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TRANSACTIONS  
OF  
THE LINNEAN SOCIETY.

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I. *The Morphology of Cyclops and the Relations of the Copepoda.* By MARCUS M. HARTOG, D.Sc., M.A., F.L.S., Professor of Natural History, Queen's College, Cork.

Read 19th June, 1884.

(Plates I.-IV.)

CONTENTS:—Introductory. Methods. Segmentation of Body and Appendages, and Voluntary Muscular System. Histology of the Integument. Cœlom and its Connective and Muscular Tissues. Digestive System (including Respiration and Circulation). Kidney. Nervous System and Sense-organs. Reproductive System. The position of the Copepoda in the Crustacean phylum.

INTRODUCTORY.

THIS paper was originally intended to convey only the new results I had obtained on certain points in the anatomy of *Cyclops*; but at the suggestion of my friend Prof. E. Ray Lankester I undertook a full anatomical description. This occupies the greater part of the following pages; and histological details have throughout been subordinated to morphological observations. I have also subjoined a discussion on the position of the Copepoda in the Crustacean phylum.

Unfortunately my work has been carried on at a distance from great libraries, and many works I should have wished to consult, especially those of Dana, Dohrn, Packard, and Van Beneden, have been inaccessible to me. The chief memoirs referred to on the subject will be found in the subjoined footnote\*; and among them those of Claus

\* BAIRD. The British Entomostraca. (Ray Soc.) 1854.

BRADY, G. S. Monograph of British Copepoda. (Ray Soc.) 1878-80.

CLAUS. Die freilebenden Copepoden, 1863; Crustacee-Systems, 1876; "Das Genus *Cyclops*, u. s. einheimische Arten," Wieg. Arch. 1857; "Weitere Mittheil. üb. d. einh. Cyclopiden," *ibid.*; "Beiträge zur Anat. u. Entw. d. Cyclopiden," Wieg. Arch. 1858; "Ueb. d. Blassen Kolben u. Cylinder a. d. Antennen d. Copepoden u. Ostracoden," Würzb. Zeitsch. 1860; Bau u. Entw. v. *Branchipus stagualis* u. *Apus caneriformis*, 1873; Bau u. Organisation d. Polyphemiden, 1877.

GIESBRECHT. Die freilebenden Copepoden d. Kieler Föhrdre, 1882.

GRUBER. "Beitr. z. Kenntn. d. Generationsorgano d. freilebenden Copepoden," Zeitschr. f. wiss. Zool. 1878.

GRENACHER. Sehorgan d. Arthropoden, 1878.

HARTOG. "Nervous System of *Cyclops*," Proc. Lit. & Phil. Soc. Manchester, 1878; "Anal Respiration of the Copepoda," *ibid.* 1879; "De l'Œil impair des Crustacés," Comptes Rendus & Arch. de Zool. Exp. 1882.

VERNET. Observations Anatomiques et Physiologiques s. l. genre *Cyclops*, 1871.

have been most valuable and suggestive. Zenker's paper, the first serious attempt to grapple with the internal structure of this group, is full of gross errors of fact and interpretation; and Vernet, the last student of the genus, having dissected but little, has added little to our knowledge.

I wish gratefully to acknowledge much friendly advice from Professors A. Milnes Marshall and G. S. Brady; valuable help in preparing sections from Mr. Walter Langton, Laboratory Assistant at Owens College; and some excellent drawings made by my friend Mr. J. Macpherson, student in Queen's College, Cork.

For the species my choice has fallen on *C. brevicornis*, Claus (Das Genus *Cycl.* &c. p. 32, t. iii. figs. 12-17), which I believe to include as a not very distinct variety the later species *C. gigas*, Cl. (Weitere Mittheil. p. 207, figs. 1-5); to this it is referred by my friend Prof. G. S. Brady, F.R.S., and my descriptions of the proportions of the appendages &c. refer to this solely.

The habitat of *Cyclops* is fresh and brackish water, usually in pools and backwaters. The species under consideration is fairly abundant, and occurs with other species, notably *C. serrulatus*, *C. coronatus*, and *C. tenuicornis*, in gatherings made in the neighbourhood of London, Birmingham, Manchester, and Cork (where it occurs in both fresh and brackish water). It is tolerant of captivity, breeding freely in pickle-bottles, &c., but usually in time degenerating in size, though often gaining in transparency. It feeds usually on living animals (*e. g.* Rotifers, the youngest of its own species, &c.), but will eat dead aquatic animals, and, in the absence of other food, browses on algæ, of which its stomach is sometimes full.

To obtain specimens in quantities for stocking-purposes, sweeping with a large muslin net may be resorted to; for taking specimens from the jar I use a dipping-tube, much narrowed above to prevent recoil, and bevelled below to make entrance more certain; with this it is easy to catch animals resting against the glass of their receptacle, towards which the bevelled side of the tube is held. The proportion of males to females is very variable: every gathering has some of each. Males are more abundant in autumn and winter.

#### METHODS.

Examination of the living specimen is of course for many things absolutely necessary. In confinement under the cover undue pressure is avoided by putting under a frond or two of duckweed (*Lemna*). This arrangement has the advantage that by a push at the edge of the cover the *Cyclops* can be rolled over and over to show in turn back, side, or belly. In this case the legs are usually bent forward, seldom the reverse; but the position may be arranged, before covering, with a needle under the simple microscope, the *Cyclops* usually shamming dead when touched.

Careful management of light and selection of objective are all-important. Points clearly made out under a wide illuminating ray and a low-angle objective disappear under other conditions, and *vice versâ*. I have found the Abbe condenser invaluable for this work.

For dissection I use French spear-head needles, and work chiefly with a Chevalier's

doublet of 3''' focus. The hard parts are best seen in water after treatment of the fresh animal with ammonia.

For preservation I follow Giesbrecht's method: kill with a few drops of osmic acid (1 per cent.), decant the liquid when the animals are dead and have sunk, wash in fresh water and replace by alcohols successively of 30, 50, 70, 90 per cent., and absolute, at about ten minutes' interval. The animals are now ready for staining, which may be done by Mayer's saturated tincture of cochineal in 70 per cent. spirit (after a preliminary immersion in spirit of that grade), or Kleinenberg's hæmatoxylin, of which I use an old dark sample thinned with absolute alcohol and filtered\*. After staining and removing to absolute alcohol they can be transferred for dissection to oil of cloves or glycerine by subsidence (after Giesbrecht's method), or for imbedding to xylol, by adding first a few drops of xylol, pouring off part of the liquid, and adding xylol and so on till they are in pure xylol. By adding paraffin little by little to the xylol, keeping the solution just melted, and replacing by fresh paraffin the imbedding is completed. For arrangement I pour the paraffin and *Cyclops* on to a slide wet with glycerine, and then with a hot wire melt the tiny slab upon the block of paraffin to fit the clamp of the microtome. For fixing the sections, I have, unfortunately, not succeeded in making the shellac† or the india-rubber process a certainty, and some of my slides only a few months old mounted with india-rubber are already showing round pale spots, a beautifully fenestrate structure in the rubber film, which interferes with observation. One more word on staining: on the whole, hæmatoxylin is the better; but the cochineal runs it close, especially when the osmic acid has distinctly browned the specimen, the resulting colours varying from brick-red to chocolate-brown or violet, much like gold chloride. The darker ones are best for the nervous system, but the nuclei of the other tissues show better in the redder ones: in glycerine this colour washes out greatly, especially if the tinge be of the redder grade. Gold chloride I have used with moderate success, owing to the tendency of the soft structures to shrink from the cuticle, and have been hence unable to use picric acid or borax-carminé; but for the rapid staining, under the cover, of dissections of specimens freshly killed with osmic acid, I have found diluted glycerine and picrocarminé a useful medium.

#### Genus CYCLOPS, O. F. Müller.

Inner maxillipeds not markedly subchelate (fresh water).

#### Species CYCLOPS BREVICORNIS, Claus.

Antennules of female 17-jointed, comparatively short and blunt, not extending beyond its free thoracic segment; 5th thoracic foot 2-jointed, bearing 2 plumes and a short tooth; size 2.5–5.5 millim.

Claus gives the size of *Cyclops brevicornis* as 3.5 millim., of *C. gigas* 5.5; Brady gives *C. gigas* as 2.7 millim. I have found it vary from 2.5 to 3.8 millim.

\* In all work with alcoholic stains I make a point of immersing the specimen in alcohol of the same grade as the solvent, both before and after staining, to avoid all chance of precipitation.

