the end of the bone. The other facet is smooth and looks outwards, downwards, and backwards, forming the upper part of the glenoid cavity for the humerus. In front of the surface for the coracoid, the bone is produced into a blunt angle.

Text-fig. 69.



Shoulder-girdle and humerus of *Metriorhynchus*: A, right half of shoulder-girdle of *M. superciliosum* (R. 2051, $\frac{2}{3}$ nat. size); B, right half of shoulder-girdle with the humerus of *M. læve* (R. 3014, $\frac{2}{3}$ nat. size).

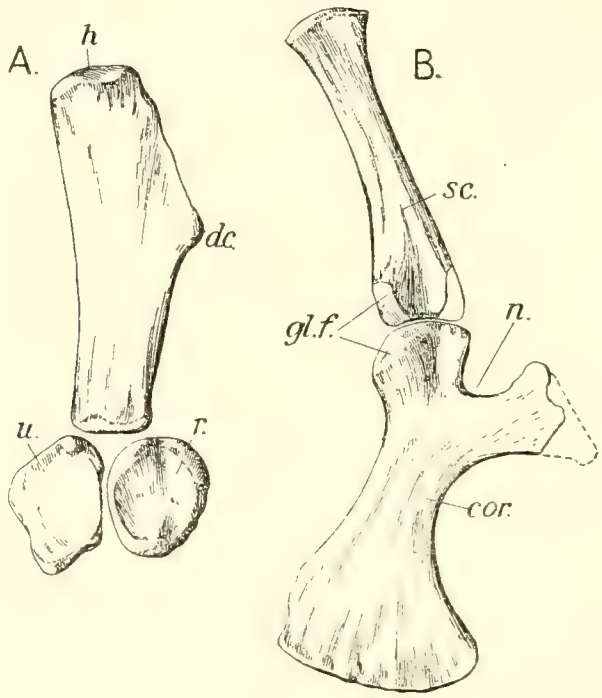
cor., coracoid; *d.c.*, deltoid crest; *f.*, coracoid foramen; *gl.f.*, glenoid fossa; *h.*, head of humerus; *n.*, notch on coracoid; *sc.*, scapula.

The *coracoid* (*cor.*) is considerably larger than the scapula; it is a strongly compressed bone, expanding to a fan-like shape at each end. The upper end is thickened posteriorly, the thickened portion bearing on its upper edge the surface for union with the scapula, while, looking backwards, there is a large oval, slightly concave surface which forms the lower two-thirds of the glenoid cavity. In front of this the bone is perforated by a large coracoid foramen (text-fig. 69, A), which, however, in some cases may become a deep notch (text-fig. 69, B). Sometimes this is the result of the breaking away of the border of the bone, but in others the notch has clearly never been closed (text-fig. 70, B). The neck of the bone is only about as wide as the upper

end. Ventrally, there is a broad expansion terminating below in a convex border; this distal expansion is very thin. The coracoid in this genus is distinguished from that of *Steneosaurus* by the greater expansion of the distal end and the relatively greater width of the neck.

Fore Limb (text-fig. 70, A).—The *humerus* is a proportionately small bone, much compressed from above downwards. The head (*h.*) is a strongly convex surface, oval in outline and nearly at right angles to the long axis of the bone, not being directed backwards as in *Steneosaurus*. Beneath it the flattened shaft widens out to the deltoid crest (*d.c.*), which forms a sharp prominence directed somewhat downwards

Text-fig. 70.



Shoulder-girdle and fore limb of *Metriorhynchus superciliosum*: A, right fore limb (incomplete); B, right coracoid and scapula. (R. 3016, ½ nat. size.)

cor., coracoid; *d.c.*, deltoid crest; *gl.f.*, glenoid fossa; *h.*, head; *n.*, notch on coracoid; *r.*, radius; *sc.*, scapula; *u.*, ulna.

and situated a little above the middle of the shaft. Beneath the deltoid crest the shaft narrows gradually to the distal articular surface, which is strongly convex, but is not divided into an outer and an inner condyle. On the dorsal surface, in the neighbourhood of the deltoid crest, there are strong rugosities for muscle-attachment, and there are also roughened surfaces on the anterior border between the deltoid crest and the distal articulation, which is in the same plane as the head, not making an angle with it as in *Steneosaurus*.

The propodial bones are flattened and disc-like, so that, as in *Geosaurus*, the fore limb was modified to form a paddle-like structure. This was first recognised by E. Auer *, who described a disc-like bone as a propodial, but was unable to be sure whether it was a radius or ulna: this specimen belonged to a skeleton from the Oxford Clay collected by Mr. Leeds. In the present collection there is one specimen of the fore limb in which both the propodials are preserved, but unfortunately no information as to their exact position with regard to one another and to the humerus is available. Indeed, it is not even possible to be sure which is the radius and which the ulna. Examination of the bones themselves and comparison with the corresponding elements in the fore limb of *Geosaurus gracilis* (see frontispiece, the figure given by Ammon †, and text-fig. B in the Introduction) suggest that the arrangement shown in text-fig. 70, A, is probably the correct one. The bone regarded as the *radius* (*r.*) is an oval disc, thin except at the postaxial side of its proximal end and at its distal extremity, where there are thickenings bearing convex surfaces, that at the proximal end being the larger and probably representing the articular surface for the humerus. The *ulna* (*u.*) is an irregular trapezoidal plate of bone, thickened at the preaxial side of its proximal end, where there is a surface presumably for union with the humerus and radius. Distally the oblique lower border is likewise thickened and no doubt united with the proximal carpals, also disc-like in form. This extreme modification of the fore limb is very similar to that described by Fraas ‡ and Ammon § in the case of *Geosaurus* and is further evidence of the extreme change undergone by members of this group in relation to their pelagic life.

The rest of the fore paddle is unknown, but a small bone figured by Arthaber ‖ as the first metacarpal, and perhaps the carpals figured by the same author, may actually belong here.

Pelvis (text-figs. 71–72).—The *ilium* (*il.*), which considering the large size of the hind limb is comparatively small, differs very much from that of *Steneosaurus* (*cf.* text-fig. 43, p. 109, & text-fig. 44, p. 111). Thus the dorsal border running backwards from the antero-superior angle (*a.a.*) is short, and so also is the posterior border, which makes a very obtuse angle with the dorsal, the whole of that part of the bone corresponding to the postero-superior corner of the ilium in *Steneosaurus* being wanting. At the same time the anterior border is very long, so that the acetabular border, instead of being nearly parallel with the dorsal edge, makes an angle of about 40° with it, sloping upwards and backwards. The outer surface of the bone is concave and much roughened, particularly in the neighbourhood of the thickened anterior

* "Die Extremitäten von *Metriorhynchus*," Centralbl. f. Min. etc. 1907, p. 536.

† Geognostische Jahreshefte, vol. xviii. p. 67 (München, 1905).

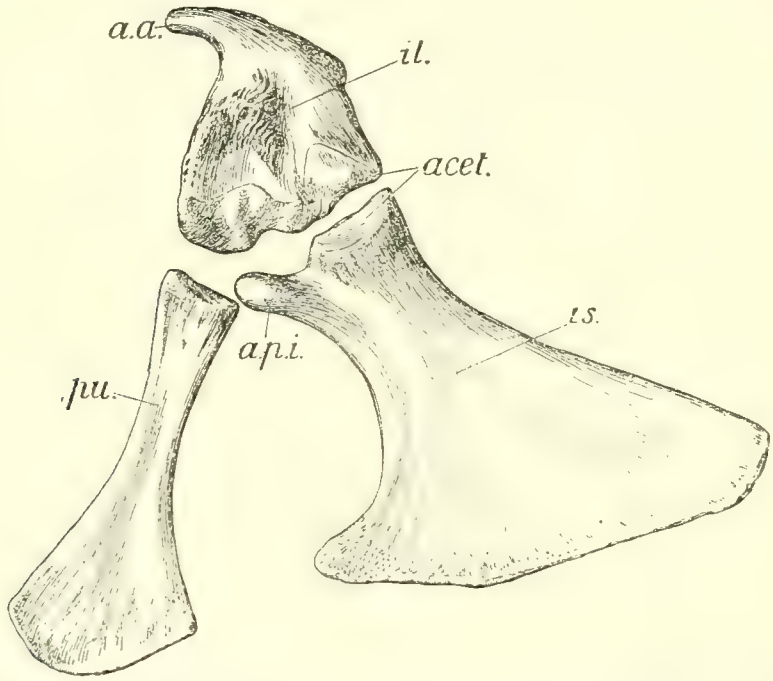
‡ Palæontographica, vol. xlix. (1902) p. 56, pl. viii. fig. 3.

§ Geognostische Jahreshefte, vol. xviii. p. 67 (München, 1905).

‖ Beitr. Paläont. Oester.-Ung. vol. xix. (1906) pl. xxv. figs. 11 *a*, *b*, *c*; also figs. 10 & 12.

border. The acetabular border is smooth, with the acetabular surface opposite the posterior union with the ischium running well up on to the outer face of the bone; from this surface the articulations for the upper end of the anterior process of the ischium and for the upper end of the pubis are separated by a notch, and form a broad smooth area above the anterior part of the acetabular border extending to the antero-ventral angle. The surface for union with the ischium is much roughened, and there seems to be no doubt that in front of it there is a surface for independent union with the upper end of the pubis. The inner face of the ilium (text-fig. 72) is convex: towards its upper border it bears two surfaces (*sac.s.*1., *sac.s.*2.) for union with the

Text-fig. 71.



Outer side of left half of pelvis of *Metriorhynchus moreli*. (R. 2054, ½ nat. size.)

a.a., anterior angle of ilium; *acet.*, acetabulum; *a.p.i.*, anterior process of ischium; *il.*, ilium; *is.*, ischium; *pu.*, pubis.

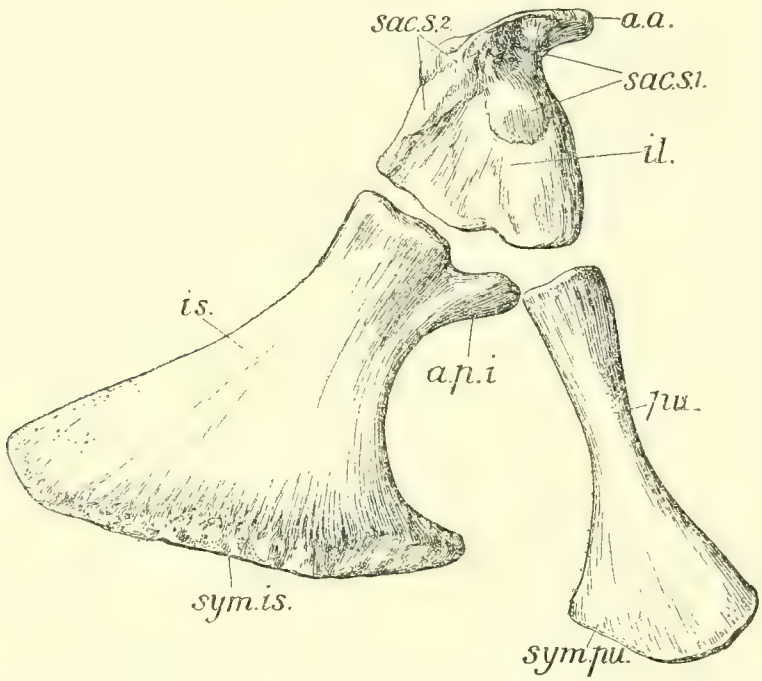
outer ends of the sacral ribs; the upper part of the surface for the first sacral forms a deep fossa beneath the dorsal border. The surface for the second sacral rib extends nearly down to the postero-inferior angle.

The *ischium* (*is.*, text-figs. 71, 72) in its general form is much like that of *Steneosaurus*, the chief difference being in the relatively rather smaller size of its anterior process. Ventrally the broad expanded blade bears a slightly curved oblique sutural surface (*sym.is.*) for union with its fellow. The neck is less sharply defined than in *Steneosaurus*, the bone narrowing gradually to just below the proximal articulation, which bears a surface for union with the posterior portion of the ventral

border of the ilium and a smooth concave facet forming the lower part of the acetabulum. The anterior process (*a.p.i.*) is nearly circular in section and terminates in a convex surface which bears no clearly defined facet for either the ilium or the upper end of the pubis; probably much cartilage was developed in this region.

The *pubis* (*pu.*, text-figs. 71, 72) is shorter and stouter than in *Steneosaurus*; in individuals in which ossification is far advanced there is a moderately long straight pubic symphysis, in front of which the bone was fringed with cartilage. The neck is less slender than in *Steneosaurus*. The upper end is usually much crushed, but in a specimen of *Metriorhynchus cultridens* (R. 3804) it terminates in an elongated oval,

Text-fig. 72.



Inner (sacral) side of left half of pelvis of *Metriorhynchus moreli*. (R. 2054, ½ nat. size.)

a.a., anterior angle of ilium; *a.p.i.*, anterior process of ischium; *il.*, ilium; *is.*, ischium; *pu.*, pubis; *sac.s.*1, *sac.s.*2, surfaces for union with the first and second sacral ribs; *sym.is.*, symphysial surface of ischium; *sym.pu.*, symphysial surface of pubis.

slightly convex surface, which seems to have been covered with cartilage and probably articulated with the ilium. Continuous with the postero-internal side of this there is a small oblique facet which may indicate an articulation with the anterior process of the ischium, but unfortunately this bone is imperfect in the skeleton in question.

On the whole, it appears from the relatively small size of the ilium and from the weakness of its union with the slender sacral ribs, that the great development of the caudal fin has, to some extent, superseded the hind paddle as a means of propulsion, at least as compared with the condition found in *Steneosaurus*.

Hind Limb (Pl. X. figs. 3–4).—The *femur* (*f.*) very closely resembles that of *Steneosaurus* in its general form, but is more compressed. The convex upper border of the shaft bears a narrow flattened rugose area extending throughout its length and apparently intended for the attachment of powerful muscles. The trochanteric roughening extends on to the ventral border of the bone instead of being confined to the inner face as in *Steneosaurus*. The distal condyles are usually incompletely ossified and, no doubt, in life were extensively covered with cartilage. The outer (fibular) condyle is much the larger and is separated from the inner by a small intercondylar notch; it articulated with the outer condyle of the tibia and the upper end of the fibula.

The *tibia* (*tib.*) and *fibula* (*fib.*) are relatively shorter than in *Steneosaurus*, being only a little more than a third the length of the femur; both seem to have been much compressed from before backwards. This compression seems to be most marked in the small species in *M. læve* (R. 3014, Pl. X. fig. 3). The upper end of the tibia is much thickened and its articular surface is divided by an obscure oblique concavity into an inner and outer condyle, the latter, together with the upper end of the fibula, articulating with the outer condyle of the femur. Beneath the widened upper articular end, the shaft narrows and is compressed from before backwards to a varying degree; at its distal end it again widens a little and terminates in a slightly convex surface for union with the astragalus; this surface is continued on to the posterior surface of the bone on its postaxial side.

The *fibula* (*fib.*) is a slender rod of bone: at its upper end it is considerably expanded and rested against the flattened surface on the outer side of the upper end of the tibia; as already noted, it articulated with part of the outer condyle of the femur. At its lower end the bone terminates in a somewhat oblique and strongly convex surface, the preaxial corner of which articulated with a facet on the astragalus, the remainder with the proximal surface of the calcaneum (Pl. X. fig. 3).

The *tarsus* (Pl. X. figs. 3–4) consists of four elements, the astragalus (*as.*) and calcaneum (*ca.*) in the proximal row, and two bones in the distal series probably representing the fused first to third and fourth and fifth tarsalia respectively. In the smaller species, *M. læve*, in which the tarsals, like the other limb-bones, are much flattened, they form a fairly closely fitting pavement of bones. The astragalus (*as.*) has on its proximal border two facets, one preaxial and much the larger for articulation with the tibia, the other, much smaller, gently concave and looking upwards and outwards, for union with the fibula. Externally, it has a nearly straight border for union with the calcaneum and distally a convex surface uniting with the fused first and second distal tarsals, and in front of this apparently supporting the first metatarsal. The proximal surface of the calcaneum (*ca.*) forms a convex facet for the fibula; anteriorly it joins the astragalus in a nearly straight border and distally it articulates with the fused fourth and fifth metatarsals. Postaxially it is produced into a strong pointed talon which projects

backwards and a little upwards. The fused first, second, and third tarsals form a small oval nodule of bone wedged in between the astragalus, the fused fourth and fifth tarsals, and the upper ends of the first three metatarsals. The united fourth and fifth tarsals form a larger nodule of bone, which unites proximally with the calcaneum and distally supports the 3–4 metatarsals; posteriorly it bears a short rounded prominence (*t.*) which seems to have been thrust against the hinder face of the calcaneum.