† At least half my attempts with shellac have resulted in the scattering of the sections, or else in a spottiness of the shellac. [I have since devised a successful improvement on the shellac method.—*June 1887.*]

## SEGMENTATION OF BODY AND APPENDAGES, AND VOLUNTARY MUSCULAR SYSTEM.

The body of *Cyclops* is somewhat pear-shaped, *i. e.* ovoid in front, narrowed, cylindrical behind (Pl. II. figs. 1 & 2). It is obviously thus divided into a fore body or cephalothorax and a hind body or abdomen, but the boundary is not easy to fix. Before a detailed description, I will run over the chief points. The cephalon bears five pairs of appendages: antennules, antennæ, mandibles, maxillæ, maxillipeds. Dorsally it forms one continuous piece fused with the first thoracic tergum to form the carapace, but ventrally the first thoracic segment is distinct. Then follow four free thoracic segments, growing smaller and smaller, the last, indeed, being smallest anteriorly, so that the joint between the fore and hind body is in front of it. All these segments of the cephalothorax are convexo-plane, the dorsal convex side being prolonged into pleuræ. The remaining five segments are cylindroidal and lack pleuræ, and the first is united with the second in the adult female, so that these five have been taken collectively as the abdomen. But the first has in both sexes a pair of appendages, reduced, it is true, to the condition of genital valves, and should, therefore be ascribed to the thorax, if we wish to be consistent in our nomenclature of the Crustacea; and I shall accordingly regard this as the last or sixth thoracic segment. We have, then, a cephalon bearing five pairs of appendages, a thorax of six segments, the first united dorsally with the cephalon, the last (in the female) with the abdomen, and four abdominal segments, the last bearing the paired furcal processes, in all fifteen segments.

The next subject before us is the full description of this body, its appendages, and muscles; for describing them together is a more intelligible plan than relegating the muscles to another section, which would seem a plan as rational as, in describing a steam-engine, to make separate articles for the wheels and the rods. In the note below the terms used for denoting the various processes of the cuticle are defined\*.

*Cephalothorax*.—As stated above, this is composed of five distinct pieces dorsally, seven ventrally; it forms an ovoid convex above, flattened below, truncate in front, widest about the posterior end of the cephalon proper, narrowed behind the end of the fourth segment; the fifth is almost triangular, with the base posterior, and the sixth squarish.

\* For brevity I use the following terms for outgrowths of the cuticle:—

*Setæ*—the finest, flexible, cuticular prominences into which no hypoderm can be seen to extend. These may be inserted singly in small circular pits, in which case I term them “*circumvallate setæ*.”

*Teeth*—coarse, simple, rigid prominences, usually pointed, containing or not processes of hypoderm.

*Spines*—much elongated teeth, usually articulate at base, with a distinct core of hypoderm.

*Hooks*—spines curved at end.

*Saws*—flattened spines serrated on one or both edges.

*Hairs*—flexible processes containing a core of hypoderm, and often punctate, probably owing to an incompletely articulate structure.

*Plumcs*—hairs fringed with fine setæ; “pinnate,” when the setæ are confined to two opposite sides.

*Lancets*—pale flattened hairs, shaped like the blade of a knife; inserted by a constricted, filiform, dark-bordered stalk.

The carapace, from the region of the antennæ backward, and all the thoracic segments but the sixth, have each distinct pleura prolonged behind downwards and backwards into auricles, most marked and acute in the fifth (fourth free) thoracic segment. In front the carapace or tergum of the cephalon and first thoracic segment is continued downwards into a blunt narrow ventral rostrum, separated from an oblong epistoma by a narrow vertical cleft (notadnate as often stated). Just above the rostrum on each side, in front of and above the sockets for the antennules, are the nearly circular, smooth, flattened corneal facets (Pl. II. fig. 7), between which, on the anterior end of the carapace, are a few symmetrically placed circumvallate setæ, probably representing the frontal organ.

The sternal region (Pl. II. fig. 3) is much more diversified. In the cephalon we may distinguish the median region from the lateral areas occupied by the sockets for the limbs.

The antennular sockets are almost lateral to the rostrum. Between the antennules is a narrow ridge, the epistoma (Pl. III. figs. 1, 4, 6), acute and V-shaped in section in front, becoming broad and bilobed behind, extending more and more downwards, and passing into the broad labrum.

The mouth (Pl. III. figs. 4, 6) is a squarish opening between the two mandibles, bounded in front by the labrum, behind by a transverse præoral bar, continuous with the thickened socket of the mandible. From the sides of this bar spring the two paragnathæ, or lobes of the "metastoma" of Huxley, which underlie the shafts of the mandibles, and form practically a floor to the mouth. All these parts will be described more fully in connection with the digestive apparatus. For the rest of the cephalon this median part of the sternal region is broad and flattened.

Laterally two sinuous "arthrodial ridges" (Pl. I. fig. 14) are formed on each side, strongly chitinized. On each side, the inner and outer ridge have the concavities of their sinuosities facing to form sockets for the appendages, while transverse processes bound these sockets in front and behind; but the only socket where they meet to form a complete bar is that for the antenna (*at''*) small and rounded. The others are incomplete in front and behind, and that of the two maxillipeds is incompletely separated by a process from the bar which joins the inner and outer arthrodial ridges behind them. The inner ridge is, indeed, incomplete at the anterior side of the socket of the outer maxilliped, probably owing to the inward and upward prolongation of the posterior inner angle into a hollow, flattened, boot-shaped, postmaxillary apodeme (*ap.p.m.*), with the "foot" projecting forwards and inwards and the "heel" backwards and outwards.

This postmaxillary apodeme\* gives attachment to the great flexor muscles of the trunk in all the Copepoda I have examined.

The free entosternite (Pl. I. fig. 15) is a small plate in the middle line of the maxillary region, flattened and concave from side to side on its upper surface; its lower surface is produced to an edge, right and left of the middle; its anterior edge is concave, and the posterior convex, so that it forms a segment of a ring; to the outer third of its posterior edge is inserted a strong muscle connecting it with the postmaxillary apodeme—the *retractors* of the entosternite; between these it is produced into a median plate with its hinder

\* Lankester considers apodemata with a hollow opening to the free surface of the body as an Arachnid character. "*Limulus* an Arachnid," in Q. J. M. S., 1882.

edge convex and also parallel to the anterior edge. At each side it gives attachment to a muscle springing from near the top of the carapace, the *suspensor* of the entosternite (Pl. III. fig. 5, *m.s.ent.*). The anterior part of the stomach rests on the upper face of the entosternite and may readily be confounded with it in sections. This entosternite is common to all the Copepoda I have examined. In Ostracods and *Cladocera* it also occurs, and its suspensors become the adductors of the shell. Prof. Lankester writes to me that he has found it in *Palæmon* and *Apus*.

The description of the anterior thoracic region (Pl. II. figs. 3, 4, 5, 6) which I am about to give differs greatly from that of previous observers, for the reason that Zenker's original account was so completely erroneous that the partial corrections made by others have only left the matter perplexed.

The peculiarity consists in this: the two sockets for the limbs are oblong holes, each extending about two-fifths of the width of the sternum from its outer edge; they are united across the middle line by a narrower slit in which works a transverse median plate, whose internal cavity opens above into the cœlom and at each side into the cavity of the coxopodite of the limb (Pl. I. fig. 10); it is not merely united thereto, as Claus says, by interlocking processes. The anterior face of this plate is marked by a longitudinal half-cylindrical ridge at each outer side; the posterior face bears halfway up a transverse row of teeth. The posterior lamella of the plate bends back directly to the sternal integument; but the anterior lamella is produced up into a  $\sqrt{\quad}\backslash$ -shaped plate, projecting into the body, but giving no attachment to muscles.

Zenker called this a "Bauchwirbel," or abdominal vertebra\*, in complete misapprehension of its structure and functions; and subsequent observers have retained the name.

A convenient designation is that of *coupler*. It is certainly a downgrowth process of the sternite, and not, as suggested by Lankester†, a coalescence of the bases of the appendages themselves.

In front of the middle of each coupler is a median, oblong, peg-like *ridge* on the sternite, pointed in front, where it fits into a notch in the segment in front. The posterior part of each sternite forms a somewhat pentagonal plate with its (notched) apex posterior, and a short bifid plate-like projection from the postero-lateral edge; from the postero-lateral angle a rod-like thickening runs up obliquely outwards and forwards to a little behind the middle of the posterior edge of the socket of the oar-foot. Two unthickened membranes run in, like transverse slits, behind the rod, but do not meet on the middle line.

The socket for the limb is wider than the coxa from before backwards, especially at the outer side, enabling it not merely to be flexed‡, but also drawn backwards, recalling the sliding-seat mechanism of the modern racing-boat. The anterior edge of the arthrodial cavities is fringed with fine teeth. Except for these structures, the sternal region of the thorax appears to be soft and pliable.

\* He described internal processes supporting the nerve-cord.

† "*Limulus* an Arachnid," Quart. Journ. Microsc. Sci. 1881, p. 633.

‡ I use the terms flexion and extension differently in different parts. In the thoracic limb flexion means motion upwards and backwards.

The first sternite is the longest from before backwards. The fourth has no pentagonal plate, but only a ring behind the insertion of the limb, and sends up a pair of short lateral apodemes for the partial insertion of part of the great pectoral flexors of the body.

In the fifth thoracic segment the sternal thickenings are simply a succession of rings incomplete dorsally, of which the last (possibly belonging to the sixth segment) sends in a strong median process for the insertion of the chief pectoral flexors of the body.