The first *metatarsal* (*mt.I.*) is very wide at its proximal end, narrowing gradually distally; its anterior border is strongly convex, the posterior concave. At its proximal end it terminates in an oblique border, bearing on its inner side a thickened convex surface for union with the tarsus, while the outer side forms a strong angular prominence; distally this bone terminates in an oblique surface for union with the first phalange, and is much more compressed than the second, third, and fourth metatarsals. These increase in size in the order mentioned: at their upper end they widen a little and terminate in convex surfaces for union with the tarsus; when articulated they are so arranged that, looked at from the dorsal surface, the posterior face of the proximal expansion of each overlaps a little the metatarsal behind. The shafts of these metatarsals are oval in section and they terminate distally in well-developed convex surfaces for articulation with the phalanges. The fifth metatarsal seems to have been always greatly reduced, and in the hind limb figured is represented only by a small, triangular, claw-like plate of bone. The *phalanges* are more flattened than the metatarsals and widen out considerably at their ends, some of the small distal phalanges being hour-glass-shaped. One of the digits, probably the fourth, terminated as a small flattened claw.

In the large species (e. g. *M. superciliosum*) the tarsus is not so well known; it differs from that of *M. læve* in having the constituent bones less flattened from above downwards, and with more strongly convex articular surfaces. Otherwise the account given above holds good for all the species so far as known.

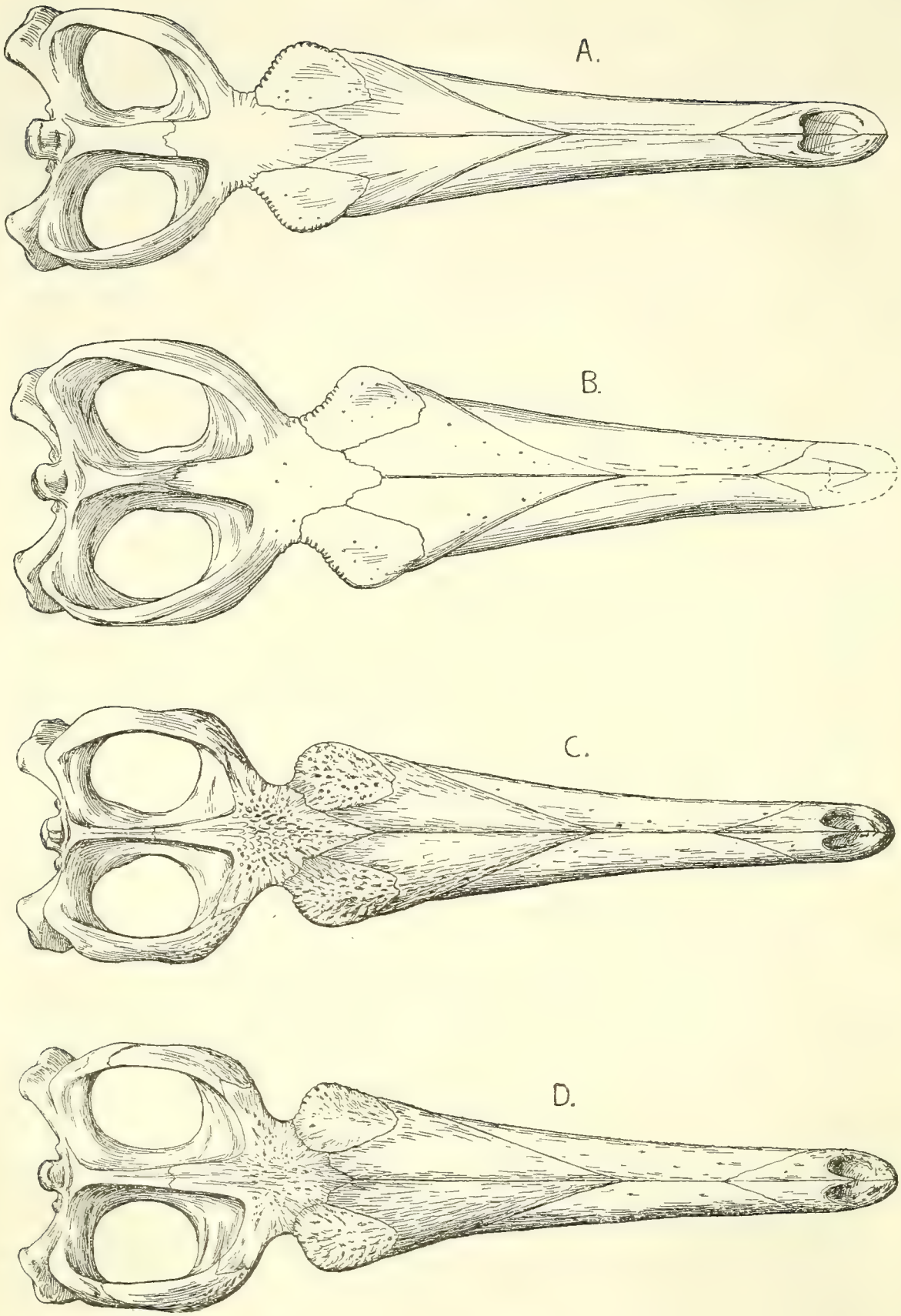
Seven species of *Metriorhynchus* from the Oxford Clay of Peterborough are here recognised. Of these, three are new, three have been described in detail by E. E. Deslongchamps in his 'Notes Paléontologiques,' and one by Lydekker, who founded the genus *Suchodus* for the short-snouted form here called *Metriorhynchus durobrivense*, there being no valid generic distinction between it and the other short-snouted species of *Metriorhynchus*.

The species here recognised may be distinguished by the characters given in the following table:—

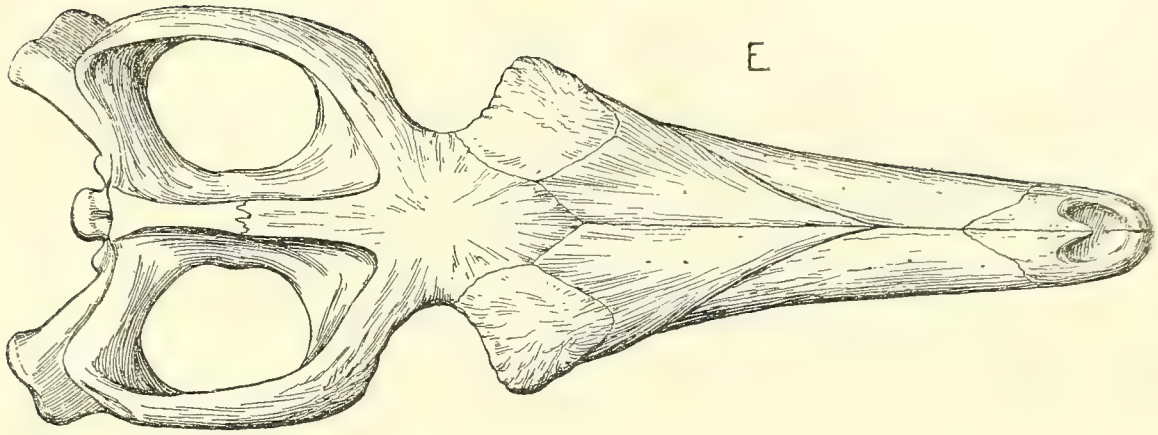
A. Forms in which the surface of the cranial bone is without sculpture.

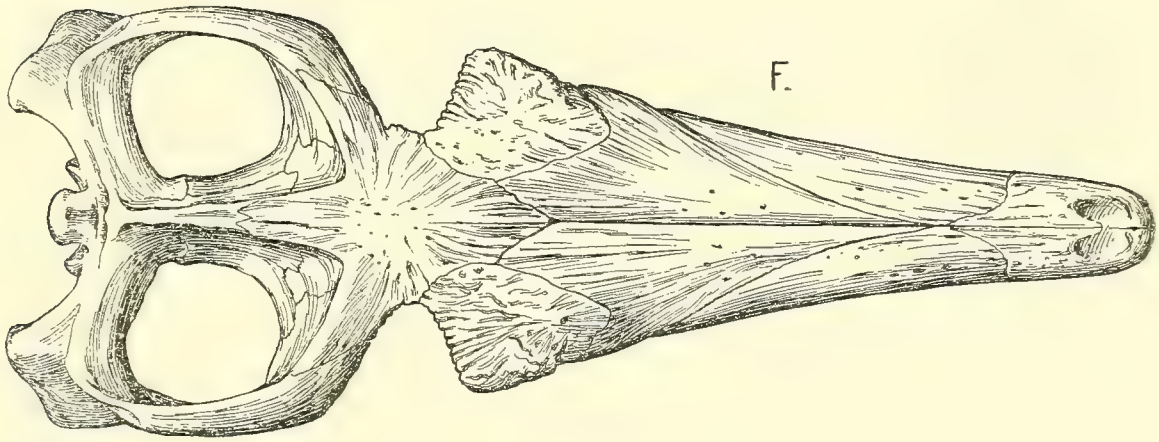
1. *Metriorhynchus læve.*—A small species with a narrow skull; teeth numerous, close-set, and small, upwards of 30 on each side of the mandible. (Text-fig. 73, A.)
2. *Metriorhynchus leedsi.*—Skull broader and more massive than in 1. Teeth large and closely set, about 36 in each maxilla. (Text-fig. 73, B.)

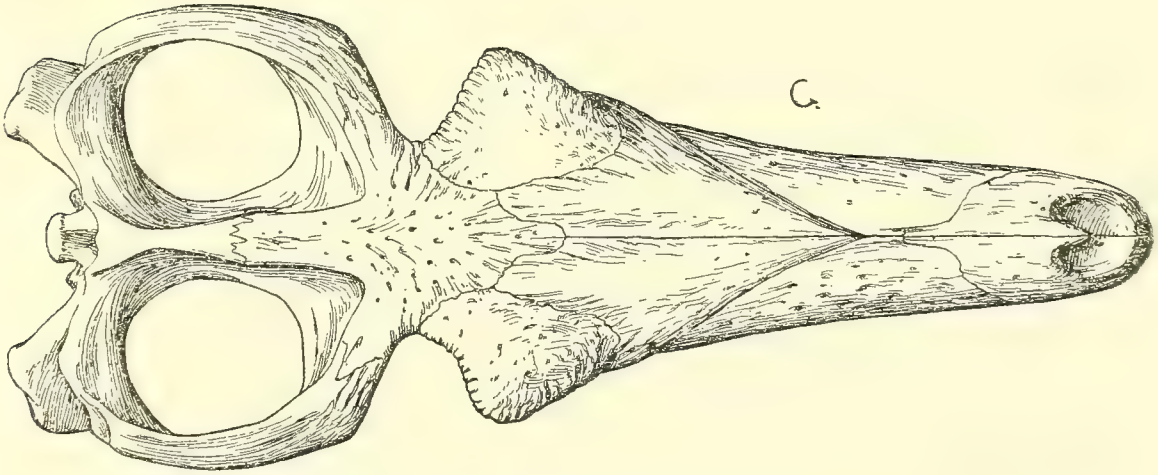
Text-fig. 73.



Text-fig. 73 (*con.*).







Semi-diagrammatic figures of the skull-roof in the various species of *Metriorhynchus* from the Oxford Clay of Peterborough.

A. *Metriorhynchus læve.*
B. ,, *leedsi.*
C. ,, *superciliosum.*
D. ,, *moreli.*
E. *Metriorhynchus cultridens.*
F. ,, *brachyrhynchus.*
G. ,, *durobrivense.*

B. Forms in which the surface of the cranial bone is more or less sculptured with pits and grooves.

a. Narrow-skulled forms.

3. *Metriorhynchus superciliosum.*—A narrow-skulled form in which the surface of the frontal is sculptured with sharply defined pits. The frontal extends forwards nearly to the level of the anterior angle of the prefrontals, and its length in front of the temporal fossæ is considerably greater than the least width between the orbits. About 25 teeth in each maxilla. (Text-fig. 73, C.)

4. *Metriorhynchus moreli.*—A narrow-skulled form in which the frontal bears a sculpture of shallow and, as it were, partly obliterated pits; its anterior angle does not extend forwards to the level of the anterior angle of the prefrontals, and its length in front of the temporal fossæ is about equal to the least width between the orbits. About 26 teeth in each maxilla. (Text-fig. 73, D.)

b. Broad-skulled forms.

5. *Metriorhynchus cultridens.*—Skull with comparatively short rostrum, in which the nasals are separated from the premaxillæ by a distance about equal to a quarter of their own length. Supraorbital notch an open continuous curve; teeth smooth and with strongly compressed crowns; about 20 teeth in the maxilla. (Text-fig. 73, E.)

6. *Metriorhynchus brachyrhynchus.*—Skull with short rostrum, in which the nasals meet or nearly meet the premaxillæ. The supraorbital notch forms a sharp angle, and a line joining the outer angles of the prefrontals passes behind the posterior angle of the nasals. About 18 teeth in the maxilla. (Text-fig. 73, F.)

7. *Metriorhynchus durobrivense.*—Skull broad with a short rostrum, in which the nasals do not quite reach the premaxillæ. A line joining the outer angles of the prefrontals passes through the hinder angle of the nasals. About 13 teeth in the maxilla. (Text-fig. 73, G.)

Metriorhynchus superciliosum, de Blainville, sp., ex Conybeare MS.

[Plate IX. figs. 1, 2; text-figs. 55–56, 61 A, 67, 68, 69 A, 70, 73 C.]

1853. *Crocodilus superciliosus*, de Blainville, Mém. Soc. Linn. Normandie, vol. ix. p. 114 (ex Conybeare, MS.).

1867. *Teleosaurus superciliosus*, Deslongchamps, Bull. Soc. Linn. Normandie, [2] vol. i. p. 149.

1867. *Metriorhynchus superciliosus*, E. E. Deslongchamps, Notes Paléontologiques, p. 118.

1869. *Steneosaurus dasyceps*, Seeley, Index to the Fossil Remains of Aves etc. in the Woodwardian Museum, p. 140. (No description.)

1904. ? *Metriorhynchus jaekeli*, Schmidt, Zeitschr. deutsch. geol. Gesell. vol. lvi. p. 97, pls. xi., xii.

Type Specimen.—A skull, a cast of which was sent by Conybeare to de Blainville, who found it identical with specimens from the Oxfordian Clay of Dives and Vaches-Noires in Normandy, and adopted Conybeare's manuscript name for the species.

The skull (Pl. IX. fig. 1; text-figs. 55–56) and mandible of this species, which is that most commonly found in the Oxford Clay of both England and France, have been described in great detail by E. E. Deslongchamps in his 'Notes Paléontologiques'

(1867), pp 306–319, where the history of the name will be found—he takes as the type the specimen in the Museum at Caen, to which de Blainville applied the name.

In this species the snout is elongated and is strongly convex from side to side; its width remains the same as far back as the point of the nasals, where it widens out to the orbits; the nasals are strongly convex posteriorly in the uncrushed skull, and are separated from the maxilla by a distinct groove. The median suture between them is also at the bottom of a groove in the uncrushed skull. The distance between the anterior points of the nasals and the facial processes of the premaxillæ varies, but is more than a third of the length of the nasals. Prefrontals very large with surface strongly sculptured with irregular pits. Frontal also with a strongly developed sculpture of pits, which tend to be arranged in rows radiating from the commencement of the intertemporal bar; the length of the frontal anterior to the temporal fossæ is greater than its width at the narrowest point between the orbits; there is no trace of any division into two elements. The intertemporal bar is broad in the anterior portion formed by the frontal, but narrows to a thin crest in the parietal region.

The teeth (Pl. IX. fig. 2) are about 28 in number on either side of the upper jaw, there being three in the premaxilla; the sharp-pointed tooth-crowns are not very much compressed and have anterior and posterior carinæ which are not serrated. The enamel is raised into numerous fine discontinuous ridges running towards the point, which is nearly smooth. The ridging on the inner face is more strongly developed than on the outer. The teeth in this species have better-marked sculpture of the enamel than is seen in any other of the long-snouted forms, cf. *M. moreli*.

R. 2030. Skull (Pl. IX. fig. 1) and mandible, not quite complete and much compressed from above downwards. The palate as usual is destroyed.

Skull (Pl. IX. fig. 1):		
Length in mid-dorsal line		63·4
„ from occipital condyle to tip of snout		66·0
„ of nasals		21·3
Distance between nasals and premaxillæ		9·0
Least width between orbits		8·1
Width between outer angles of prefrontals	(approx.)	15·0
„ „ „ „ frontal		12·7
„ „ „ „ quadrates		18·5
Width of premaxillary region		5·2
Mandible: length	(approx.)	72·0
length of symphysis		30·5
depth at coronoid angle	(approx.)	7·0

R. 2051 (Leeds Coll. 30). A nearly complete skull and mandible, the former much crushed from above downwards; odontoid, axis and four other cervical vertebræ, fifteen dorsals, two sacrals, thirty-two caudals; ribs; shoulder-girdle (text-fig. 69, A), wanting half one scapula, pelvic girdle, femora, portions of tibiæ and fibulæ, and numerous bones of

the hind foot. Some sclerotic plates are preserved. This skeleton, with others, was described and figured by Hulke in Proc. Zool. Soc. 1888, pp. 418–433, pl. xvii. figs. 2–5 (vertebræ), pl. xix. figs. 1–2 (ilium), text-fig. 2 (coracoid). There seems no doubt that this specimen is a rather small individual of the present species.

The dimensions (in centimetres) of this specimen are :—

Skull: length in mid-dorsal line	(approx.)	51·0
„ from occipital condyle to tip of snout	(approx.)	55·5
„ of the nasals		20·0
distance between the nasals and premaxillæ		5·5
least width between orbits		7·1
width between outer angles of prefrontals		11·7
„ „ „ „ frontal		12·5
Mandible: length	(approx.)	56·0
depth at coronoid angle		6·5

Vertebræ	Axis.	Middle cervical.	Anterior dorsal.	Posterior dorsal.	First sacral.	Second caudal.	Anterior caudal.	Three vertebræ at bend of tail.		
Length of centrum in mid-ventral line	2·9	3·0	3·3	3·3	3·4	3·2	2·6	2·1	1·8	1·7
Width of posterior face of centrum	2·1	2·6 (app.)	2·5	2·7	2·6	2·6	2·8	1·7	1·4	1·4
Height of posterior face of centrum	2·5	2·6 (app.)	2·5	2·7	2·3	2·7	2·7	1·8	1·9	2·0
Height to top of neural spine	5·6	6·6	..	..	..	..	..	3·9	4·8	5·3

The measurements of the vertebræ are only approximate, much crushing having taken place.

The length of the centrum of the first vertebra at the bend of the tail in the mid-ventral line is 1·8 cm., in the mid-dorsal line 2·3 cm.; the same measurements in the second are 1·7 cm. and 2·4 cm.

Shoulder-girdle:		
Scapula (text-fig. 69, A): length		5·6
width of articular end		1·9
„ shaft at narrowest point.		1·0
„ upper end		1·3
Coracoid (text-fig. 69, A): length		6·0
width of upper end		3·5
„ shaft at narrowest point		1·4
„ lower end	(approx.)	4·0
Humerus: length		5·8
width of head		1·7
„ distal end		1·6
Pelvis:		
Ilium (fig. by Hulke, *tom. cit.* pl. xix. figs. 1, 2):		
length of the dorsal border		3·8
„ from antero-superior to postero-inferior angle.		5·3
„ of the acetabular border		4·0

Ischium: length of symphysial border	8·5
width from articular end to posterior angle (approx.)	8·6
,, of neck at narrowest	2·6
greatest width of proximal end	3·5
Pubis: greatest length	7·8
width of neck at narrowest	1·0
,, upper end	1·7
Hind limb:	
Femur: length in straight line	19·3
greatest width of proximal end	3·4
long diameter of the middle of the shaft	2·2
Fibula: length	6·3

R. 1530. Imperfect skull and mandible, teeth, atlas, axis and five other cervical vertebræ, sixteen dorsals, two sacrals and thirty-five caudals, of which eighteen bear ribs; numerous ribs (text-fig. 67), coracoid, scapula, humeri, ilia, ischia, pubes, femora, tibiæ, fibula, and numerous bones of the hind feet; a few chevrons (text-fig. 68).

In this skeleton the back of the skull is wanting, but the anterior portion is much less crushed than usual; the same is true of the mandible. The vertebræ have nearly all lost their neural arches and are much crushed. The coracoid seems to have had a notch instead of a foramen.

The dimensions (in centimetres) of this skeleton are:—

Distance between premaxillæ and nasals	9·0
Length of mandibular symphysis	36·0

The cervical and dorsal vertebræ are mostly too much crushed to supply measurements of any value, but the following are probably nearly accurate:—

Vertebræ	Middle dorsal.	First caudal.	Posterior caudals.		
			a.	*b.*	*c.*
Length of centrum in mid-ventral line	4·3	3·3	2·6	2·1	2·0
Width of posterior face	3·5	3·5	2·6	2·0	2·0
Height of posterior face	3·2	3·7	2·3	2·5	2·5

a, last vertebra before downward flexure; *b*, *c*, two vertebræ at downward flexure.

The length of the centra in *b* and *c* along their dorsal edge is 2·9 and 2·7 respectively.

Length of rib of atlas	5·0
,, ,, axis	7·9
Shoulder-girdle:	
Coracoid: length	8·0
width of upper end	4·9
,, shaft	1·8
,, distal expansion (approx.)	5·0

Scapula: length	7·9
width of upper end	1·9
„ shaft	1·0
„ articular end	2·8
Humerus: length	8·3
width of head	2·0
„ at deltoid crest	2·8
„ of distal articulation	1·8
Pelvis:	
Ilium: length of dorsal border	5·2
„ acetabular border	5·5
Ischium: length of symphysial border	11·9
width from articular end to the posterior angle	11·4
greatest width at proximal end	4·5
Pubis: greatest length	9·8
width of lower expansion	5·7
„ upper end	2·4
Hind limb:	
Femur: length in straight line	26·4
greatest width at proximal end	4·0
long diameter of the middle of the shaft	2·7
Tibia: length	9·4
Fibula: length	9·0
First metatarsal: length	8·3
width of upper end	2·5

R. 2033 (Leeds Coll. 32). Portions of skull and mandible, teeth (Pl. IX. fig. 2), atlas, axis, and five other cervical vertebræ, seventeen dorsals, two sacrals, and twenty-nine caudals, ribs, ilia, ischia, pubis, femora, one tibia and fibula, two metatarsals.

The skull is very fragmentary, but the frontals show the sculpture characteristic of this species. This specimen is interesting from the fact that the right ilium and ischium and the upper end of the femur are greatly deformed by the development of extensive exostoses. The ilium and ischium are closely fused, and the greatly thickened upper end of the femur bears a rough concave surface. Possibly these deformities are the result of some severe injury received by the animal.

The dimensions (in centimetres) of this specimen are :—

Vertebræ	Axis.	Last cervical.	Middle dorsal.	First sacral.	Caudal at bend of tail.
Length of centrum in mid-ventral line	3·6	3·5	4·3	3·4	2·2
Width of posterior face of centrum	2·8	3·8	3·5	3·5	2·1
Height of posterior face of centrum	3·3	3·8	3·7	3·2	2·9
Height to top of neural spine	..	8·8	..	..	7·4

Pelvis:	
Ilium: length of dorsal border	5·3
„ acetabular border	5·8
Ischium: length of symphysial border	11·9
„ from articular surface to posterior angle	12·5
Pubis: length	11·0
width of distal expansion	4·6
Hind limb:	
Femur: length in straight line	25·4
greatest diameter of head	4·1
Tibia: length	8·3
Fibula: length	8·2
First metatarsal: length	7·8

R. 3016. Skull (imperfect), mandible, right coracoid and scapulæ (text-fig. 70, B), humeri, (?) radii, and ulna (text-fig. 70, A) of a large individual, probably belonging to the present species.

The skull is much broken, but the palate is nearly all preserved. The mandible is well preserved and the teeth, of which several are *in situ*, show the well-developed ridging of the enamel usually found in the present species. The bones of the fore limb (see text-fig. 70, A) are the only specimens in the whole collection which definitely prove that the paddle-like form, similar to that found in *Geosaurus*, also occurs in *Metriorhynchus*, though perhaps in a less modified condition.

The dimensions (in centimetres) of this specimen are:—

Mandible: length (approx.)	88·0
length of symphysis	38·0
depth at coronoid angle	9·6
Coracoid (text-fig. 70, B): length	9·7
width of lower end (approx.)	6·0
„ neck	2·0
„ articular end	2·8
Scapula (text-fig. 70, B): length	8·7
width of articular end	2·5
„ upper end	1·9
Humerus (text-fig. 70, A): length	9·8
width of head	2·5
„ at deltoid crest	3·4
„ of distal end	2·1
Radius (?) (text-fig. 70, A): length	3·2
width	2·7
Ulna (?) (text-fig. 70, A): length	3·7
width	2·7

R. 2053 (Leeds Coll. 36). A small crushed skull wanting the anterior portion of the snout.

The dimensions (in centimetres) of this specimen are :—

Length in middle line to tip of nasals	31·5
„ of nasals	18·0
Distance between nasals and premaxillæ	4·5
Least width between orbits	6·0
Width between outer angles of prefrontals	10·7
„ „ „ frontal	9·0

R. 2041 (Leeds Coll. 16). A nearly complete skull, the premaxillary region of which is well preserved. The whole is, as usual, much flattened from above downwards, the palate being almost entirely destroyed.

The dimensions (in centimetres) of this specimen are :—

Length in mid-dorsal line		52·2
„ to tip of nasals	(approx.)	34·5
„ from occipital condyle to tip of snout		55·2
„ of nasals	(approx.)	19·5
Distance between nasals and premaxillæ		5·5
Least width between the orbits		6·7
Width between outer angles of prefrontals		11·4
„ „ „ frontal		10·7
„ „ „ quadrates		15·6
Width of premaxillary region		3·0

R. 2055 (Leeds Coll. 38). Imperfect skull.

The approximate dimensions (in centimetres) of this specimen are :—

Skull : approximate length in mid-dorsal line	48·0
length to anterior end of nasals	31·0
„ of nasals	17·0
distance between nasals and premaxillæ	7·0
least width between orbits	6·4
width between outer angles of prefrontals	11·4
„ „ „ frontal	10·7
„ „ „ quadrates	13·5

R. 1529. Skull and mandible of a young individual. This specimen shows that the sculpture of the frontals is already well developed in the young. The teeth seem to be less rugose on the outer side than in larger specimens.

The dimensions (in centimetres) of this specimen are :—

Skull : length in middle line from occiput to tip of nasals	27·5
width between orbits	5·0
width at outer angles of prefrontals	9·2
length of frontal anterior to temporal fossæ	7·0
Mandible : length of symphysis (approx.)	17·5

R. 2065. Portions of skull of a very young individual, in which the frontal sculpture is already sharply defined.

Least width between orbits	4·5
Width between outer angles of prefrontals	8·1

R. 2048 (Leeds Coll. 27). Imperfect skull, probably of this species, with teeth. In this specimen the anterior part of the palate is better preserved than usual.

R. 2069. Portions of the skull and mandible of a very young individual, with the odontoid and the centra of the axis and three other cervical vertebræ.

R. 2056 (Leeds Coll. 39). Portions of the skull and mandible of a young individual.

R. 2036 (Leeds Coll. 24). Portions of skull and mandible with one cervical vertebra. This specimen is notable for the strongly developed pitted sculpture on the frontal and prefrontal.

Least width between orbits	7·1
Width between outer angles of prefrontals	12·5
Length of frontal anterior to temporal fossæ	9·5

R. 2058 (Leeds Coll. 41). Skull with anterior portion of mandible. Less crushed than usual, the middle part of the rostrum especially being nearly of its natural shape. One or two sclerotic plates are preserved adhering to the prefrontal.

The dimensions (in centimetres) of this specimen are :—

Length in mid-dorsal line		60·0
Distance between nasals and premaxillæ		7·5
Width between orbits		8·2
„ between outer angles of prefrontals	(approx.)	13·0
„ of snout at anterior end of nasals		4·5

The following specimens may belong to this species :—

R. 2064. Imperfect atlas and axis, five other cervicals and one dorsal : some of the cervicals have their ribs and neural arches still attached.

R. 2080. Two anterior dorsals with their centra fused by the development of exostoses.

R. 2775. Portions of the skeleton of a very young individual. The parts preserved are the odontoid, axis, the centra of four dorsal, two sacral, and three caudal vertebræ, the left ilium, parts of an ischium, and the femora.

The length of the femur is about 15·5 cm.

R. 2062. Basioccipital, portions of mandible, odontoid, axis, and the centra of four other cervical, and four dorsal vertebræ of a young individual.

R. 2077. Several anterior chevron-bones.

R. 2062 a. Nearly uncrushed anterior portion of mandibular symphysis (? of *M. moreli*).

Metriorhynchus aff. **moreli,** Deslongchamps.

[Plate IX. figs. 3, 4; text-figs. 57, 62–64, 71, 72, 73 D.]

The type specimen of *M. moreli* is a skull from the Oxford Clay of Villers-sur-Mer in Normandy. It was described and figured in detail by E. E. Deslongchamps in 'Notes Paléontologiques' (1867), p. 320, pl. xxi. figs. 4 & 5, pl. xxii. figs. 1 & 2. The specimens from the Oxford Clay of Peterborough, here referred provisionally to this species, resemble Deslongchamps's type in many respects, but at the same time present some differences. The sculpture of the frontal, which appears as if half obliterated, and the comparative massiveness of the snout, are points of similarity; the frontal also, in both the Oxford Clay specimens and the type, are shorter in front of the temporal fossa than in *M. superciliosum*, with which alone this form is likely to be confused; at the same time, in the specimens here described this shortening of the frontal is carried further than in the type, their anterior extremity being at a greater distance behind the anterior angles of the prefrontals. The length of the frontal anterior to the temporal fossæ is about equal to the least width between the orbits, while in *M. superciliosum* it is considerably greater. The bar of the frontal between the temporal fossæ is narrow. The distance between the anterior angle of the nasals and the posterior point of the premaxillæ is about equal to a third of the length of the former.

The teeth are less sculptured than in *M. superciliosum*, the outer, somewhat flattened side of the crown being almost entirely smooth. There are twenty-six teeth in each maxilla, two more than are given by Deslongchamps for the type specimen.

The similarity between the type and the Peterborough specimens being so great, it has been thought best to refer them provisionally to the same species: the differences may indicate a local race or variety.

R. 2054 (Leeds Coll. 37). Skull (Pl. IX. fig. 3), mandible, atlas, axis, and four other cervicals (the last being wanting), eighteen dorsals (text-fig. 62), two sacrals (text-figs. 63, 64), and twenty-eight caudals, numerous ribs and chevron-bones, ilium, ischium, pubes (text-figs. 71, 72), tibia, fibula, and numerous bones of the hind foot. The atlas and axis were figured and described by Hulke in Proc. Zool. Soc. 1888, p. 418, pl. xviii. fig. 1; in this specimen a well-developed diapophysis is borne on the base of each half of the neural arch of the axis.

The dimensions (in centimetres) of this specimen are :—

Skull (Pl. IX. fig. 3):

Length in middle dorsal line	(approx.)	60·7
„ from occipital surface to tip of nasals		40·3
„ of nasals		24·3
Distance between nasals and premaxillæ		7·4
Width between outer angles of quadrates		18·5
Least width between orbits		8·4
Width between outer angles of prefrontals		14·8
Length of the frontal anterior to the temporal fossæ		8·4
Mandible: length		72·0
length of symphysis	(approx.)	36·0
depth at coronoid process		7·5

Vertebræ	Atlas & axis.	Middle cervical.	Anterior dorsal.	Middle dorsal.	First sacral.	Anterior caudal.	Middle caudal.	Caudals at bend of tail. 1.	2.	3.
Length of centrum in mid-ventral line	6·4	4·0	4·0	4·2	3·1	3·9	4·0	2·5	1·9	2·1
Width of posterior face of centrum	3·1	3·5	3·5	3·6	3·5	3·7	3·1	2·3	2·1	2·0
Height of posterior face of centrum	3·5	3·4	3·5	3·5	3·1	3·0	3·0	2·3	2·3	2·4
Height to top of neural spine.	6·3	8·1	8·0 (app.)	8·3	9·5	8·0	6·3	5·7	6·6	6·7

Pelvis (text-figs. 71, 72):

Ilium: length of the dorsal border		4·8
„ from the antero-superior to the postero-inferior angle		7·2
„ of the acetabular border		5·7
Ischium: length of the symphysial border	(approx.)	12·0
width from articular end to posterior angle		12·5
greatest width of proximal end		5·0
Pubis: greatest length		11·0
width of lower expansion		5·0
„ neck		1·3
„ upper end		2·1
Hind limb:		
Femur: length in straight line		26·0
greatest width of head		4·0
long diameter of middle of shaft		3·0
Tibia: length		8·9
width of proximal end		2·8
„ distal end		2·1
Fibula: length		8·7
width of proximal end		2·3
„ distal end		2·0
First metatarsal: length		7·9
width of proximal end		2·3

R. 2032 (Leeds Coll. 31). Imperfect skull and mandible, atlas and axis, four other cervical vertebræ, seventeen dorsals, two sacrals, and thirty-seven caudals, fragments of ribs, portion of a scapula, imperfect coracoids, humerus, ilium, part of ischium, femur. The restored coracoid is figured by Hulke (Proc. Zool. Soc. 1888, p. 428, fig. 1) as a scapula.

The dimensions (in centimetres) of this specimen are :—

Skull : length in middle dorsal line	(approx.)	59·5
,, of nasals		20·6
distance between nasals and premaxillæ		7·9
least width between orbits		8·0
length of the frontal anterior to temporal fossæ		8·0
Mandible : length	(approx.)	67·0
length of symphysis	(approx.)	27·0
depth at coronoid angle		6·8

Vertebræ	Atlas & axis.	Caudals at bend of tail.			
Length of centrum in mid-ventral line	6·2	2·8	2·5	2·0	2·1
Width of posterior face of centrum	3·0	2·4	2·1	1·9	2·0
Height of posterior face of centrum	3·4	2·6	2·6	2·7	2·7
Height to top of neural spine.	6·5	4·9	6·0	7·5	..

The other vertebræ are too much crushed to give any reliable measurements. The caudals in front of the bend in the tail are peculiar in bearing on the sides of their anterior and posterior borders prominences which give the outline of the articular surfaces a hexagonal form.