The five succeeding segments narrow gradually; each is nearly cylindrical and overlaps its successor. The last thoracic segment is much swollen ventrally in both sexes, containing the *vesiculae seminales* or the anterior part of the *spermatheca*, as the case may be; in the female it is united with the first true abdominal segment.

The proper abdominal segments have their posterior overlapping edge fringed with teeth, sharp and elongated in the last at the base of the furca. I give the formula of the relative lengths of the segments, furca (*f*), and caudal setæ (*s*)—

th. vi.	abd. i.	ii.	iii.	iv.	<i>f.</i>	<i>s.</i>	
11	10	5	4	4	14	52	male.
th. vi + abd. i.	ii.	iii.	iv.	<i>f.</i>	<i>s.</i>		
24	9	8	7	20	66		female.

The unit of these measurements =  $\frac{1}{95}$  mm.

The upper surface of the posterior half of the last abdominal segment is excavated, with the adjoining parts of the furca, into a squarish supra-anal cavity, into which the anus opens as a longitudinal cleft. Over this the tergum is prolonged as a semicircular plate, called by Claus "Afterklappe," but which is immovable and should rather be termed "Afterdecke." Elsewhere\* I have called this the *supra-anal plate* (Pl. III. fig. 2), and shown that it is equivalent to that part of the telson of the Decapoda which projects beyond the anus, while the furcal lobes exist, even in the Astacinae, as little, oblong, setose, retral processes. The furcal processes I regard as equivalent, if not to limbs, to the paired outgrowths of the body that develop elsewhere into limbs†; if they have no muscles, it is because their position on a terminal segment makes them unnecessary. I should not be surprised to find them movable, with proper muscles, in some member of this group. A small crown of teeth surrounds the distal end of the furcal process. The process is setose on its inner side, and bears on its dorsal surface a flexible plume, about one third its length from its distal end, and a similar one at its outer side. At the end are four long pointed spines with (horizontal) pinnately attached setæ. Of these spines the outermost is the shortest, the inner twice as long (longer than the furca), the second outermost six times as long, and the second innermost seven and a half times as long, nearly as long as the after-body and furca together. Both of these long plumes are articulated by an *internal* thinning of their cuticle a little above their base.

This is a convenient place for a list of measurements of two adult specimens, male and female‡.

\* British Association Report, 1882.

† In development they agree with limbs. They do not exist in the youngest *Nauplius*, but after the first moult appear as distinctly *ventral* outgrowths.

‡ The specimens from which these measurements were taken were confined with as little pressure as possible to avoid distortion, and I do not think that the width is much exaggerated, if at all.

	Male.	Female.
Length of carapace . . . . .	505 $\mu$	726 $\mu$
Length from rostrum to end of thor. v. . . . .	863 $\mu$	1242 $\mu$
Length from thor. vi. to abd. iv. inclusive } (hind body excluding furca) . . . . . }	399 $\mu$	548 $\mu$
Length of furca . . . . .	126 $\mu$	210 $\mu$
Longest fureal spine (taken between two } transverse parallels) . . . . . }	568 $\mu$	726 $\mu$
Total length . . . . .	1946 $\mu$	2726 $\mu$
Greatest width . . . . .	484 $\mu$	684 $\mu$
Width : length . . . . .	10 : 40	10 : 39

The proper trunk-muscles are not very complicated; they fall into two groups, *extensors* and *flexors*. In the fore body, the great extensors of the body form two symmetrical groups taking origin at the anterior lateral portion of the carapace (below and external to the muscles of the antennules and antennæ) and are attached chiefly to the anterior edges of the third and partly the fourth thoracic segment. Medial of these a series of small extensors form V's with the apex backwards, running from the anterior edges of the third, fourth, and fifth segments to those in front of them, the muscles running over most segments being external. Two pairs of these extensors go from the dorsal region of the carapace to the second (first free) thoracic segment—one anterior starting from just above the great extensors; the other internal and posterior from about the level of the maxillipeds.

The great flexors (Pl. II. figs. 4 & 5) take origin on the upper edge of the "leg" and posterior edge of the "foot" of the postmaxillary apodeme, and converge with inter-segmental tendinous intersections on the ventral surface (which, however, do not extend through the whole thickness of the muscle), and are inserted partly into a pair of apodemes on the sternal region of the fourth thoracic segment, near the middle line and posterior to the limbs; but their chief insertion is into a median peg-like apodeme on the incomplete sternal ring of chitin forming the hinder limit of the fifth (or anterior detached piece of the sixth?) segment; while the outer part of these flexors appears to become continuous with those of the abdomen.

In the hind body the muscles are divided into four groups, two *supero-lateral* and two *infero-lateral*, the uppermost of the former group acting as extensors, and the lowermost of the latter as flexors. Here all the muscles are parallel, and the nearer the middle line the shorter their course, just as in the dorsal thoracic region. No muscles extend to the furca.

A series of short pleural muscles connect the two walls of the pleura together, especially visible in transverse sections of the carapace. The other body-muscles belong either to the limbs or to the visceral system, and will be described with them.

The *paired appendages* are confined to the cephalothorax (unless we regard the fureal processes as such) and are eleven in number: antennules, antennæ, mandibles, maxillæ of first pair, maxillæ of second pair (of which the rami are discrete to the very base, so that they are conveniently and commonly described as outer and inner, or anterior and posterior maxillipeds), four pairs of oar-feet, and two pairs of *rudimentary feet*, the hinder of which serve the purpose of genital valves. The only sexual differences to be noted are in the antennules and the genital valves.

I. *Antennule or first antenna*\* (Pl. I. figs. 1, 2).—This is differently formed in the two sexes, in both acting as a strong oar, but in the male acting also as a elasper and correspondingly complicated. In the female the preaxial edge is convex to the extensor edge, while the reverse holds for the male. Chiefly on the preaxial and ventral edges in both are borne hairs and spines, partly olfactory in function, partly plumes increasing the swimming-surface. There are 17 segments in both sexes of this species, and its total length in the female is about as long as the cephalothorax and first thoracic segment, but may not extend beyond the earpace.

Female (Pl. I. fig. 1).—1st joint oblong falciform, 5 preaxial, 3 ventral plumes.

2nd annular, 2 preaxial, 2 ventral plumes.

3rd annular shorter, 1 preaxial, 1 ventral plume.

4th shortly cylindrical, 4 preaxial, 2 ventral plumes.

5th smaller in all dimensions, shortly cylindrical, 2 preaxial pl. and 1 hair, 1 dorsal plume.

6th annular, 1 preaxial plume, 1 hair.

7th cylindrical, 1 preax. olf. hair, 1 ventral plume.

8th and 9th annular, conical (distal ends expanded), each with 1 preaxial plume.

10th broadly annular, 1 preaxial plume.

11th broadly annular, no plume.

12th truncate, conical, dilated distally, 1 preaxial plume, 1 olfactory lancet.

13th shortly cylindrical, no plumes.

14th „ „ 1 ventral plume.

15th cylindrical, conical, dilated distally, 1 preaxial, 1 postaxial plume.

16th „ „ „ 2 preaxial, 1 postaxial plumes.

17th, elongated cylindrical, slightly dilated distally, ending in an obtuse knob, 1 post-axial plume halfway up, and a wreath round apex of 5 plumes, a (preaxial) pale hair, a hooked hair, and an olfactory (with a dark-bordered shaft and a long taper apex).

The following table gives the relative lengths of the separate segments of the female antennule:—

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
25	4	3	11	8	4	10	4	4	5	6	7	5	6	9	11	11

The *proper muscles* are as follows:—*Extensors*. (1) *Short extensors*: a group of three arising together on the preaxial side of the basal joint; the most proximal and postaxial inserted at the base of the 2nd joint; the next with a partial insertion at the base of the 2nd, and a full insertion at the base of the 5th, the third, most preaxial, running with intersections or partial insertions with the two former to its proper insertion in the base of the 8th joint. (2) *Long extensor*: origin behind the former; insertion into base of 17th joint. *Flexor*: a muscular slip running from postaxial side of 1st to base of last joint.

Male (Pl. I. fig. 2).—Divided into 3 distinct folding segments by special joints so as to serve as elasper, and jointed by a ball-and-socket with a basal segment; these will be noticed after detailed consideration of the joints.

1st joint elongated, constricted at base, convex on anterior surface, which bears 4 short plumes and 2 long ones; lateral face with three olfactory lancets (the 3rd “lancet” with one of the long plumes is really on the distal arthro-dial membrane).

2nd joint shortly cylindrical, 2 short plumes.

3rd „ short, annular, 1 long and 1 short plume (att. of basal extensors).

\* A consideration of the morphology of these and the next pair of appendages is deferred to the section on the nervous system.

- { 4th joint short annular, } with the interarthrodial membranes as long as the segments ;  
 { 5th " " " } plumes very long, olfactory lancet on 4th.  
 { 6th " " " }  
 { 7th " obliquely truncated, annular, conical, longest on extero-dorsal side, overlapping }  
 { 8th, especially on outer side. }  
 { 8th joint similar to 7th but longer, overlapping 9th segment. }  
 { 9th " a narrow ring bearing on inner (anterior) edge an olfactory lancet. }  
 { 10th " almost bell-shaped, its produced distal margin overlapping the next on all sides, }  
 { especially ventrally and anteriorly ; 1 short plume. }

These constitute the basal segment.