Scapula : width of articular end		2·5
Coracoid : length	(approx.)	8·0
width of upper end		4·5
Humerus : length		7·9
width of head		2·0
,, at deltoid crest		1·9
Femur : length in straight line		25·0
width of head		4·4
long diameter of middle of shaft		2·7

R. 2044 (Leeds Coll. 19). Skull and mandible less crushed than usual, so that the true form of the rostrum is, to a great extent, preserved.

Some dimensions (in centimetres) of this specimen are :—

Skull : length in middle dorsal line	57·5
,, to anterior end of nasals	38·7
,, of nasals	22·5

Skull: distance between nasals and premaxillæ		6·0
least width between orbits		8·9
width of snout at anterior end of nasals		4·9
distance between outer angles of prefrontals		13·0
length of the frontal anterior to the temporal fossæ		9·1
Mandible: length	(approx.)	63·5
length of symphysis		27·0
depth at coronoid angle		6 4

R. 2049 (Leeds Coll. 28). Imperfect skull and mandible, with two dorsal and one sacral vertebra, ilia, ischia, femora, tibiæ, fibulæ, and bones of hind foot. In this specimen the left ilium and the upper end of the left femur are deformed by the irregular outgrowths of bone due to disease or accident (see *M. superciliosum*, R. 2033, p. 184).

Some dimensions (in centimetres) of this specimen are :—

Skull: width between orbits		7·4
length of nasals	(approx.)	20·0
Ilium: length of dorsal border		3·7
,, acetabular border		4·7
Femur: length in straight line		22·6
long diameter of middle of shaft		2·1
Tibia: length		7·2
width of proximal end		2·3
,, distal end		1·8

R. 3900. Antorbital region of one side of rostrum. This specimen is almost completely uncrushed, displaying the relations of the prefrontals, nasals, and lachrymals as they are not shown in any other specimen examined (text-fig. 57). Although from the absence of compression, and incompleteness, it is difficult to compare this specimen with those in the usual condition, the relative slenderness of the rostrum, and the form of the sculpture on the prefrontals, make it probable that it belongs to the present species.

The dimensions (in centimetres) of this specimen are :—

Length of nasal	20·0
Distance between nasals and premaxillæ	9·5
Length of prefrontal	6·9
Width of prefrontal	4·9
Distance of antorbital foramen in front of orbit	3·6

R. 1666. Skull and mandible of a small individual probably of the present species, though the dorsal surface of the parietal bar between the supratemporal fossæ is somewhat wider than in other specimens. The length of the frontal anterior to the temporal fossæ is about equal to the interorbital width, as usual in this species; the frontal sculpture is not sharply defined.

Least width between the orbits	7·5
Width at outer angles of prefrontals	13·0
Length of the frontal anterior to the temporal fossæ	7·9

In the Catal. Foss. Rept., Brit. Mus. (pt. iv. p. 232) Mr. Lydekker refers this specimen to *M. superciliosum*, but, for the reasons given above, it seems more probably to belong to *M. moreli*.

R. 2040 (Leeds Coll. 15). Imperfect skull, probably of this species.

Metriorhynchus læve, n. sp.

[Pl. X.; text-figs. 65, 69 B, 73 A.]

Type Specimen.—Skull (Pl. X. figs. 1, 2; text-fig. 73, A), mandible, atlas, axis and five other cervicals, sixteen dorsals, all much crushed, cervical and dorsal ribs, coracoid, scapula, humerus, and right femur (R. 3015, Leeds Coll. 0). This specimen is selected as the type rather than the more nearly complete skeleton no. R. 3014, because the skull is in a better state of preservation.

The skull (Pl. X. fig. 1; text-fig. 73, A) is long and slender, and there is scarcely a trace of sculpture on any of the bones. The bar between the temporal fossæ is broad, especially in the frontal region. The anterior end of the frontal extends nearly to the level of the anterior angles of the prefrontals. The nasals are separated from the premaxillæ by an interval equal to about half their own length. The teeth are numerous, small, and rather close-set (Pl. X. fig. 2), there being ten teeth in the anterior ten centimetres of the mandible; their crowns are somewhat compressed, and the enamel only slightly sculptured with irregular ridges. The exact number cannot be made out, but there seem to have been upwards of 30 on each side of a mandible, the total length of which is about 49 cm.

The *fore limb* (text-fig. 69, B) is greatly reduced, the humerus being shorter than the scapula, which exceeds the coracoid in length; the reverse is the case in *M. superciliosum*. On the other hand, the tibia (Pl. X. fig. 3) is a little longer in proportion to the femur than in *M. superciliosum*. The slenderness of the skull, the absence of sculpture on the frontals and other bones, the comparative smoothness of the teeth, and the great reduction of the fore limb, point to the probable descent of *Geosaurus gracilis* from this or a closely similar species.

R. 3015 (Leeds Coll. 0). Skull (Pl. X. fig. 1), mandible, atlas, axis, and five other cervicals, sixteen dorsals, all much crushed, cervical and dorsal ribs, coracoid, scapula, humerus, right femur. Type specimen.

The dimensions (in centimetres) of this specimen are :—

Skull (Pl. X. fig. 1):		
length in mid-dorsal line		48·0
length of nasals		15·0
distance between nasals and premaxillæ		10·0
least width between orbits		5·5
width between outer angles of prefrontals		11·4
„ „ „ frontals		9·8
length of frontal anterior to temporal fossæ		8·2
Coracoid: length	(approx.)	5·3
Scapula: length	(approx.)	6·4
width of articular end		2·0
Humerus: length		5·2
Femur: length in straight line		21·0
width of head		3·8

R. 3014 (Leeds Coll. 5). Skull (Pl. X. fig. 2) and mandible, atlas, axis, and five other cervical vertebral centra, sixteen dorsals with transverse processes, two sacrals, and thirty-five caudals (Pl. X. fig. 5 ; text-fig. 65), numerous cervical and dorsal ribs, right coracoid and scapula (text-fig. 69, B), humeri (text-fig. 69, B), right femur, tibia, fibula, and almost all the bones of the tarsus and pes (Pl. X. figs. 3, 4) ; some chevrons.

This specimen exhibits very well the form of the vertebræ at the bend of the tail (text-fig. 65). The right hind limb (Pl. X. figs. 3, 4) is the most nearly complete in the collection, and its value is increased by the fact that, so far at least as the relations of the tibia and fibula to the astragalus and calcaneum are concerned, the position shown is certainly correct, the bones being partially united in the natural position by matrix. The structure of the tarsus is closely similar to that shown by v. Meyer * in his figure of the foot of *Rhacheosaurus* ; it is also very similar to the tarsus of *Geosaurus* figured by Fraas †. The tail in this specimen seems to be nearly complete, probably only one, or at most two, terminal vertebræ being wanting (Pl. X. fig. 5).

The dimensions (in centimetres) of this specimen are :—

Skull (Pl. X. fig. 2):		
length in mid-dorsal line		45·0
length of nasals	(approx.)	13·5
distance between nasals and premaxillæ	(approx.)	9·5
least width between orbits	(approx.)	4·0
width between outer angles of prefrontals	(approx.)	9·0
Mandible: length		49·2
depth at coronoid process		4·5

* Fauna der Vorwelt: Rept. Lith. Schiefer (1860), pl. xvi. fig. 8.

† Palæontographica, vol. xlix. (1902), pl. viii. fig. 9.

The vertebræ are for the most part crushed, so that the following measurements can be only partly accurate :—

	Axis.	Middle cervical.	First dorsal.	Posterior dorsal.	Anterior caudal.	Vertebræ at the curve of the tail.			Vertebræ at end of tail.	
						1.	2.	3.		
Length of centrum in mid-ventral line . .	2·9	2·9	3·2	3·6	3·3	1·8	1·3	1·5	1·7	1·3
Width of posterior face of centrum . . .	1·9	2·3	2·5	2·3	2·4	1·6	1·4	1·5	0·6	0·5
Height of posterior face of centrum . . .	2·5	2·3	..	2·5	2·6	2·0	1·9	1·9	1·2	0·8
Height to top of neural spine	..	..	..	..	6·8	3·3	4·5	4·4	..	..

The length in the middle dorsal line of the centra of the second and third caudal vertebræ at the curve of the tail is 2·2 and 2·3 respectively.

Shoulder-girdle (text-fig. 69, B):	
Coracoid: length	4·9
width of distal expansion	3·0
,, neck	1·0
Scapula: length	6·0
width of articular end	1·8
,, middle of shaft	0·6
,, upper end	0·8
Humerus (text-fig. 69, B): length	4·3
width of head	1·0
,, at deltoid crest	1·3
Hind limb (Pl. X. figs. 3, 4):	
Femur: length in straight line	17·8
greatest width of head	3·1
long diameter of the middle of the shaft	1·9
width of condyles	1·9
Tibia: length	6·8
width of upper end	2·2
,, lower end	1·5
Fibula: length	6·8
width of upper end	1·7
,, lower end	1·5
Astragalus: width	2·1
length	1·3
Calcaneum: width	2·0
length	1·3
First metatarsal: length	5·7
width of upper end	2·2
Second metatarsal: length	6·2
Third metatarsal: length	6·5

R. 2042 (Leeds Coll. 17). Imperfect skull and mandible, teeth, imperfect atlas and axis, three other cervicals, and twenty other much crushed vertebræ, numerous fragments of ribs.

The approximate dimensions (in centimetres) of this specimen are :—

Skull: length in mid-dorsal line		51·0
„ to tip of nasals		34·5
length of nasals		18·5
distance between nasals and premaxillæ		8·0
least width between orbits		7·0
distance between outer angles of prefrontals		12·0
Mandible: length of symphysis	(approx.)	21·0

R. 2031 (Leeds Coll. 22). A small imperfect and much-crushed skull.

The dimensions (in centimetres) of this specimen are :—

Length from occipital surface to tip of maxillæ	(approx.)	43·0
„ to tip of nasals		28·2
„ of nasals		16·3
Distance between nasals and premaxillæ		9·0
Width between outer angles of quadrates		13·3
Least width between orbits		5·7
Width between outer angles of prefrontals		10·9
Length of the frontal anterior to temporal fossæ		7·9

Metriorhynchus leedsi, n. sp.

[Plate XI. fig. 1 ; text-fig. 73, B.]

Type Specimen.—An incomplete skull (R. 3540) (Pl. XI. fig. 1).

Only the skull is known in this species, and in both the specimens available the premaxillæ are wanting. As in *M. læve*, there is no sculpture on the frontals and prefrontals, which exhibit a slightly roughened fibrous appearance ; but the skull, in proportion to its length, is broader and more heavily built than in *M. læve*. The length of the frontal anterior to the temporal fossæ is about equal to the least width between the orbits ; in *M. læve* it is much greater. The form of the frontals will be best understood from the figures (Pl. XI. fig. 1 ; text-fig. 73, B) ; the prefrontals take a greater share in the formation of the upper border of the orbit than in *M. læve*, and their orbital edge bears a series of small irregular notches. The nasals are separated from the premaxillæ by a space rather greater than half their own length.

This species is distinguished from all the others, not only by the smoothness of the skull-bones, but also by the great number of the teeth. Of these, there are about 36 in each maxilla, the alveoli being separated from one another only by thin walls.

R. 3540 (Leeds Coll. 140). Imperfect skull (Pl. XI. fig. 1) wanting the premaxillæ and the jugal arch; the whole is much crushed from above downwards, so that, as usual, the palate is almost entirely destroyed. Type specimen.

The dimensions (in centimetres) of this specimen are :—

Length from occipital surface to tip of maxillæ	51·7
„ „ „ nasals	35·5
Length of nasals	20·0
Distance between nasals and premaxillæ	8·5
Width between outer angles of quadrates	17·8
Least width between orbits	9·5
Width between outer angles of prefrontals	14·6
Length of the frontal anterior to temporal fossæ	9·3

R. 3899. Imperfect skull wanting the premaxillæ and jugal arch: much crushed from above downwards.

The dimensions (in centimetres) of this specimen are :—

Length from occipital surface to tip of maxillæ	(approx.)	52·0
„ to tip of nasals		34·8
„ of nasals		19·4
Distance between nasals and premaxillæ	(approx.)	10·0
Width between outer angles of quadrates		18·0
Least width between orbits		7·7
Width between outer angles of prefrontals		13·8
Length of the frontal anterior to temporal fossæ		8·5

Metriorhynchus cultridens, n. sp.

[Pl. XI. figs. 2–4; text-figs. 60, 61 B, C, 66, 73 E.]

Type Specimen.—A skull and mandible (Pl. XI. figs. 2, 3; text-fig. 60, 73 E), teeth (Pl. XI. figs. 4, 4 *a*, 4 *b*, 4 *c*), atlas and axis (text-figs. 61 B, C), four other cervicals, sixteen dorsals, two sacrals and thirty-seven caudals (text-fig. 66), numerous ribs, chevrons, ilium, ischia, pubes, femora, and odd bones of hind foot. (R. 3804, Leeds Coll. 170.)

This species has been founded for a type of *Metriorhynchus* in which the rostrum is comparatively short, though the shortening is not carried so far as in *M. brachyrhynchus*, and the nasals are separated from the premaxillæ by an interval equal to about a quarter of their own length. The supraorbital notch forms a very open continuous curve; the frontals bear a slightly developed sculpture of irregular grooves, which are much more strongly developed on the prefrontals. The teeth (Pl. XI. fig. 4) are strongly compressed, with long, relatively slender, and almost completely smooth

crown, with sharp carinæ. There are twenty teeth in the premaxilla and maxilla, and seventeen in the mandible.

R. 3804 (Leeds Coll. 170). Skull, mandible, teeth (Pl. XI. figs. 2–4 ; text-fig. 60), atlas and axis (text-fig. 61 B, C), four other cervicals, sixteen dorsals, two sacrals, and thirty-seven caudals (text-fig. 66), ilium, ischia, pubes, femora and some odd foot-bones. Type specimen.

In this specimen the posterior part of the skull was embedded in hard matrix, and consequently is little crushed, the form of the occipital region being exceptionally well shown ; the mandible also is very well preserved.

The dimensions (in centimetres) of this specimen are :—

Skull (Pl. XI. fig. 2) :	
length in mid-dorsal line	73·8
„ from occipital condyle to tip of snout	76·8
„ from occipital surface to tip of nasals	52·8
„ of the nasals	25·2
distance between nasals and premaxillæ	5·8
least width between orbits	12·3
width between outer angles of prefrontals	25·5
length of the frontal anterior to temporal fossæ	14·3
width between outer angles of quadrates (approx.)	25·4
Mandible (Pl. XI. fig. 3 ; text-fig. 60) :	
length	80·9
length of symphysis	34·0
depth at coronoid angle	10·7

Vertebræ	Axis.	Middle cervical.	Middle dorsal.	Second sacral.	Anterior caudal.	Middle caudal.	Caudals at bend of tail.			
							1.	2.	3.	4.
Length of centrum in mid-ventral line	4·2	4 5	5·5	..	4·4	4·8	3·0	2·5	2·4	2·7
Width of posterior face of centrum	3·9	4·5	4·2	4·1	5·0	3·3	2·3	2·2	2·9	2·1
Height of posterior face of centrum	3·8	?3·9	4·1	4·0	4·2	3·3	2·9	2·9	2·9	2·8
Height to top of neural spine	..	..	..	9·9	10·3	7·7	6·2	7·5	7·8	..

The width of the body of the atlas (odontoid) is 4·6, the height 4·1. The width of the anterior subvertebral wedge-bone is 4·7.

Ilium : length from antero-superior to postero-inferior border.	8·0
„ of acetabular border	6·8
Ischium : length of symphysial border.	15·9
„ from articular surface to posterior angle	14·8

Pubis:	length	13·0
	width of distal expansion	6·7
	length of straight symphysial border	5·2
	width of upper end	2·5
Femur:	length in straight line	31·0
	greatest width of head	5·0
	long diameter of middle of shaft	3·2
First metatarsal:	length	9·6

R. 3541 (Leeds Coll. 146). An imperfect skull.

The dimensions (in centimetres) of this specimen are :—

Length of nasals	19·5
Distance between nasals and premaxillæ	3·8
Least width between orbits	8·8
Width between outer angles of prefrontals	16·6
Length of the frontal anterior to temporal fossæ	10·5

Metriorhynchus brachyrhynchus, Deslongchamps.

[Pl. XII.; text-figs. 58, 59, 73 F.]

1867. *Metriorhynchus brachyrhynchus*, E. E. Deslongchamps, Notes Paléontologiques, p. 333.

Type Specimen.—A skull from the Oxfordian beds of Calvados (Normandy) described and figured by E. E. Deslongchamps in 'Notes Paléontologiques' (1867), p. 333, pl. xxiii. fig. 1 *a–d*.

Skull (Pl. XII.) with short rostrum, in which the nasals meet, or nearly meet, the premaxillæ. The outer angles of the prefrontals are about right angles, and the supraorbital notch forms an acute angle. The posterior angles of the nasals are considerably in front of a line joining the outer angles of the prefrontals. The sculpture on the frontals is only slightly developed, but on the prefrontals, and especially on the processes of the nasals external to the prefrontals, it is strongly marked. There are twenty-one or twenty-two teeth on each side of the upper jaw; the crowns of the teeth are stout and moderately compressed, and the posterior carina is more strongly marked than the anterior one; the enamel is nearly smooth.