- { 11th joint short, cylindrical, expanding distally, convex postaxially, concave preaxially, }  
 { bears on a projecting ridge at preaxial flexor edge a plume and hook, serrated at base. }  
 { 12th joint annular, bears on preaxial edge a plume, a hook serrated at base, and a short spine. }  
 { 13th " annular, bears a short olfactory lancet, and a small slender hooked spine. }  
 { 14th " cylindrical, tapering distally, excavated on the preaxial side, distally for the }  
 { reception of the 15th segment, and bearing on its preaxial side a short process, which }  
 { gives off proximally and distally a strong spine, resembling together those vegetable }  
 { hairs known as "medifixi" or "malpighiaceous." }

These constitute the first segment of the clasper.

- { 15th joint an elongated sclerite, practically undeveloped on the postaxial side, strongly convex, }  
 { bulging out preaxially and, as it were, let in between the 14th and 16th segments (lying }  
 { chiefly in the former in flexion), and produced at each end into an apodeme. }  
 { 16th joint elongated cylindrical-falciform, convex on its postaxial edge and bearing a long }  
 { plume ; preaxially bearing 2 stout "medifixed spines," a proximal and a distal, bearing }  
 { on the apex of the 15th and the base of the 17th joints respectively. }

These form the second segment of the clasper.

- 17th joint elongated bluntly falciform, with a strong basal convexity on the preaxial side  
 underlying the spine of the 16th segment, and showing a slight indication of division  
 about its middle ; bearing on its postaxial side 6 plumes and a tuft of about 3 round its  
 apex, among these hairs one or two are pale\*. This forms the last segment of the clasper.

Many segments have little angular processes both dorsally and ventrally near the post-axial side, at their distal ends, articulating with corresponding notches on the adjoining segments, and forming hinges limiting extension. Thus constituted, the male antennule is a powerful clasper, formed of four consecutive pieces ; the basal extending to the 9th and 10th joints, and having there a practically ball-and-socket motion, owing to the way 7 and 8 overlap 9, and 10 overlaps 11 ; the second piece extends from 11 to 14 inclusive, and with the next piece forms the clasper proper ; 15 is simply a hinge by which 16 flexes on 14, and 17 alone constitutes the last piece, flexing on 16 and lying on its dorsal surface. All the joints flex in the same direction—preaxially.

*Proper Muscles.*—1. Basal group : (1) a long basal extensor originating in the outer part of socket inserted on extensor edge of base of 4th joint ; (2) a short basal extensor originating on flexor side of base of 1st joint, crossing over and inserted with the former ;

\* Claus describes the pale hairs as ending with a dark-coloured ring, like the hairs of the antennule of *Daphnia*. In the specimen before me one is ringed at the apex, that of the fellow antennule is not.

(3) a short basal flexor, originating in base of first joint just distal to last muscle and inserted on flexor side of second joint.

2. Muscles acting on 9th-13th joints: a fine muscle extending from the insertion of basal extensors to the flexor side of 9th joint; part at least being continued to the base of 13 on its extensor side must be an extensor of the 13th joint. A pair of slips from the flexor edges of 2 and 3 inserted on the flexor side of 9.

3. Flexor of the clasping-joint: a great thick-bellied muscle, taking origin in 9 and inserted in apodeme of 15, which acts, indeed, as a tendon by its ventral insertion lying inside 14 (which is exceptional, for, as a rule, the proximal segment of an appendage overlaps the distal).

4. Flexor of last piece: origin on extensor side of 16, insertion into flexor proximal edge of 17.

The noteworthy points are these: the 15th segment acts purely as a sesamoid in the flexor of the 15th segment, changing the direction to make the pull more direct: in flexion it lies almost entirely inside 14. An extraordinary mechanical device is the "lock-spring" arrangement for extension of the 16th and 17th segments, and possibly of the 13th. Both the 14th and 16th segments have on their flexor edges short processes bearing a horizontal medifixed spine like the '*pili malpighiacearum*' of botanists. The ends of the spines lie on the two adjoining segments in each case, which, indeed, are tumid and convex (the 13th only slightly so), so that in flexion the spines are forced over them, and when the muscles relax their elasticity determines extension. The hooked and serrated spines on the 11th-14th segments must help to tighten the hold on the female.

This pair of appendages is, in both sexes, acted on as a whole by extrinsic muscles, inserted into the proximal end of its basal joint, running obliquely upwards and backwards to the sides of the carapace. These are a double extensor, nearly vertical, pulling the antennule forward, a double *short* flexor taking origin just a little further back, and a double *long* flexor running obliquely upwards and backwards internal to the other extrinsic muscles of the cephalic appendages, to be inserted at the upper lateral part of the carapace in the region of the maxillipeds. (This muscle consists distinctly of two great fascicles, one in front of the other, but I cannot make out distinct insertions.) This might be regarded as lending some support to the view that the carapace is formed in part by a backward extension of the cephalic region; but mechanical advantage may have determined the gradual backward shifting of the insertion. This pair of appendages is innervated from the postero-lateral region of the brain.

II. *Antenna proper* (Pl. I. fig. 3), clinging antenna or second antenna: 4-jointed, flexor, postaxial or outer or hinder edge serrated with fine teeth along its whole length.

Basal joint oblong, concave externally, convex internally, bears at distal end on extensor side two flexible hairs sparsely setose; on flexor side, on a distinct but slight prominence, a long flexible hair as long as rest of limb, fringed abundantly with coarse almost tooth-like setæ, probably equivalent to the exopodite or palp found here in some other families of the Copepoda.

Second joint shortest of all, hinged to allow limited extension and flexion; cylindrical, bears a thinly fringed plume halfway up extensor edge.

Third joint longer, cylindrical, widening distally, with greater range of extension and flexion; on extensor ridge are in succession a plume and five hooked spines, getting larger distally, and three others lie at extensor side of distal end.

Fourth joint narrower, slender, oblong, bears seven hooks of various sizes, and round apex inserted into a thin chitinous membrane, forming the apex of the limb.

*Proper Muscles of the Antenna.*—Flexor, origin doubtful; insertion on flexor side of base of second joint. Extensor of third joint, from base of second to base of third joint. Detaching muscles: one taking origin about the middle of the basal joint, going to the insertion of the three terminal hooks of the third joint; another, stouter, taking origin a little beyond the last, and ending in the membrane forming the distal end of the limb, on which are inserted the seven hooks. The action of these muscles must be to detach the hooks and release the animal for purposes of chase or safety.

*Extrinsic Muscles of the Antenna.*—At least four take origin near the top of the carapace, two extensors, and two flexors, both sets inclining backwards. A fifth muscle springs from the free entosternite. The innervation of this limb is from the circum-oesophageal cord, a point discussed below.

III. *Mandible* (Pl. I. figs. 4, 4*a*; Pl. III. fig. 6).—Inserted by a squarish base, having the form of an oblong block, excavated, as it were, on the posterior ventral side to form a long falciform process, the shaft, flattened from before backwards; at its end it expands into a cutting-blade divided into strong teeth, and bearing at its dorsal edge a short blunt hair bearing a unilateral (ventral) fringe of fine short setæ, and presumably tactile or gustatory. Palp a short knob on the antero-ventral side of the basal block, bearing a fine hair, two long plumes as long as the carapace, turned back, and usually lying in the subpleural space.

The shafts, which are underlain by the paragnathæ of their respective sides, curve not only forwards but upwards, so that the two overlapping and interlocking blades lie actually in the gullet; and even in extreme abduction they never leave the oral cavity.

Correlated with the rudimentary palp and want of joints, the mandible lacks completely all proper muscles except a single slip running to the palp.

*Extrinsic Muscles of Mandible.*—Long adductor from near top of carapace to inner edge of base, with an external slip continued to the palp.

Short adductor from side of carapace to same insertion as long adductor.

Long abductor originating in front of the long adductor, and passing in front of short abductors to be inserted on outer edge of base.

Short abductors, two strong muscles from free entosternite, inserted on outer side of base, just distal to long abductor.

IV. *Maxilla of the first pair or Maxilla proper* (Pl. I. figs. 5, 5*a*).—A two-jointed limb, with a rudimentary biramous palp on the lower joint.

Basal joint ovoid, slightly sigmoid, flattened above downwards at its distal end; obliquely truncated on its inner side for the insertion of the distal joint.

Distal joint triangular, with the apex forwards and inwards, compressed from above downwards, outer edge convex, prolonged at apex into a strong falciform tooth, just below which is a fine plumose hair. Inner border coarsely toothed, some of the teeth

again serrated, followed proximally by a conical hair, pale-bordered distally, and a conical setose plume near the base.

*Palp* inserted on ventral anterior border of basal joint, just before its distal end; squarish and continued into a terminal shorter ramus and a lateral longer ramus (exopodite?), both oblong. *Basal part* bearing a plume on its outer preaxial edge. *Terminal ramus* bearing a somewhat falciform saw, serrated only on inner concave edge, and two rather longer plumes. *Lateral ramus* bearing three long strongly setose plumes. The two rami of the palp are not at all articulate, and are what Lankester terms 'inarticulate phyllites.' The maxillæ lie turned forwards beneath the paragnathæ, which they usually underlie, and in normal extension do not come far from the body.

*Proper Muscles of the Maxilla*.—A strong *flexor of the distal joint* (*m. fl.*<sup>2</sup>), taking origin on the outer side of the basal joint; an *extensor of the distal joint* (*m. ex.*<sup>2</sup>) takes origin just beyond this; and two small muscles run to the base of the palp.

*Extrinsic Muscles of the Maxilla* (Pl. III. fig. 5).—These are of unusual complication, having origins in the free entosternite, the postmaxillary apodeme, and the dorso-lateral regions of the carapace. I believe the following is a correct classification by function:—

Long adductor obliquely inwards, downwards, and forwards from latero-dorsal region of carapace to anterior and inner angle of base.

Short adductor from side of carapace to same insertion.

Long abductor directly downwards and forwards from its insertion near top of carapace behind long adductor to outer side of base.

Lateral abductor from side of carapace to same insertion.

Short abductor from entosternite to same insertion as last.

Flexor (?) from "toe" of postmaxillary apodeme to anterior side of basal joint.

Extensor (?) from same insertion to posterior side. Doubtless the adductors and abductors also contribute to flexion and extension respectively.

V. *Maxilla of second pair, Maxilliped*.—The peculiarity of this limb is its division down to the base into two rami, with distinct extrinsic muscles. Claus figures them correctly as inserted into a single arthrodial cavity, imperfectly divided by a peg on the posterior side; but his interpretation that they are connected by a chitinous bar is erroneous. As mentioned above, they are completely separate. In *Cyclopidæ* they are inserted nearly at the same level, the area for the outer ramus being prolonged inwards anteriorly in front of the inner; in many Copepoda this is so exaggerated that the outer is completely in front of the inner, so that they are often termed *anterior* and *posterior maxillipeds*\*. I shall describe these two rami, each with its musculature, as *outer* and *inner maxillipeds* respectively.

V a. *Outer Maxilliped* (Pl. I. fig. 6).—*Basal joint* elongated and strong; at base of trapezoidal section the anterior side longer than the posterior; above rather narrowed and compressed from before and without; marked about one third its length up by a transverse interruption of its thickened cuticle to form an imperfect joint; outer

\* Van Beneden, according to Gerstäcker, regards them as distinct limbs (Bronn's 'Thierreich,' Bd. v. Abth. 1).

(posterior) edge arched, inner concave up to the false articulation, below which it bears a stumpy *palpiform process*, with two setose plumes; above bearing a tapering setose plume, and then trending obliquely back to the end of the joint. Posterior edge of base prolonged obliquely inwards and forwards towards the opposite side into a foot-like *proper apodeme*. The nephridium opens near the base of this joint on its posterior inner face.

*Second joint* developed only on the anterior inner edge and, as it were, let in between the first and third; prolonged inwards like a sort of finger, bearing a terminal strong spine twice its length, fringed with a few coarse setæ, and a much shorter spine, curved, and lying on the distal edge of the former.

*Third joint* flattened, oblong, bent inwards at an obtuse angle, the first produced at its inner anterior edge into a process ending in a falciform spine, bearing on its concave (upper) edge, a little below its end, a row of setiform teeth ending in a larger one; facing the concavity of the spine is jointed another, tapering and pinnate, with coarse setæ in its lowest two thirds, and just at the junction of the two, on the inner side, is a fine hair.

*Fourth joint* inserted just at the base of the introrse process of the last; it is squarish, and bears at its distal end, on the inner side, a fine curved hair, a strong, smooth, somewhat falciform acute spine, fringed on its concavity, near the base, with a few setæ.

*Fifth joint* a mere knob at the end of the last, but, as we shall see, with distinct extensor and flexor muscles of its own; it bears two strong falciform spines, toothed on the concave upper side (*i. e.* towards the body). The several spines being all on the anterior inner side, and capable of approximation by the muscles acting on the joints that bear them, convert the limb into a prehensile member, justly termed "hand" by Jurine.

*Proper Muscles of the Outer Maxilliped.*—Extensor of the false joint originating on the carapace (with the extensor abductor of the limb external to which it lies), inserted into the limb on its extensor side, just beyond the false joint.

*Muscles of the palpiform process:* extensor from proper apodeme, flexor from top of carapace (internal to extensor abductor).

*Muscles of second joint:* flexor from post-maxillary apodeme, extensor from proper apodeme; these muscles run near the flexor side of the limb.

*Muscles of third joint:* extensor and flexor; strong-bellied muscles from proper apodeme to inner and outer proximal margins of third joint.

*Muscles of fourth joint:* extensor and flexor; two strong slips from base of third to base of fourth joint.

*Muscles of fifth joint:* extensor and flexor; two small slips from same origin as last two, and running between them and through fourth joint to base of fifth.

*Extrinsic Muscles of Outer Maxilliped.*—Long flexor-adductor. A broad fan-shaped muscle, converging upwards from sides of carapace to upper side of basal apodeme.

*Second and Third flexor-adductors,* from free entosternite and intermaxillary septum respectively to proper apodeme.

*Extensor abductor* from near top of carapace, descending posterior to *flexors*, to be inserted in proper apodeme at hinder outer part.

In the flexed position the limb comes forward and inward, and the setæ of the palpiform process pass through the notch of the retracted postoral bar into the mouth. In full extension the limb does not go beyond a right angle with the body.

*Vb. Inner Maxilliped* (Pl. I. fig. 7.)—This is about equal in length to the first and half the third joints of the outer. It is less compressed, and is squarish in section at base.

*First joint*, nearly half the total length, produced inwards, upwards, and forwards at base into a strong toe-like apodeme, elongated, constricted just above its base, bearing on its inner face, halfway up, a palpiform process with two setæ, a lower one, short and tapering, and an upper one, distinctly jointed at its insertion, both plumose, with distant coarse setæ; and above this process the limb bears a similar plume, but shorter and finer.

*Second joint* elongated, nearly equal to the first; an oblique ridge of teeth runs from the base obliquely across to the posterior edge at about three fifths its length, and is continued along that edge to the end of the joint. The anterior edge is ventricose, with the greatest swelling beyond the middle, bearing a stout tapering spine with a few scattered setæ.

*Third joint* short, almost triangular, wider behind, its outer angle produced into a short process, bearing a spine similar to that of the preceding joint, but longer.

*Fourth joint* a little knob bearing on its anterior edge a spine similar and equal to the last, and at its apex a hooked spine half the length of the former, and a shorter pale hair.

The *Proper Muscles of the Inner Maxilliped* are as follows:—

A levator of the palpiform process, originating from the postmaxillary apodeme, and inserted in the inner edge of the limb just beyond the process, depression being effected by its elasticity.

An extensor and flexor of the second joint, inserted into its base, and originating in the apodeme of the limb.

An extensor and flexor of the third joint, inserted into its base, and springing from the base of the second joint.

An extensor and flexor of the fourth joint, inserted into its base, originating with the last two muscles, and running a little nearer the middle of the limb through the second and third joints.

These muscles render the limb distinctly prehensile.

*Extrinsic Muscles of the Inner Maxilliped*:—

An adductor flexor and abductor extensor spring from the sides of the carapace below and behind those of the outer maxilliped, and are inserted into the basal apodeme of the limb.

A second adductor springs from the postmaxillary apodeme, and is inserted on the posterior side of the limb, near its base.

This limb, in flexion, has its distal processes passing into the mouth, and, in extension, like the outer ramus, is never more than perpendicular to the body.

VI.-IX. *Anterior Thoracic Appendages. Swimming-Foot, Oar-Foot\** (Pl. I. figs. 8, 9).—The first four pairs of thoracic appendages are biramous swimming-feet, which have given the name to the order. They resemble one another in so many points that the description of one is that of all, save in slight details. We shall therefore commence with the description of the anterior or first thoracic limb. It is flattened from before backwards, with a thicker protopodite, composed of a coxopodite, united across the middle line with its fellow by a median coupler, and a basipodite; the latter bears the two rami (endopodite and exopodite).

*Coxopodite* transversely oblong, bevelled off at inner angle, where it bears a long plume †; above this, joined to the coupler (curved), distal edge bearing a row of fine teeth; another row traverses the middle of the posterior face, and is continued across the coupler. Its outer edge is fringed with long setæ.

*Basipodite* oblong, much shorter (from above downwards) than coxopodite, and not extending inwards beyond the bevel of the latter. Distally it is excavated on the outer side by a concave bevel for the insertion of the exopodite, external to which is a long plume, while in the middle of this edge a short process, on which is inserted the endopodite between an (internal) plume and an external tooth. The inner edge is rounded at the angle and finely fringed with setæ.