The skull in this species was described in detail by E. E. Deslongchamps in 'Notes Paléontologiques' (1867), p. 333, and more recently by Mr. E. Thurlow Leeds in the Quart. Journ. Geol. Soc. vol. lxiv. (1908), p. 345. The last-named writer has given a good account of the palate, which in this species is better preserved than in any other, probably on account of the relatively greater massiveness of the bones. Except perhaps a few vertebræ (see below, R. 3939), nothing is known of this species except the skull.

R. 3700 (Leeds Coll. 165). Skull (Pl. XII.; text-figs. 58, 59) wanting the anterior portion of the premaxilla. Much of the palate (Pl. XII. fig. 2) is preserved, and has been described and figured by E. T. Leeds in Quart. Journ. Geol. Soc. vol. lxiv. (1908), pp. 351–356, figs. 1 & 2; the skull as a whole is figured on pls. xl. & xli. fig. 2 of the same paper.

The dimensions (in centimetres) of this specimen are:—

Length in mid-dorsal line	(approx.)	61·5
„ from occipital condyle to tip of snout	(approx.)	68·0
Greatest length of nasals		25·0
Distance between nasals and premaxillæ		0·0
Length of the frontal anterior to temporal fossa		11·0
Least width between orbits		10·4
Width between outer angles of prefrontals		21·3

R. 3699 (Leeds Coll. 164). A much-crushed skull wanting a great part of the right premaxilla and the right jugal arch; a large part of the palate is preserved. Figured by E. T. Leeds in Quart. Journ. Geol. Soc. vol. lxiv. (1908) pls. xl. & xli. fig. 1.

The dimensions (in centimetres) of this specimen are:—

Length of skull in mid-dorsal line	63·5
„ from occipital condyle to tip of snout	70·0
Greatest length of nasals	24·7
Distance between nasals and premaxillæ	1·6
Length of the frontal anterior to temporal fossæ	12·8
Least width between orbits	10·5
Width between outer angles of prefrontals	22·4
„ „ „ quadrates	24·7

R. 3939. Imperfect skull and mandible, with eight distorted vertebræ, of a large individual, probably of this species. Some of the teeth are well preserved in this specimen.

Owing to the imperfection of the specimen very few measurements can be given. These (in centimetres) are:—

Length of the frontal anterior to temporal fossæ	14·5
Least width between orbits	12·6
Width between the outer angles of the prefrontals	23·3

Metriorhynchus durobrivense, Lydekker, sp.

[Pl. XIII.; text-fig. 73, G.]

1890. *Suchodus durobrivensis*, Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. p. 284.

Type Specimen.—Symphysial portion of a mandible described and figured by Lydekker in Quart. Journ. Geol. Soc. vol. xlvi. (1890) p. 284, fig. 2. (R. 1994.)

This species is a broad-skulled, short-snouted form (text-fig. 73, G), in which the nasals do not quite reach the premaxillæ; a line drawn through the posterior end of the

nasals passes through the outer angles of the prefrontals. The supraorbital notch is sharply angulated. The portion of the frontals between the temporal fossæ is broad and flat; in the parietal region the intertemporal bar narrows very rapidly. The pitted sculpture is moderately well developed on the frontals, but is most marked on the outer edge of the prefrontals. The teeth are about sixteen on each side in the upper jaw and twelve to fourteen in the lower; their crowns are compressed, and the anterior and posterior carinæ well marked; the enamel is nearly smooth, there being only an extremely fine sculpture of numerous longitudinal ridges.

R. 1994. Symphysial portion of a mandible and some teeth. Type specimen described and figured by Lydekker in Quart. Journ. Geol. Soc. vol. xlvi. (1890) p. 284, figs. 2 & 3. This specimen seems to have undergone considerable compression from above downwards, so that its width is exaggerated. There are twelve dental alveoli on the right side and thirteen on the left. The splenials extend forwards to the level of the seventh tooth on the left side. The length of the symphysis is about 21 cm., that of the alveolus-bearing part of the dentary about 23 cm.

R. 3321. An imperfect and much flattened skull of a large individual; the premaxillary region is wanting. A few teeth are preserved.

Some dimensions (in centimetres) of this specimen are :—

Length in mid-dorsal line to hinder extremity of premaxillæ	42·4
„ to anterior end of nasals	40·7
„ of nasals	19·6
Distance between nasals and premaxillæ	1·8
Least width between orbits	11·9
Width between outer angles of prefrontals	22·9
Length of the frontal anterior to the temporal fossæ	10·9

The measurements of width are too great, through the crushing that has been undergone.

R. 2039 (Leeds Coll. 8). An incomplete skull wanting the occipital, premaxillary, and palatine regions; also an imperfect left ramus of the mandible, which is strongly compressed laterally, so that it differs widely in appearance from the type mandible (R. 1994), in which the compression is vertical; the number of mandibular teeth is thirteen or fourteen.

Some dimensions (in centimetres) of this specimen are :—

Length of nasals	18·7
Distance between nasals and premaxillæ	2·5
Least width between orbits	12·7
Width between outer angles of prefrontals	22·9
Length of the frontal anterior to the temporal fossæ	11·2
„ mandibular symphysis (approx.)	25·0

R. 2618. A nearly complete skull (Pl. XIII.) and mandible of a young individual, comparatively little crushed and with many of the bones disarticulated; the vomer (Pl. XIII. fig. 4) and other bones of the palate are well preserved. Also atlas and axis (wanting neural arch of atlas), four other cervical vertebræ, fourteen dorsals, two sacrals, and some caudals, some ribs, right and part of left ilium, pubes, left and part of right femur, tibia, fibula, odd bones of foot.

Some approximate dimensions (in centimetres) of this specimen are:—

Skull (Pl. XIII.):

length in mid-dorsal line	42·5
,, to anterior angle of nasals	30·0
,, of nasals	14·8
distance between nasals and premaxillæ	2·6
least width between orbits	7·2
width between outer angles of prefrontals	14·9
length of the frontal anterior to temporal fossæ	8·0

Vertebræ	Axis.	Middle cervical.	Last cervical.	Middle dorsal.	Second sacral.	Middle caudal.
Length in mid-ventral line.	2·6	2·7	3·2	3·6	3·2	3·1
Width of posterior face of centrum	2·2	2·5	2·5 (app.)	2·5	2·4	1·9
Height of posterior face of centrum	2·4	2·6	..	2·4	2·4	2·2

Ilium: length of dorsal border	2·8
,, acetabular border	3·9
distance from antero-superior to postero-inferior angle	4·2
Pubis: length	7·7
width of distal expansion	3·9
Femur: length in straight line	17·0
greatest width of head	2·8
long diameter of middle of shaft	1·7
Tibia: length	7·3
width of upper end	2·4
,, lower end	1·6

ADDENDUM.

THE teeth of *Peloneustes philarchus* (Pl. IV. figs. 3–5) vary much in different parts of the jaw (see pp. 42, 43, and 46). The larger teeth (Pl. IV. figs. 3, 5) have a high, sharp-pointed, and somewhat curved crown, which is nearly circular in section. At the base the enamel is raised into numerous fine ridges running towards the point, but for the most part not reaching more than half-way; only two of the strongest ridges actually reach the tip. The ridges are more numerous on the inner (concave) than on the outer (convex) side of the crown. The root is long, circular in section, and narrowing towards its lower end: there is a large pulp-cavity. The smaller teeth (Pl. IV. fig. 4) have a short, somewhat sharply curved crown with numerous strong enamel-ridges all round. In the upper jaw there are six teeth in the premaxilla and twenty-eight to thirty in the maxilla. In the lower jaw the number is about forty, of which fourteen to sixteen are in the symphysial region.

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[The asterisk denotes a figure on that page.]

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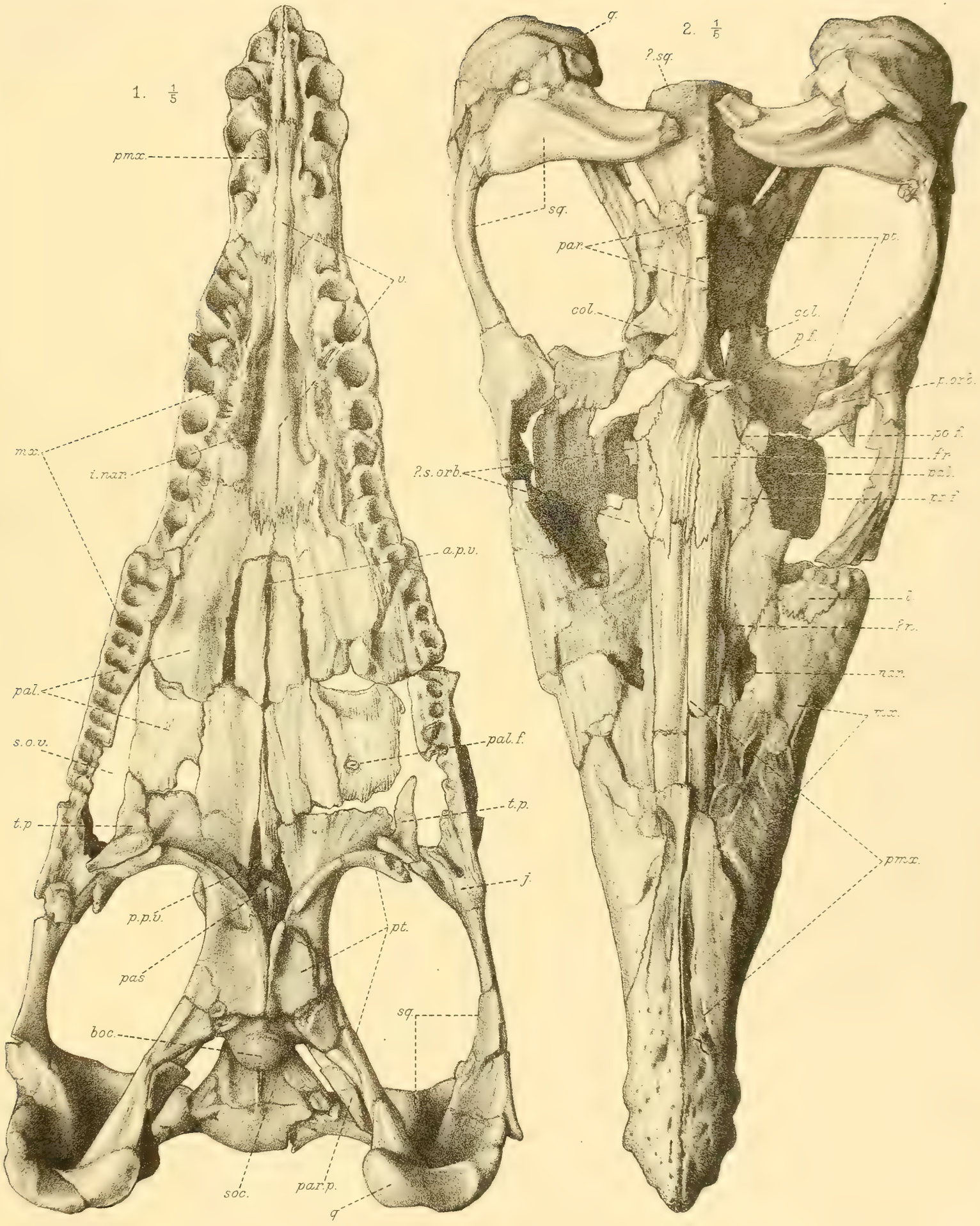
a.p.v., anterior interpterygoid vacuity.
boc., basioccipital.
col., columella cranii (epipterygoid).
fr., frontal.
i.nar., internal nares.
j., jugal.
l., lachrymal.
mx., maxilla.
?n., nasal.
nar., external nares.
pal., palatine.
pal.f., palatine foramen.
par., parietal.
par.p., paroccipital process.
pas., parasphenoid.
p.f., pineal foramen.
pmx., premaxilla.
po.f., postfrontal.
p.orb., postorbital.
p.p.v., posterior interpterygoid vacuity.
pr.f., prefrontal.
pt., pterygoid.
q., quadrate.
soc., supraoccipital.
?s.orb., ? supraorbital bone.
s.o.v., suborbital vacuity.
sq., squamosal.
t.p., transpalatine.
v., vomer.



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PLIOSAURUS FEROX.

PLATE II.

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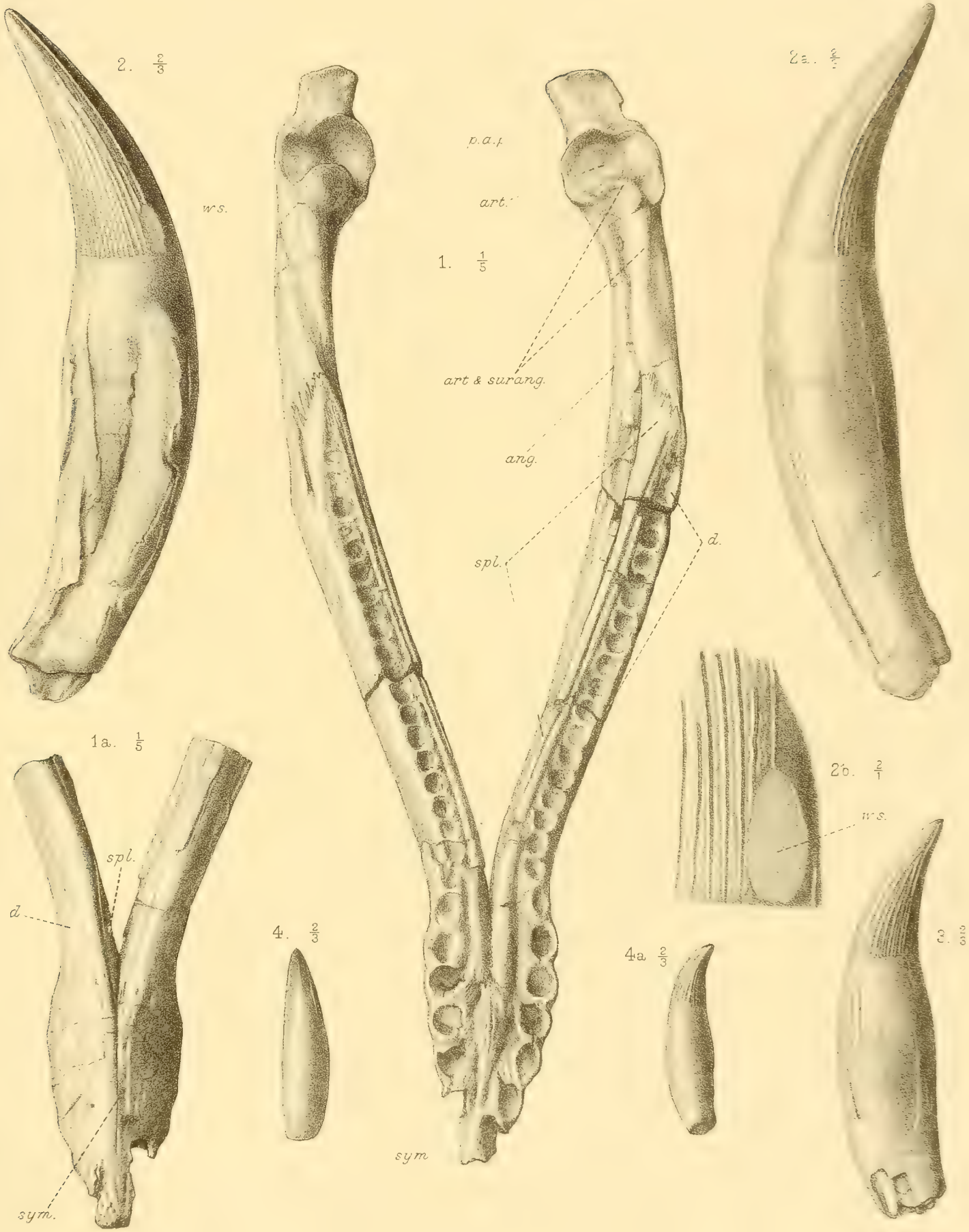
ang., angular.
art., articular surface for quadrate.
art. & surang., conjoined articular and surangular.
d., dentary.
p.a.p., postarticular process.
spl., splenial.
sym., symphysis.
w.s., wear-surface of tooth.



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PLIOSAURUS FEROX.

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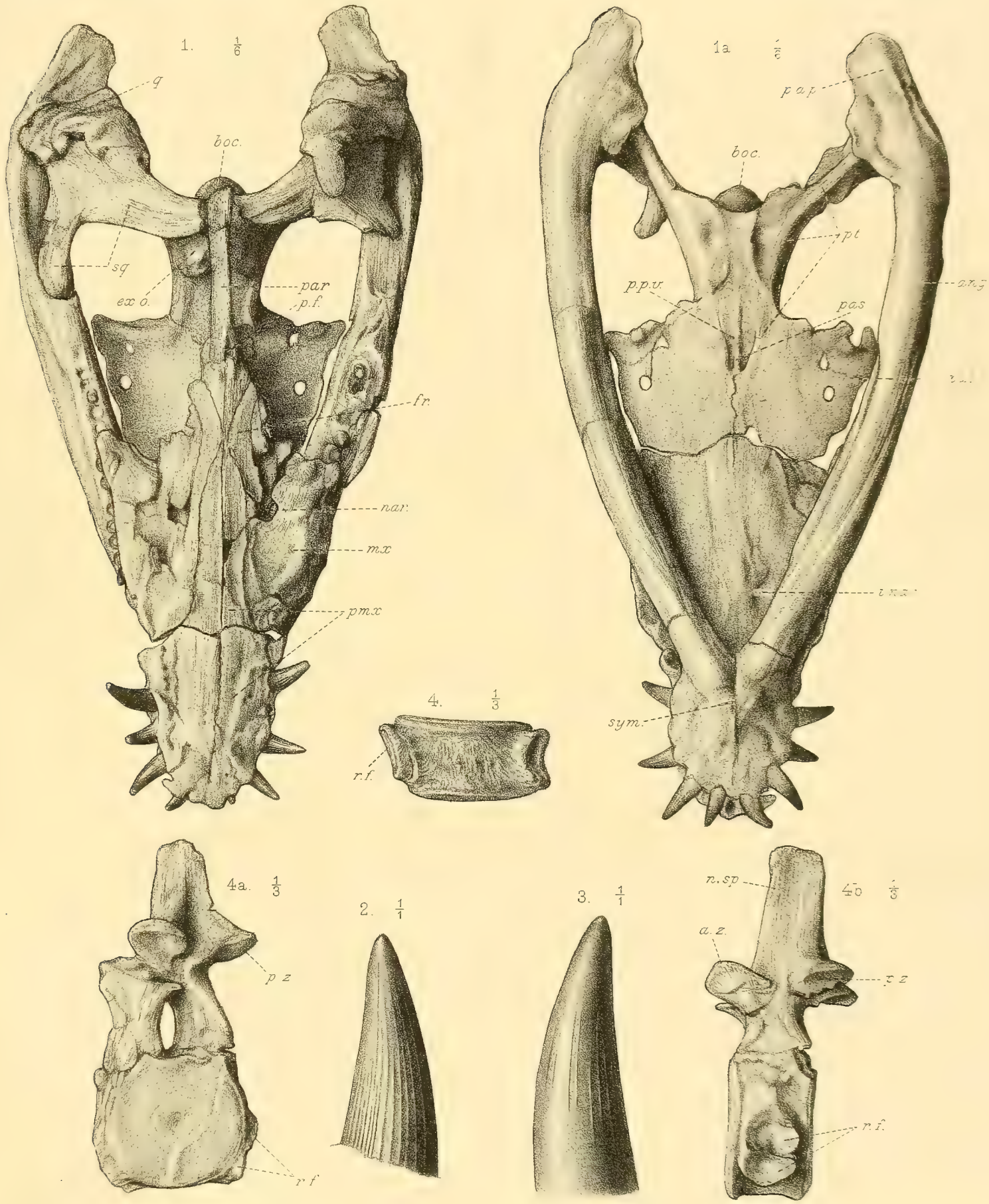
All the specimens figured in this Plate are parts of the type-skeleton, **R. 3319.**

ang., angular.
a.z., anterior zygapophysis.
boc., basioccipital.
ex.o., exoccipital.
fr., frontal.
i.nar., internal nares.
mx., maxilla.
nar., external nares.
n.sp., neural spine.
pal., palatine.
par., parietal.
p.a.p., postarticular process.
pas., parasphenoid.
p.f., pineal foramen.
pmx., premaxilla.
p.p.v., posterior interpterygoid vacuity.
pt., pterygoid.
p.z., posterior zygapophysis.
q., quadrate.
r.f., facet for cervical rib.
sq., squamosal.
sym., symphysis of mandible.



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SIMOLESTES VORAX.

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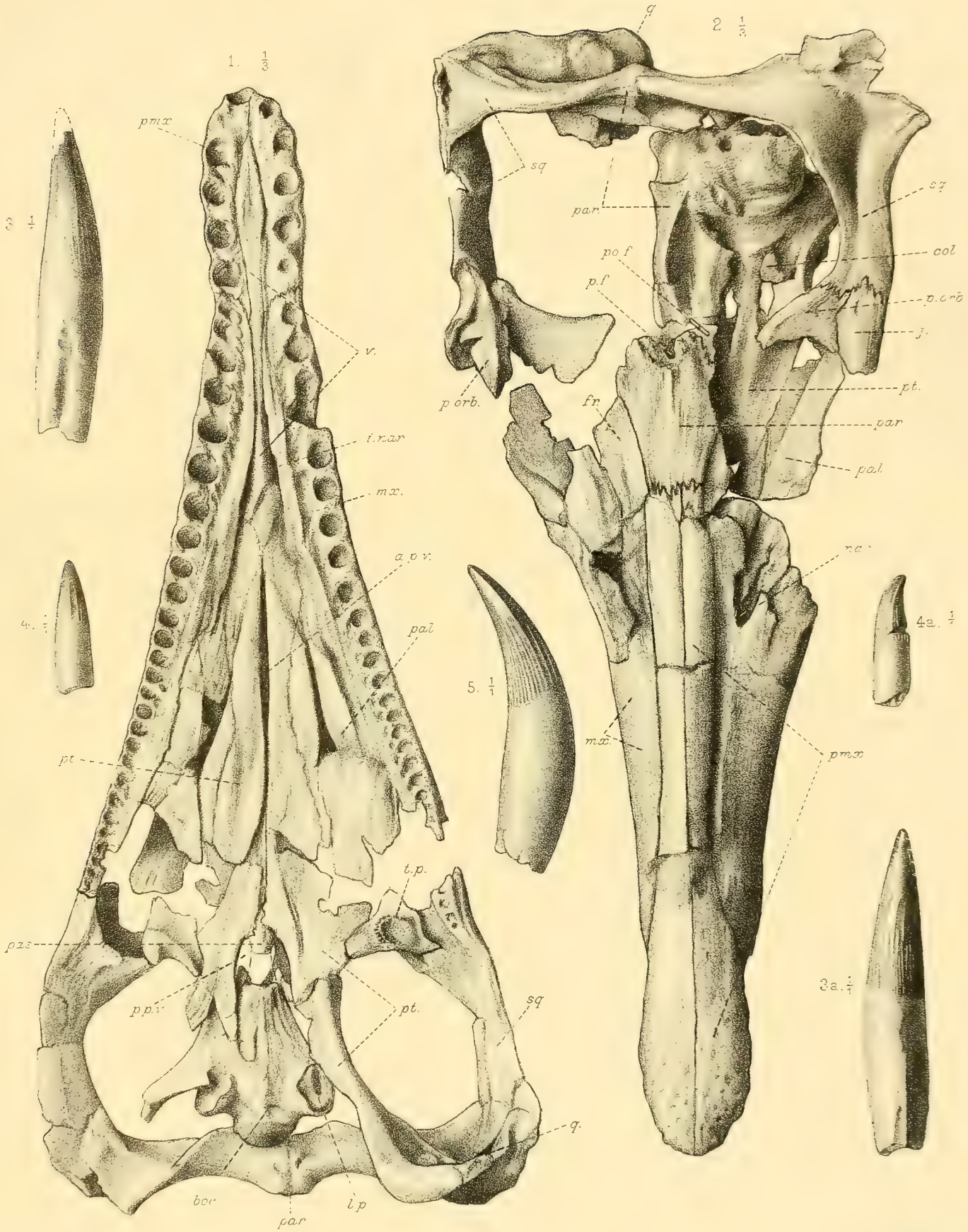
a.p.v., anterior interpterygoid vacuity.
boc., basioccipital.
col., columella cranii (epipterygoid).
fr., frontal.
i.nar., internal nares.
j., jugal.
l.p., lateral processes of basioccipital.
mx., maxilla.
n.ex., external nares.
pal., palatine.
par., parietal.
pas., parasphenoid.
p.f., pineal foramen.
pmx., premaxilla.
po.f., postfrontal.
p.orb., postorbital.
p.p.v., posterior interpterygoid vacuities.
pt., pterygoid.
q., quadrate.
sq., squamosal.
t.p., transpalatine.
v., vomer.



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PELONEUSTES PHILARCHUS.

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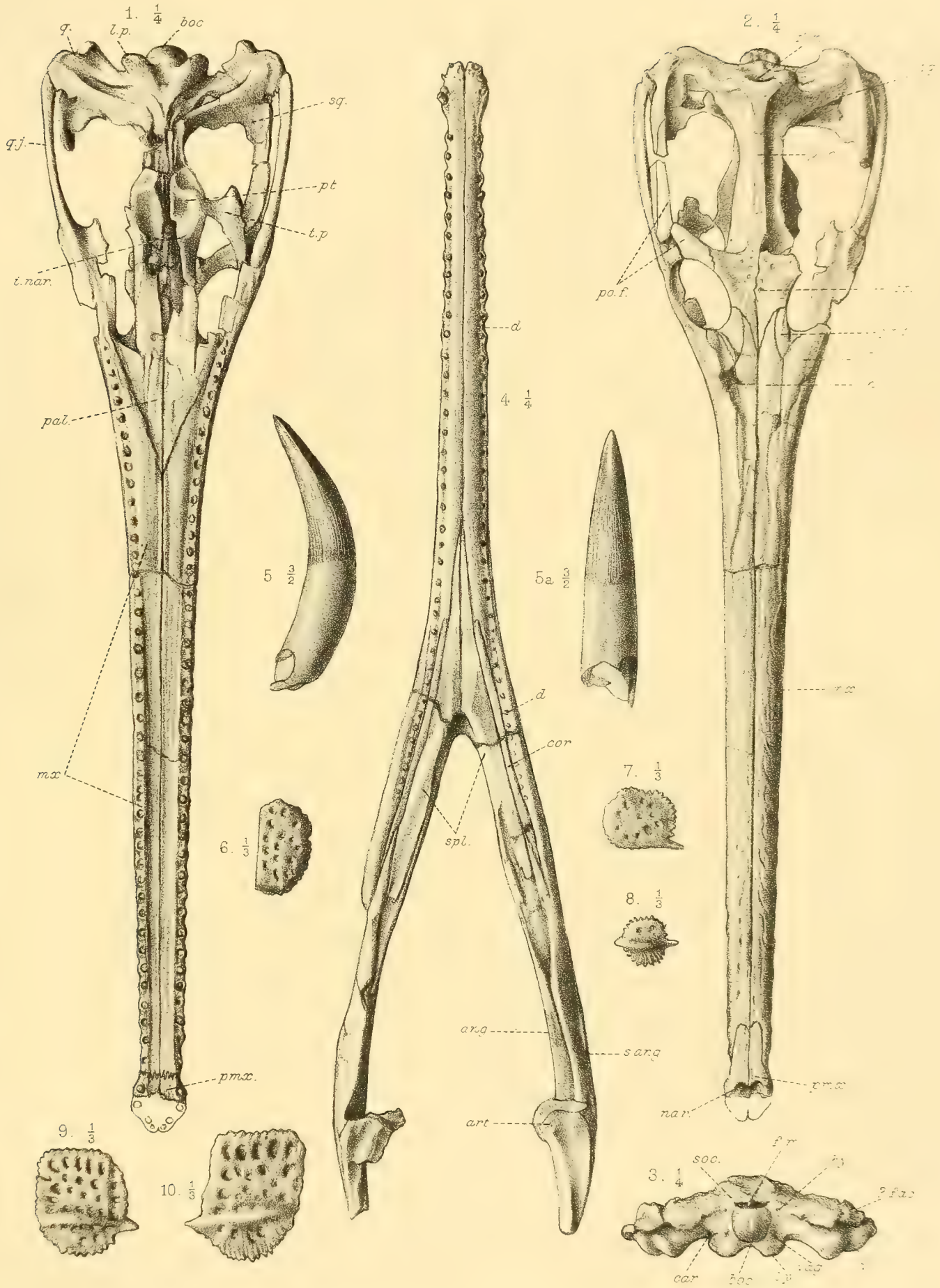
ang., angular.
art., articular.
boc., basioccipital.
car., carotid foramen.
cor., coronoid.
d., dentary.
fac., foramen for facial nerve (VII.).
f.m., foramen magnum.
fr., frontal.
hy., hypoglossal foramen.
i.nar., internal nares.
l., lachrymal.
l.p., lateral processes of basioccipital.
mx., maxilla.
n., nasal.
nar., external nares.
pal., palatine.
par., parietal.
pmx., premaxilla.
po.f., postfrontal.
pr.f., prefrontal.
pt., pterygoid.
q., quadrate.
q.j., quadrato-jugal.
s.ang., surangular.
soc., supraoccipital.
spl., splenial.
sq., squamosal.
t.p., transpalatine.
vag., foramen for vagus nerve (X.).



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STENEOSAURUS LEEDSI.

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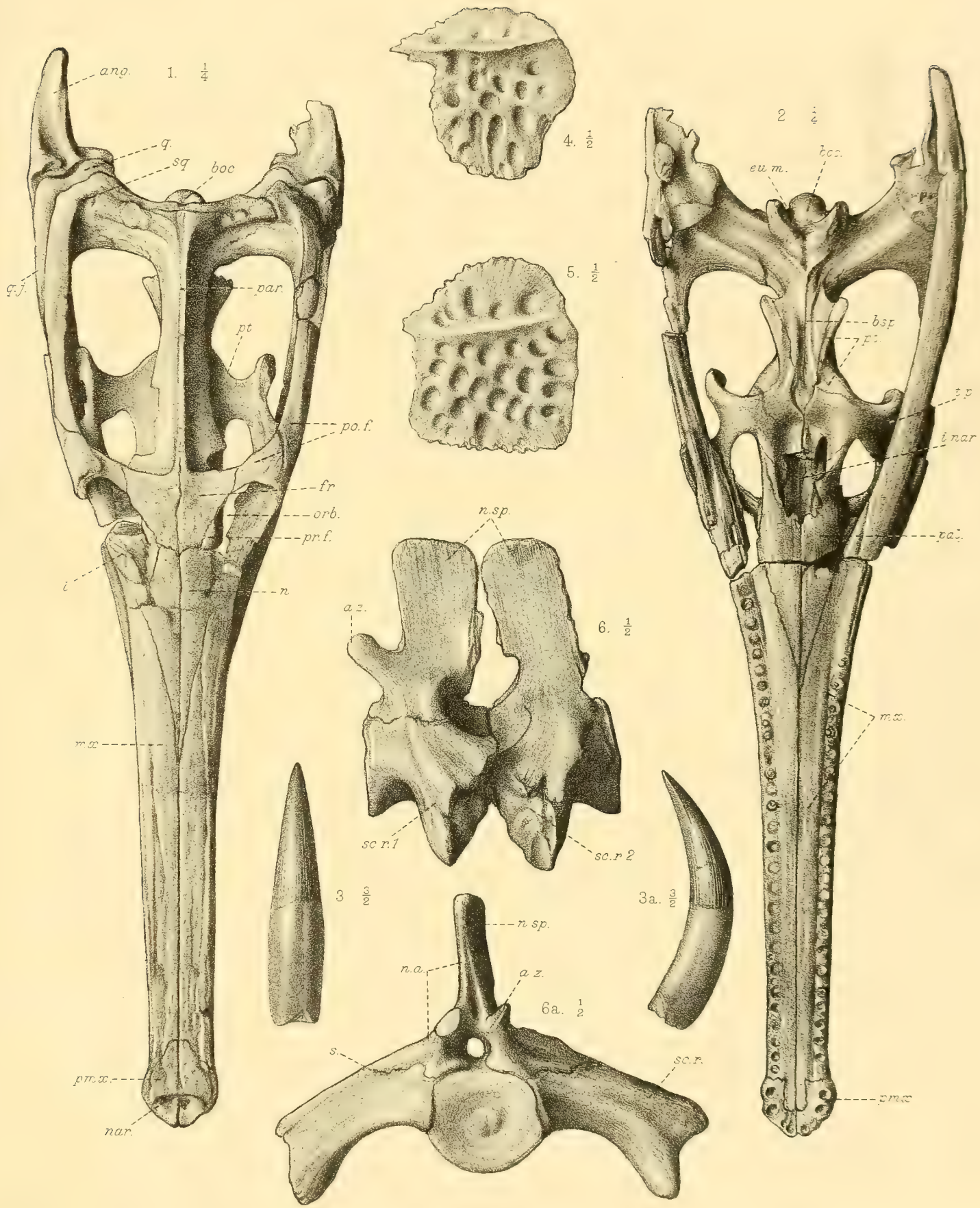
All the specimens figured in this Plate are parts of the type skeleton, **R. 3701.**

ang., angular.
a.z., anterior zygapophysis.
boc., basioccipital.
bsp., basisphenoid.
eu.m., median eustachian opening.
fr., frontal.
i.nar., internal nares.
l., lachrymal.
mx., maxilla.
n., nasal.
n.a., neural arch.
nar., external nares.
n.sp., neural spine.
orb., orbit.
pal., palatine.
par., parietal.
pmx., premaxilla.
po.f., postfrontal.
pr.f., prefrontal.
pt., pterygoid.
q., quadrate.
q.j., quadrato-jugal.
s., suture between neural arch and sacral rib.
sc.r., sacral rib.
sq., squamosal.
t.p., transpalatine.