*Endopodite*.—*First joint* squarish, convexly tapered at insertion; distal edge finely toothed; inner edge bearing beyond its middle, on a step-like indentation, a long plume, above which is a strong tooth; outer edge finely setose, produced at distal angle into a sharp tooth. *Second joint* stouter, half elliptical; distal edge finely toothed; inner edge bearing on successive step-like processes two plumes, setose, proximal to the first, and ending at distal angle in a sharp tooth; outer edge as in first joint. *Third joint* elliptical, truncate at both ends; distal edge bearing a strong saw between an (internal) plume and an (external) strong tooth; inner edge bearing three plumes; outer finely setose.

*Exopodite* rather shorter than endopodite, and from its more proximal insertion reaching little beyond the base of its third joint; resembling it in the general form of its joints, which are, however, broader; and the third is longer, almost triangular, with the base proximal.

*First joint* setose on inner edge, with a single plume at distal angle; outer edge setose, with a saw between two teeth (*i. e.* proximal and distal) at distal angle.

*Second joint* like first.

*Third joint*, distal edge bearing two plumes; inner edge not fringed, bearing two plumes; outer edge bearing distally three distant teeth, and in the intervals a saw.

The other three pairs of limbs are similar to the first, but more elongated. The third is the largest and stoutest, the fourth the most elongated and slender. In the fourth the internal plume of the basipodite is replaced by a strong tooth, and, as in the second and third, the fringe along the outer edge of the protopodite is finely serrated instead of being

\* I regard the oar-feet as *flexed* when bent backwards and upwards; *extended* when bent forwards.

† All the plumes of the limbs are pinnately setose on the transverse plane only.

setose. The slight differences in the chitinous appendages of the several limbs may be seen in the following table; the order is from proximal to distal, and from within outwards.

*Table of Differences in the Hairs &c. borne on the respective Oar-feet, in order from proximal to distal, and from within outwards. P=plume; S=saw; T=tooth.*

ENDOPODITES.	Inner edge. Joints.			Outer edge. Joints.			Apex.
	1.	2.	3.	1.	2.	3.	
Limb 1 . . . .	PT	PPT	PPPT	T	T	TP	PST
Limb 2 . . . .	PT	PPT	PPPT	T	T	TP	PST
Limb 3 . . . .	PT	PPT	PPPT	T	T	TP	PST
Limb 4 . . . .	PT	PPT	PP	T	T	TP	TSST
EXOPODITES.							
Limb 1 . . . .	P	PT	PP	TST	TST	TSTS	PPT
Limb 2 . . . .	P	PT	PPPP	TST	TST	TS	STST
Limb 3 . . . .	P	PT	PPPP	TST	TST	TS	STST
Limb 4 . . . .	P	PT	PPP	TST	TST	TS	PSTST

*Proper Muscles of the Protopodite.* Inner, middle, and outer extensors of basipodite.—Three groups of muscles pass from short tendinous origins\* on the anterior side of the base of the coxopodite to the anterior face of the basipodite—an inner group of three bands, a middle group of three, and a single slip of a single band to the outer angle of the basipodite; all these three are extensors, the first, and possibly the second, also adductors, while the third must abduct, and probably restores to place at end of fore stroke. Internal to the inner group of extensors is the fourth extensor, a very fine slip (showing exquisite striation in osmic-acid specimens), originating from the apodeme of the posterior face of the limb, and inserted in the inner angle of the basipodite.

The flexors of the basipodite.—Two strong muscles, come obliquely across from the posterior edge towards the inner angle of the coxopodite, to be inserted a little outside the middle of the base of basipodite on its outer side. These are flexor abductors of the basipodite, and a third, rather fan-shaped, comes straight down from the junction of the outer and middle thirds of the base of the coxopodite to the posterior face of the basipodite.

Adductor of the exopodite.—A double slip from the middle of the inner edge of the basipodite, joined by a third from the middle of its posterior face; inserted in the inner angle of the base of the exopodite.

Abductor of the exopodite.—A strong muscle from proximal angle of inner edge of basipodite running across the joint to be inserted into the outer angle of the exopodite.

*Proper Muscles of Endopodite.*—A double slip rises at the base of basipodite and runs on its anterior face, anterior to the muscles just mentioned, straight to the base of the 2nd and 3rd joints of the endopodite, having an insertion in the inner angle of each; this probably adducts these joints and, I believe, flexes them too.

A single slip from the base of basipodite, between two of the middle flexor muscles, runs

\* Distinct by their paleness in well-stained balsam specimens.

inwards and downwards to enter the endopodite and runs along its outer side to the basal angle of the 2nd joint; this must *abduct*, but probably also *flexes* the joint.

*Muscles of Exopodite.*—A double slip rises from the outer angle of the base of the ramus and is inserted into the inner basal angles of the 2nd and 3rd joints of the exopodite, which it *adducts* and probably *flexes*.

*Extrinsic Muscles of Oar-feet.*—Sets converging like a fan from their insertions on the sides and top of the tergum of the segment to be inserted at the base of the coxopodite, the posterior or flexor sets being inserted into the apodeme referred to above. The motion of the limbs as oars may now be understood; starting from *extension*, they are inclined slightly forward at an angle of about  $70^\circ$  to the body. Then, in *flexion*, they are drawn rapidly back so as to lie almost horizontally against the body; at the same time by abduction of the basipodite the limbs of the pair are drawn away from the middle line, while the proper abductor of the exopodite draws it again away from the inner ramus, so that the grasp of the limb on the water is at its fullest, owing to the fringes of plumes and saws. In extreme flexion the limb is further drawn back on the outer side, where its socket is, as it were, too big for it, thus producing the sliding-seat effect mentioned above.

Then the limb is extended; during this the flexors of the rami come into play so as to keep them bent with their axes parallel to the body, and at the same time their adductors come into play, rotating the limb and its rami, which now have their outer edges (fringed with saws and not with plumes) turned forwards, while their inturned adducted apices meet on the middle line; thus there is a decided feathering. In extreme extension a slight abduction takes place and the rami straighten, presumably by the spring action of their joints, as I have noticed in my dissections that the joints of the rami are always extended\*.

X. *Rudimentary Feet, 1st pair (5th Thoracic)*† (Pl. II. figs. 4, 5, 6), at the extreme sides of the ventral surface, but still not at all lateral. *Basal joint* squarish, prolonged at outer angle into a process bearing a long plume; bevelled at inner angle to bear the distal joint. *Distal joint* elongated, cylindrical, about as long as basal joint, bearing on inner edge a sharp tooth ‡ and tipped by a long plume.

Muscles, an extensor and a flexor attached to the sides of the tergum of its segment.

XI. *Rudimentary Feet, 2nd pair (6th Thoracic)*. Differing slightly in the two sexes; in both reduced to an elliptical flap overlying the sexual aperture and forming a valve, with its distal edge close against the boundary of the next segment.

*Female*. Best seen in profile position; forms a transverse oval flap stretching one third of the width of animal from ventral edge; bears towards outer lower angle two teeth and a short plume.

*Male*. Distinctly ventral and approximated, almost united along their anterior edge,

\* From Giesbrecht's beautiful figures it would appear that the musculature I have described is typical in the Copepoda; he gives, however, no description of what he has so carefully drawn.

† In this genus specific characters of great constancy are to be got from this limb.

‡ I once found, as a monstrosity, this tooth prolonged into a short serrated spine—an approach to its condition in *C. scrrulatus*.

which is crescentic (the convexity anterior); posteriorly separated by a median cleft. Each valve forms a right-angled triangle, with rounded sides and the right angle posterior and internal; outer angle slightly produced and bearing three plumes, the innermost coarsest, the intermediate smallest in every way, the outermost longest.

*Muscles of the Rudimentary Feet.*—In the *female* these consist of two sets: the one of a number of slips taking origin near the anterior edge of the segment and converging like a fan to be inserted at a slightly lower level into the base of the limb; the other, crossing this obliquely, consists of a few slips taking origin a little ventral to the former, which it crosses on the inner surface and is inserted on the distal side of the vulvar slit. The former probably closes the genital valve and would be its depressor. Possibly what I have described as the attachment of the latter may be its insertion, in which case it would raise the genital valve by leverage on the proximal end; or it may rectify the curve of the spermathecal duct described below\*.

In the *male* a small slip, very difficult to see, runs from the outer side of the segment, about its middle, obliquely inwards to the ventral wall of the limb, and is doubtless a *levator*.

#### HISTOLOGY OF THE INTEGUMENT.

The *chitinous cuticle* forms everywhere an investment to the animal, and is continued inwards to the mouth, gullet, and fore part of the stomach, into the kidneys and into the rectum. The processes it bears have been already noticed. Its thickness varies greatly, being at a maximum in the shaft of the mandible and the inner arthrodial ridge, at a minimum in the arthrodial membranes; its consistency varies from complete flexibility to strong rigidity and brittleness, but it is nowhere calcified. In sections of the inner arthrodial ridge alone have I seen traces of lamination. It is everywhere underlain by a *hypoderm*, except perhaps at the insertions of the muscles, which in some cases, at least (muscles of the gullet), appear to rest directly on the cuticle. The cuticle is readily traversed by even dilute acids.