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STENEOSAURUS DUROBRIVENSIS.

PLATE VII.

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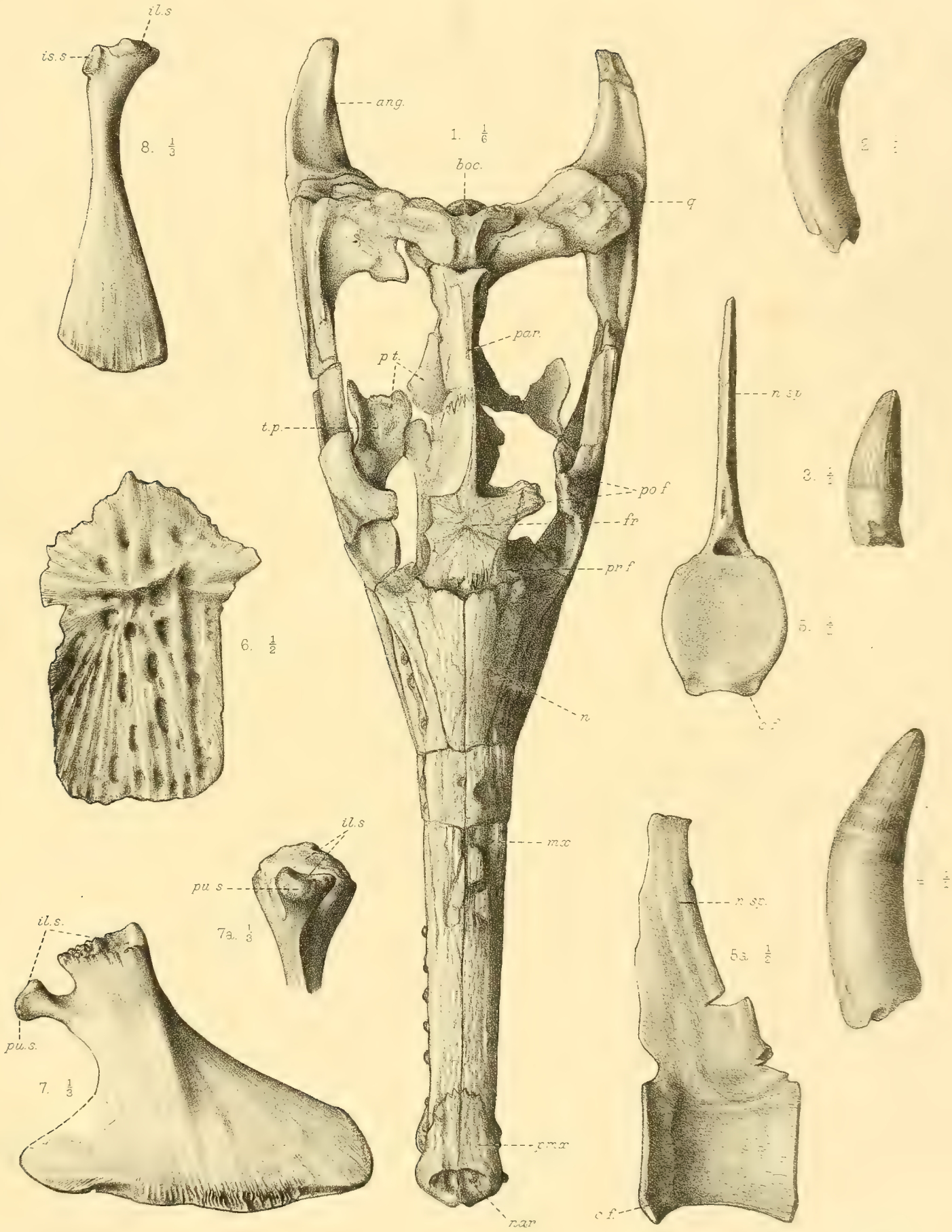
ang., post-articular process of mandible.
boc., basioccipital.
c.f., chevron facet.
fr., frontal.
il.s., surface for ilium.
is.s., surface for ischium.
mx., maxilla.
n., nasal.
n.sp., neural spine.
nar., external nares.
par., parietal.
pmx., premaxilla.
po.f., postfrontal.
pr.f., prefrontal.
pt., pterygoid.
pu.s., surface for pubis.
q., quadrate.
t.p., transpalatine.



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STENEOSAURUS OBTUSIDENS.

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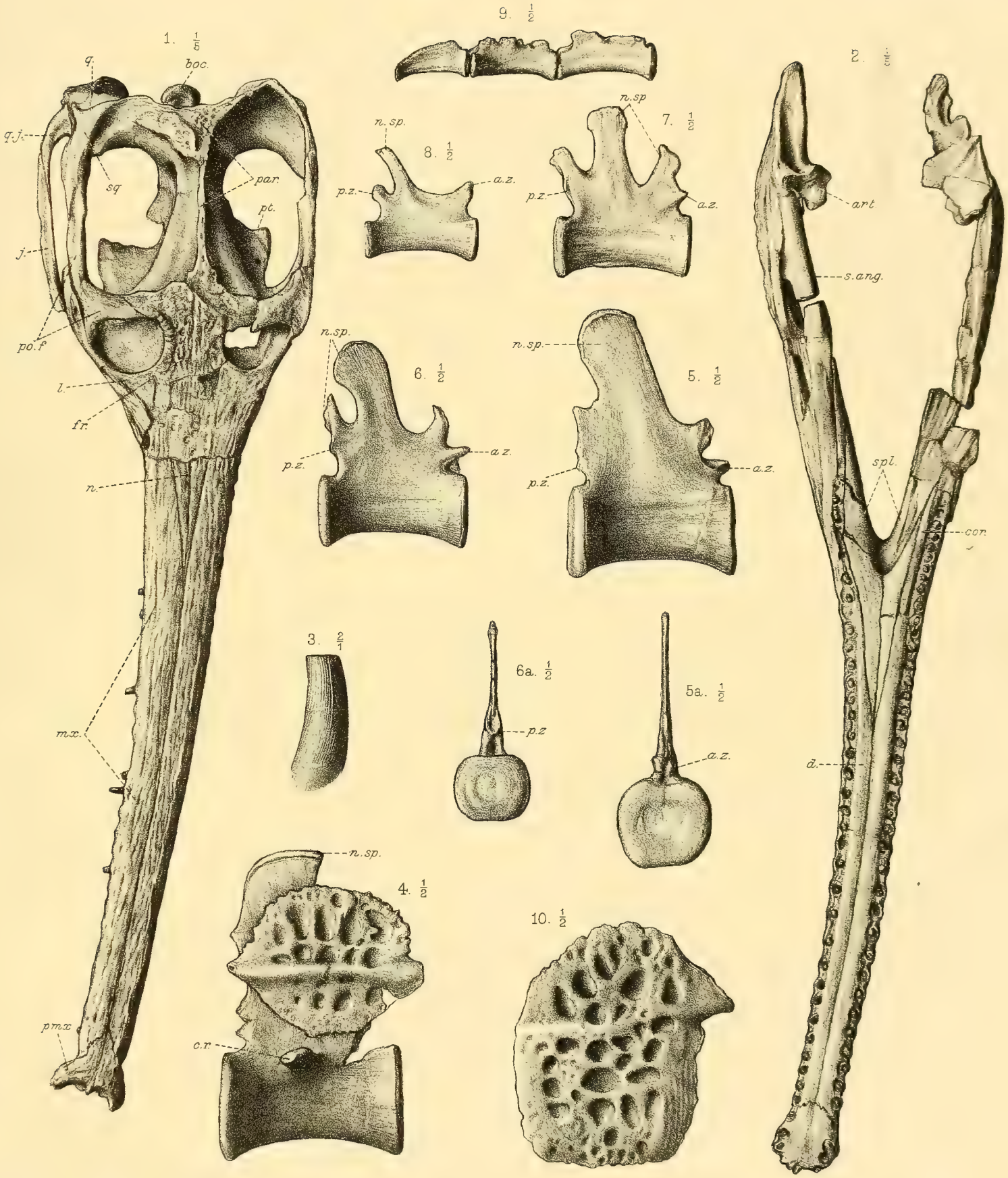
All the specimens figured in this Plate are parts of the type skeleton (**R. 2617**).

art., articular.
a.z., anterior zygapophysis.
boc., basioccipital.
c.r., caudal rib.
cor., coronoid.
d., dentary.
fr., frontal.
j., jugal.
l., lachrymal.
mx., maxilla.
n., nasal.
n.sp., neural spine.
par., parietal.
pmx., premaxilla.
po.f., postfrontal.
pt., pterygoid.
p.z., posterior zygapophysis.
q., quadrate.
q.j., quadrato-jugal.
s.ang., surangular.
spl., splenial.
sq., squamosal.



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MYCTEROSUCHUS NASUTUS.

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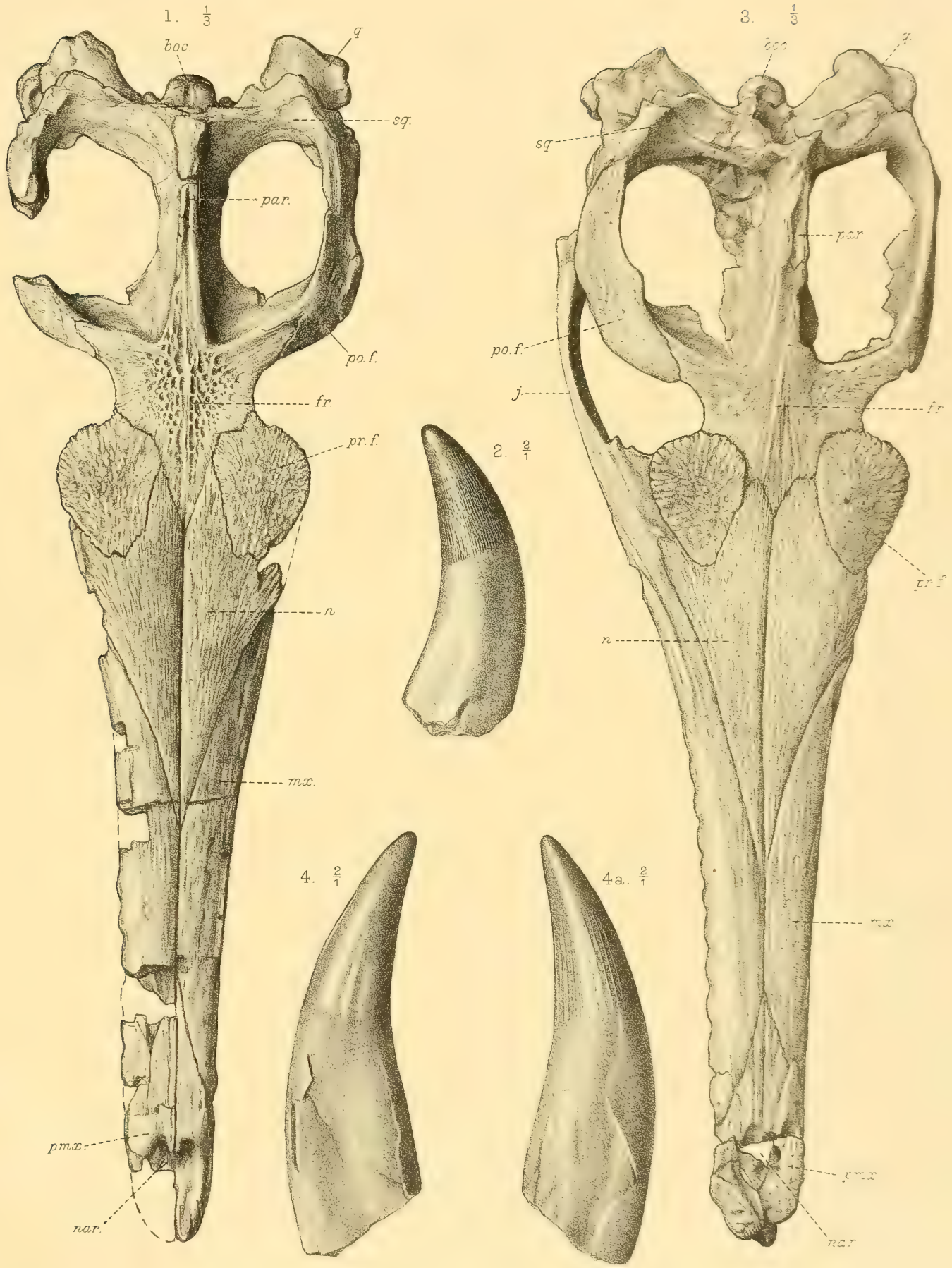
boc., basioccipital.
fr., frontal.
j., jugal.
mx., maxilla.
n., nasal.
nar., external nares.
par., parietal.
pmx., premaxilla.
po. f., postfrontal.
pr.f., prefrontal.
q., quadrate.
sq., squamosal.



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1, 2. METRIORHYNCHUS SUPERCILIOSUM.
3, 4. METRIORHYNCHUS MORELI.

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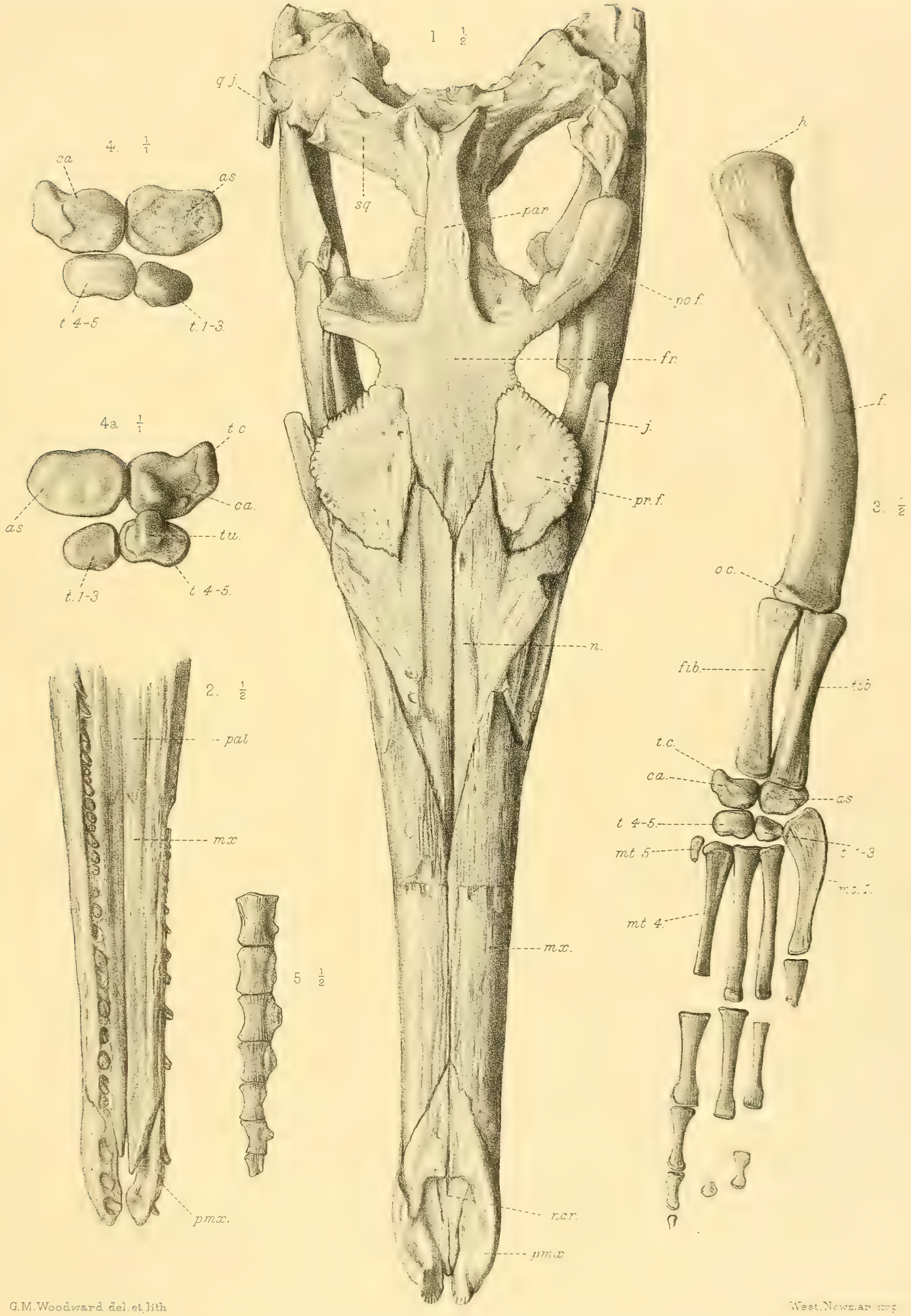
as., astragalus.
ca., calcaneum.
f., femur.
fib., fibula.
fr., frontal.
h., head of femur.
j., jugal.
mt. 1–5., metatarsals.
mx., maxilla.
n., nasal.
nar., external nares.
o.c., outer condyle of femur.
pal., palatine.
par., parietal.
pmx., premaxilla.
po.f., postfrontal.
pr.f., prefrontal.
q.j., quadrato-jugal.
sq., squamosal.
t. 1–3., fused distal tarsals 1–3.
t. 4–5., ,, ,, ,, 4 and 5.
t.c., tuber calcis.
tib., tibia.
tu., tuberosity on back of tarsal 4–5.



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METRIORHYNCHUS LÆVE.

PLATE XI.

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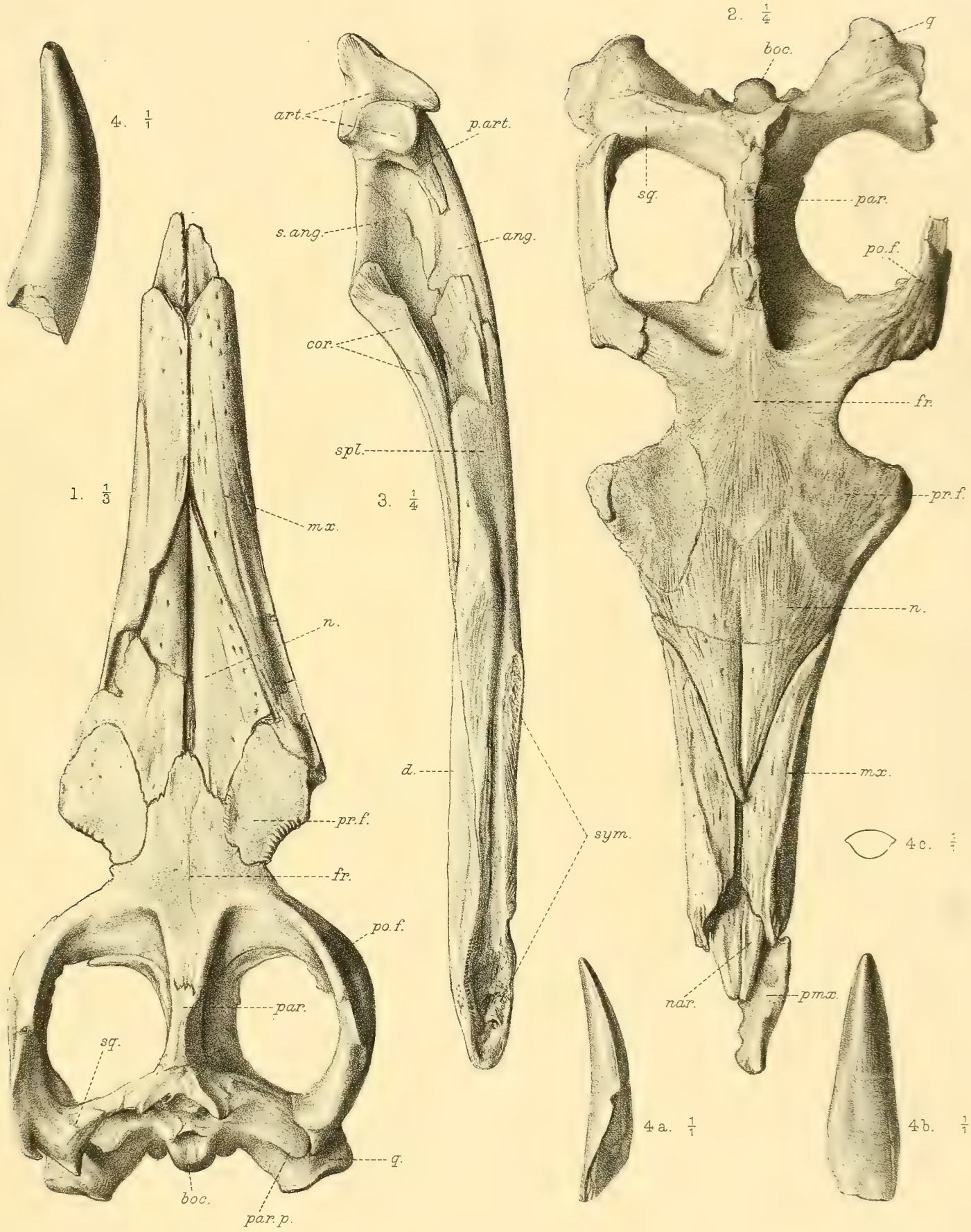
ang., angular.
art., articular.
boc., basioccipital.
cor., coronoid.
d., dentary.
fr., frontal.
mx., maxilla.
n., nasal.
nar., external nares.
par., parietal.
par.p., paroccipital process.
p.art., prearticular.
pmx., premaxilla.
po.f., postfrontal.
pr.f., prefrontal.
q., quadrate.
s.ang., surangular.
spl., splenial.
sq., squamosal.
sym., symphysis.



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1. METRIORHYNCHUS LEEDSI.
2–4. METRIORHYNCHUS CULTRIDENS.

PLATE XII.

Fig.		Page
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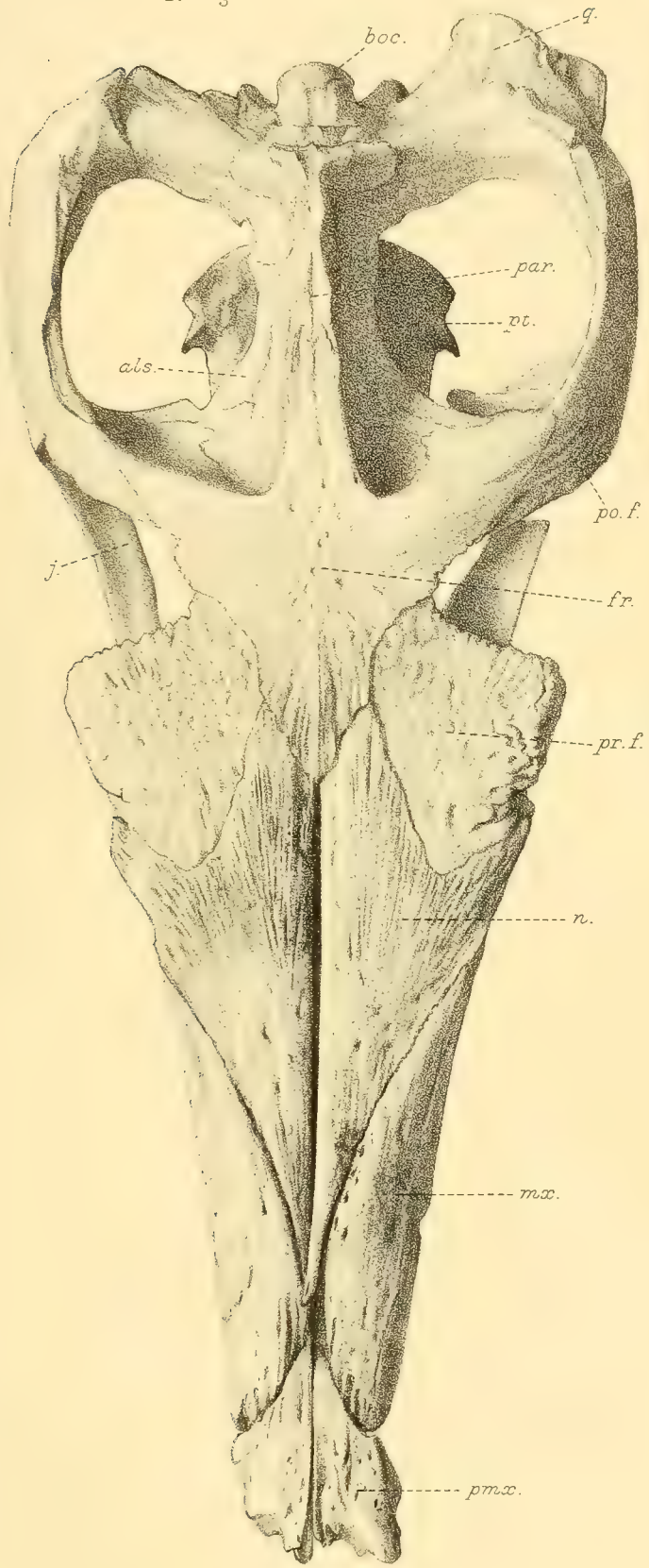
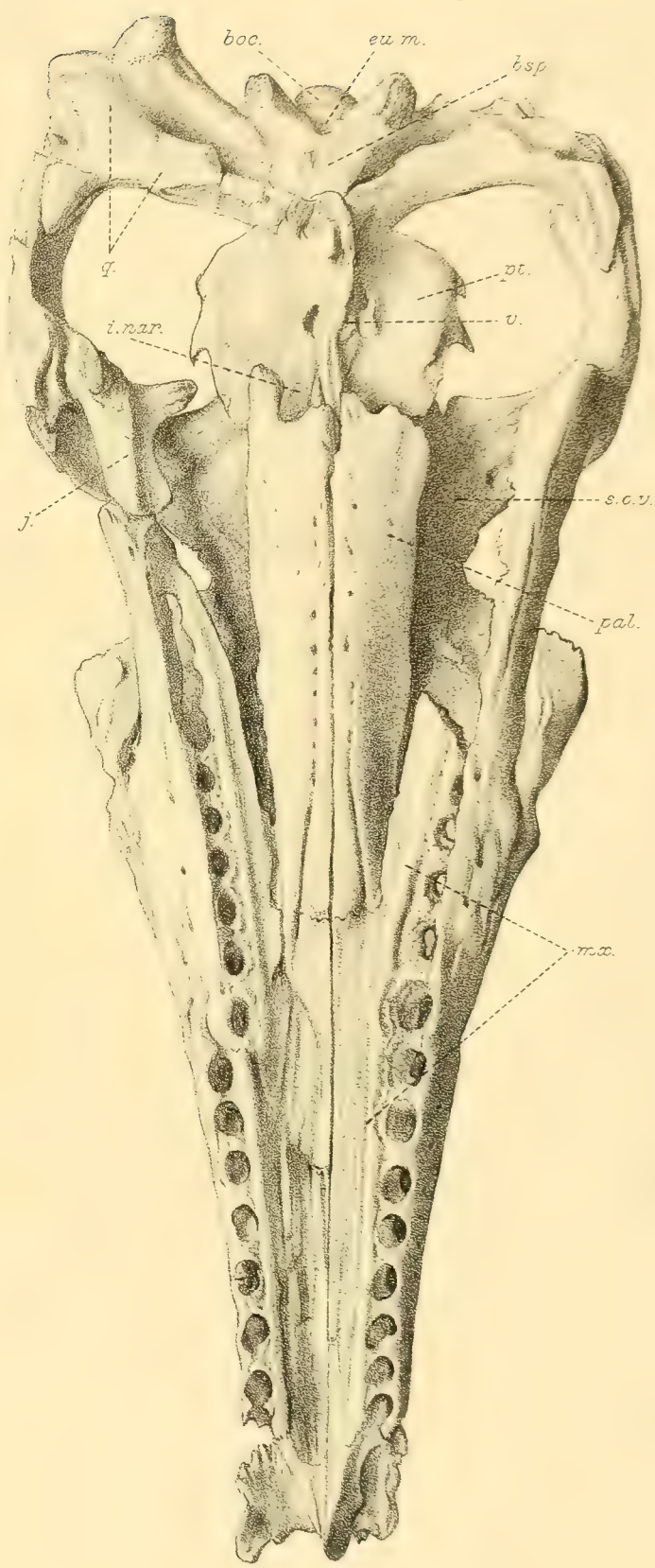
2. Ditto; palatal view of skull: one-third nat. size.	[R. 3700.]	198

als., alisphenoid.
boc., basioccipital.
bsp., basisphenoid.
eu.m., median eustachian opening.
fr., frontal.
i.nar., internal nares.
j., jugal.
mx., maxilla.
n., nasal.
pal., palatine.
par., parietal.
pmx., premaxilla.
po.f., postfrontal.
pr.f., prefrontal.
pt., pterygoid.
q., quadrate.
s.o.v., suborbital vacuity.
v., vomer.

1. $\frac{1}{3}$



2. $\frac{1}{3}$



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METRIORHYNCHUS BRACHYRHYNCHUS.

PLATE XIII.

Fig.			Page
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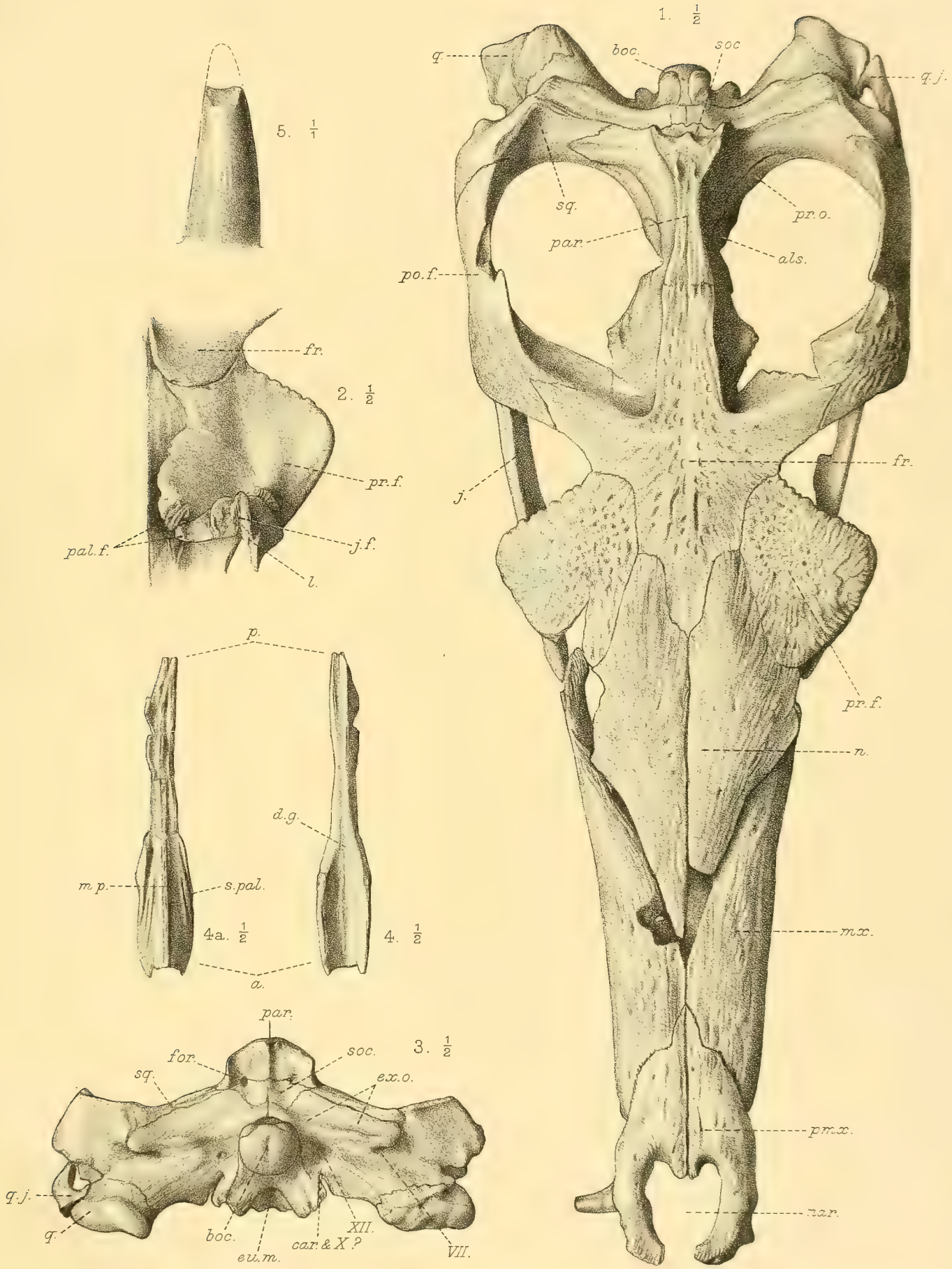
a., anterior end.
als., alisphenoid.
boc., basioccipital.
car. & X?, foramen for the carotid artery and (?) vagus nerve.
d.g., dorsal groove of vomer (parasphenoid).
eu.m., median eustachian opening.
ex.o., exoccipital.
for., foramen between parietal and supra-occipital.
fr., frontal.
j., jugal.
j.f., facet on lachrymal for union with jugal.
l., lachrymal.
m.p., median plate of vomer (parasphenoid).
mx., maxilla.
n., nasal.
nar., external nares.
p., posterior end.
pal.f., facets for union with the palatine.
par., parietal.
pmx., premaxilla.
po.f., postfrontal.
pr.f., prefrontal.
pr.o., prootic.
q., quadrate.
q.j., quadrato-jugal.
soc., supraoccipital.
s.pal., surface for palatine.
sq., squamosal.
VII., foramen for the seventh (facial) nerve.
XII., „ „ „ twelfth (hypoglossal) nerve.



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METRIORHYNCHUS DUROBRIVENSE.