*Hypoderm.*—This is composed of polygonal, mostly hexagonal, nucleated cells. In the living state neither nucleus nor cell-boundary is seen, only a smeary-looking vacuolated synectium, in which, however, the existence of nuclei is readily demonstrated by drawing a little weak acetic acid (one per cent. or less) under the cover. The oval nuclei then come clearly into view. They have no exceptional features, and like the connective-tissue nuclei, which they much resemble, show, when well stained, a reticulated structure. The continued action of the acid determines a shrinking of the hypoderm from the cuticle, as mentioned above. Nuclei are of rare occurrence in hairs and spines.

The only successful demonstration obtained of the boundaries of the hypoderm cells has been by the action of silver nitrate. For this I wash a few live animals in a filter with distilled water, put them in distilled water in a watch-glass and add a few drops of the silver solution (one per cent.); after about twenty minutes' I wash in distilled

\* We must note that this limb, at the base of which the genital opening is situated, corresponds exactly in this respect with the sixth limb behind the second maxille of the female Leptostraca and Malacostraca, a coincidence found in no other Entomostraca than the Copepoda.

water, and leave them exposed to sunlight for a day or two, transfer through the alcohols to oil of cloves, and then in *some* dissections the areas will be found especially visible on the appendages (Pl. I. fig. 9). They are very large for the size of the animal.

I would note here that while the cuticle is fairly impervious to stains, it is very readily traversed by even dilute acids (as well as gold and silver solutions), so that it probably offers no great impediment to cutaneous respiration. That the hypoderm stains so badly, as a rule, is comparable to the difficulty with which the underside of a section or soft animal lying on glass takes its proper coloration.

A tabular list of the various forms of hair has been given above. In connection with the skin the following points about moulting are of interest. Before each moult a collection of connective-tissue cells is seen below the integument, which only disappear gradually after the moult. The hypoderm is withdrawn from the old hairs; and the new hairs (even the long caudal spines) are inverted into the body to be everted at the moult. At each moult an increase takes place in the number of segments and the joints of the appendages, especially the antennules; when the full number is reached no further moult takes place. It is probable that even the finest setæ and teeth contain a process of hypoderm, or are at least hollow, for the cuticle of the plume or saw is traversed, in silver-nitrate specimens, by a dark line at the base of each seta.

*Pore-canals and Glands.*—These occur regularly in certain parts. They are oval, much vacuolated cells, with a spheroidal nucleus toward the proximal end, in all cases inclined obliquely towards the surface, and open distally in a minute slit-shaped pore in the cuticle. Each receives at its base a nerve-fibre, which passes just before through a bipolar ganglion-cell. In some cases I observed in a large vacuole, adjacent if not belonging to a pore-canal, irregular concretions. These I found at one time constant at the base of the 5th thoracic limb in a collection of males of this species, and regarded as auditory organs\*.

The distribution of some of the most obvious is as follows:—

Trunk: 5th thoracic segment, one at base of each appendage, innervated from ganglion in 4th segment; 6th thoracic segment, one pair ventro-lateral, internal to genital aperture (innervated from enlargement on ventral cord close to its bifurcation); 1st, 2nd, 3rd, 4th abdominal segments each one ventral pair, and (except the fourth) one lateral pair.

Furca: one pair on outer side, opening about one third the way down, and at least two near distal end, on ventral side.

Swimming-feet: one at the base of each "saw" on the exopodite, opening distally and anterior to it, and one at the base of each corresponding tooth or plume on the endopodite (Pl. I. fig. 9, *pc.*).

Whether these organs are to be regarded as rather nervous or excretory is uncertain. Similar "glands" are found in many groups of *Vermes* as well as in *Arthropoda*.

#### CELOM AND ITS CONNECTIVE AND MUSCULAR TISSUES.

The connective tissues of the body form irregular lacunar trabeculæ, with nuclei scattered through them. They are so distributed as to form *mesenteries* to the alimentary canal and reproductive organs, and in some cases form a sarcolemma to the muscles,

\* See also below, in the account of the nervous system.

which is at other times entirely absent. My silver specimens have not shown the cell-limits. In the living state these membranes have a smeary look. Under certain conditions, and especially in young specimens between the moults, and in those specimens which, from their load of epiphytic life, I judge to be aged, they are gorged with oil-globules, especially abundant in the serosa of the back of the stomach. Their colour varies from straw-colour to bright orange, or else is prussian blue. The curious point is the usually symmetrical arrangement of these, a globule of either colour being repeated by a similar one at the opposite side of the middle line. In individuals rich in globules of the yellower shade I have made out an absorption at the purple end of the spectrum, but I have not had access to sufficiently high powers to ascertain whether the globules individually give a distinct absorption spectrum. (The same blue pigment occurs sometimes diffused in the hypoderm, especially about the junction of the segments.)

The muscles are all well striated, and show typically every line and space enumerated by the histologist. They consist, in the adult, exclusively of contractile substance, and show neither nuclei nor sarcolemma in the adult, though in immature specimens a nucleated mass of protoplasm remains outside the fibre. As mentioned, they may end in the cuticle itself, or be inserted in the parietal connective tissue (muscles of stomach and intestine). In some cases, however, they are inserted by short tendons, into which their fibrillæ penetrate a short distance. This is best seen, in the living animal, in the short extensors of the thorax\*.

*Cœlomic fluid and Corpuscles.*—The cœlomic fluid is colourless; and, indeed, I have been quite unable to distinguish hæmoglobin in any of the tissues. No heart is present in this group†. The corpuscles are *amœbiform*, richly vacuolated and granular, with fine pseudopodia, by means of which they crawl about; they may be best seen in the live specimen (supine) in the fourth and fifth thoracic segments, where one rarely fails to see them crawling over the nerve-cord and nerves, without causing any twinges of the muscles. For this reason I gave up my first impression of their being parasitic, and I see that another observer‡ has found them generally in the Copepoda, and takes the same view of their nature, for which of course he has priority. In preserved and mounted specimens they almost elude observation; but when found they present 1–3 small rounded nuclei. The circulation of the cœlomic fluid is effected by the digestive system, and will be described below.

#### DIGESTIVE SYSTEM (INCLUDING RESPIRATION AND CIRCULATION).

The *alimentary canal* (Pl. III. figs. 1, 2, 3, 4, 5) begins in a distinct *oral cavity* bounded by the masticatory limbs and other processes; from this a narrow gullet rises and ends on the ventral anterior end of the *stomach*, which is continued back as *intestine* and *rectum* to the *anus*. We shall take these in order.

\* So far as I know, these connective-tissue terminations to muscles have been universally denied for the muscles in the Arthropoda.

† In the *Calanida* a heart is present in the dorsal region behind the reproductive gland (*i. e.* in the first and second thoracic segments). Like that of *Cladocera* it is an ovoid sac with meridionally arranged muscular fibres forming its walls, with a posterior and two lateral venous ostia, and an arterial ostium in front.

‡ Frié, Zool. Anzeiger, Jahrg. v. 1882, p. 498, abstracted Journ. Roy. Microscopical Society, 1882, p. 778.

The *mouth* (Pl. I. figs. 12, 13; Pl. III. figs. 1, 4, 6, *mo.*) is bounded by the *labrum* in front, by the *postoral bar* behind, by the socket and base of the mandibles at the side, and ventral to them by the *paragnathæ* and *maxillæ*, which also in adduction form its ventral limit.

The *labrum* (Pl. I. figs. 11, 12; Pl. III. fig. 4) is a broad plate continuous with the epistoma, inclined backwards and downwards and bevelled at the angles; its free margin ends in a row of eight teeth inclined to the median line and larger as they are more external; outside each of the external teeth is another, smaller, and then, separated by a short space, inclined upwards and outwards is another large tooth.

On the anterior aspect, *i. e.* external, are two longitudinal rounded ridges bearing a transverse row of long curved setæ turned downwards and forwards, like a moustache, overhanging the toothed edge. The inner, posterior, or oral face bears just above the teeth a fine transverse ridge of chitin, some way above which is a median circular *porc*, the *opening of the salivary duct* (Pl. III. fig. 6, *sa. p.*). The labrum must be raised to close the mouth by the action of the anterior divaricators of the gullet, and returns to its former position by elasticity.

The *paragnathæ* (Pl. I. figs. 12, 13, 14; Pl. III. figs. 5, 6, *pg.*) (Claus) are two processes running forwards below the shafts of the mandibles from the *postoral bar*, together with which they form the "bilobed metastoma" of Huxley. They have a very irregular shape, as will be seen by the figures; and either bears on its ventral outer edge a row of fine setæ, internal to this a row of teeth, and one or two isolated teeth, and on its inner side a transverse plate (pectinate process) flattened from before backwards, and incised into a number of strong teeth lying behind and parallel with the plates of the mandibles. The paragnathæ are attached to the outer angles of the postoral bar, where it joins the inner arthroal ridge between the sockets of the mandibles and maxillæ. This bar is prolonged inwards and backwards at its middle into a short apodeme, receiving the insertions of four muscular slips (*retractors of the postoral bar*) (Pl. III. figs. 4, 5, *m. r. pob.*) which run downwards and forwards from their origin on the lower surface of the free entosternite, perforating the ventral nerve-cord in two collateral pairs; this draws the postoral bar into a V, the result being the approximation of the paragnathæ under the mouth, and the meeting of their toothed plates; while adduction is due simply to the elasticity of the postoral bar. Thus the oral cavity is a hollow wedge with a squarish base rapidly narrowing above and in front of the gullet, which, when closed, has its anterior and posterior walls approximated so as to form a slit. The upper parts of the mouth are covered with transverse rows of very fine, short, close-set setæ, which probably exist also in the gullet\*.

The anterior wall of the mouth contains incomplete semicircular *constrictors*, *transverse muscular strips* (Pl. III. fig. 6, *m. cons. or.*). In their intervals are inserted, by brush-like diverging ends abutting directly against the cuticle, the anterior apertors of the mouth

\* I may note here that food, in *Cyclops* and the other members of *Cyclopidae* and *Harpacticidae*, is directly put into the mouth by the appendages, not whirled in by the vortices they produce (as writers have repeatedly stated), for the simple reason that they are not capable of producing vortices. The statement is correct as regards *Diaptomus* and probably all the *Calanida*.

(Pl. III. fig. 4), narrow slips, most of them inserted into the junction of the labrum and epistoma; but the uppermost pair cross the internal divaricators of the lower limb of the gullet to be inserted into the upper end of the anterior edge of the epistome.

The *posterior apertors of the mouth*, are one or two paired slips, from the lower surface of the entosternite, the chief work being done here by the retractors of the postoral bar.

The *gullet* (Pl. III. fig. 4, *a.*) is a short tube bent at a sharp *angle* halfway up, so that it is divided into a *lower limb* running upwards and forwards, and an *upper limb* running upwards and backwards. The lining membrane of the gullet is strongly chitinized, longitudinally plicate when contracted. It is certainly in parts fringed with very fine (gustatory?) setæ. Its *constrictors* are complete hoops of muscle.

The *anterior divaricators of the lower limb* (Pl. III. fig. 4) are paired slips, originating in the ventral and anterior edge of the epistoma, and inserted by brush-like ends abutting against the cuticle; the *posterior divaricators* have similar relations at their insertion into the posterior wall of this limb and converge to their origin on the lower side of the anterior edge of the entosternite.

The *divaricators of the angle of the gullet* (Pl. III. fig. 4) are a radiating series of paired muscles inserted between the base of the rostrum and the socket of the antennule; between the sockets of the antennules and of the antennæ, those of the antennæ and of the mandibles, those of the mandibles and the maxillæ, each muscle consisting of at least two slips; a strong pair to the angles of the free entosternite; and a posterior pair, crossing the posterior divaricators of the lower limb to be inserted behind them on the lower surface of the entosternite in front of the attachments of the retractors of the postoral bar. The two most anterior pairs of these divaricators perforate the brain.

The *upper limb* (Pl. III. fig. 4) of the gullet is surrounded by about six complete *constrictors*, in two groups, an upper and a lower, of three each. The *anterior divaricators* (or better, perhaps, *levator*s) of this limb arise from the carapace just behind and below the insertion of the anterior (shorter) muscles of the antennule, and diverge to their insertion; a strong bundle is inserted between the two groups of constrictors, and two others in the intervals between the three upper constrictors. There are no posterior divaricators to this limb.

*Stomach* (Pl. III. figs. 1, 5).—This is an oval sac, extending back to about the second thoracic segment, the gullet opening by a transverse slit into the lower part of its anterior end. Its anterior third differs from the rest in being lined by a thin chitinous cuticle ("intima" of Leydig), secreted by a flattened hypoderm, and thrown into longitudinal folds when contracted. The muscular coat of this part is composed of very fine irregularly arranged muscles, contrasting strongly with their regular disposition over the rest of the stomach. This part of the stomach may be compared with the chitinized gizzard found in all Crustacea except the Phyllopods and some of the Copepods themselves. The rest of the stomach is lined by large vacuolated columnar cells, loose at their rounded ends, which project into the cavity of the stomach; their ovoid nucleus lies near the base of the cells. They contain fat-globules in the anterior part, and posteriorly

the granules, regarded as urinary by Leydig and Claus, from their resistance to acids and alkalies and their presence in the excrements. I have, however, failed to obtain the murexide reaction in the stomach isolated on the slide. These concretions are apparently removed by the casting off or degradation of the free ends of the cells containing them, as they occur in the fæces surrounded by a clear space and membrane. The muscular coat of the stomach is composed of an inner layer of longitudinal fibres, and an outer of circular, all very fine, obscurely striated, and quite separate. The circular fibres are really semicircular, extending from near the middle line of the one surface to that of the other; approximated towards their middle, and spreading out in fans on the upper and lower surface, the fans of opposite sides being opposite one another. These circular fibres are comparatively few and distant over the stomach, and in contraction sometimes make it into a series of pouches.

The *intestine* (Pl. III. figs. 1, 3, *i.*) is a tube extending to the hinder end of the second abdominal segment. It differs from the stomach in its more abundant transverse muscles (of similar arrangement, however), in its smaller lumen, and its less vacuolated shorter columnar or cubical epithelial cells, which do not project in the same way at their ends, except at the posterior boundary of the intestine, where they project inwards and forwards into it to form a sort of prerectal valve (Pl. III. fig. 2, *pr. v.*).

The *rectum* (Pl. III. figs. 1, 2, *r.*) is a short tube with a very delicate chitinous cuticle secreted by a tabular hypoderm, and with a strong close investment of circular muscular fibres. It opens dorsally by two *anal valves*, leaving a dorsal longitudinal slit into the squarish supra-anal cavity, partly overlain by the supra-anal plate. A row of fine teeth or coarse setæ extends along the dorsal side of each anal valve.

The stomach is invested by connective tissue ("*serosa*" of Leydig) loosely connected with the median line above, and with the side walls of the body so as to form mesenteries. Two distinct *anterior levators* or *protractor muscles*, each a single slip, run from the upper surface of the stomach, some way behind the junction of the anterior and middle thirds, upwards and forwards, to be inserted into the parietal connective tissue of the body near the middle line of the carapace, a little in front of the separation of the sexual ducts from the generative gland. Two *posterior levators*\* run from the junction of the stomach and intestine to be inserted in the anterior edge of the tergum of the third thoracic segment, close to the middle line.

The *depressors* (two pairs) are fine slips running obliquely outwards from the lower serosa, diverging, as it were, from the four corners of a parallelogram, two forwards and two backwards. From their position they are very difficult to see, only appearing in horizontal sections of a certain thickness; and the only ones I have clearly made out are the *anterior* slips, originating from the sternal region at or behind the base of the post-maxillary apodeme, and running upwards inwards and backwards. The two posterior, I can see, are inserted further back on the lower serosa of the stomach, to which they converge inwards and forwards from their origin.

The intestine and rectum are fixed by two lateral pairs of mesenteries, deficient or only represented by muscles posteriorly. They are moved by two sets of muscles, *median* and *lateral*. The *median* are attached to the parietal connective tissue at the

\* These levators are best seen in living immature animals lying on their sides.

junction of the second and third abdominal segments; from which two muscles diverge, the *anterior* being a *retractor* and the posterior a *protractor*. Two muscles extend backwards from the anterior edge of the fourth segment, and are inserted into the upper wall of the rectum just before the anus; they would *protract* the rectum and *dilate* the anus at the same time. Besides these, on the ventral side a sheet of fine fibres passes from the anterior end of the fourth segment upwards and backwards on to the rectum, and acts at once as retractor and dilator.

*Lateral Muscles.*—A pair of transverse slips, inserted near the ventral median line of the serosa of the intestine and passing outwards dorsad of the great flexors to be attached to the anterior edge of the fourth thoracic segment, pull the front of the intestine downwards and backwards. On each side, about halfway down the second abdominal segment, two muscles diverge to the wall of the intestine, the anterior being a *retractor*, the posterior a *protractor*. A similar set are placed in the third segment; acting together, they would serve as *dilators*.

Two muscles attached to the anal valve of each side are its *apertors*; the one (*lateral*) runs to the side wall of the fourth abdominal segment, the other (*ventral*) to its ventral wall.

Owing to the action of the muscles just described, the stomach and intestine move backwards and forwards in a regular rhythmic sway. First the stomach moves upwards and forwards, becoming strongly arched; then backwards and downwards, flattening again, so that the intestine forms at its commencement a vertical sigmoid loop; third, the rectum is pulled back, straightening the gut, and at this moment the anal valve opens; fourth, the anal valves close while the rectum is pulled forward, especially at its hinder end. In this way it is obvious that the coelomic fluid is moved forwards along the dorsal, and backwards along the ventral chambers left above and below the alimentary canal\*.

The only *accessory glands* to the alimentary canal are the *salivary glands* (Pl. III. fig. 6, *sg.*). In the fresh state, these form great paired botryoidal masses lying at the outer sides of the labrum and epistoma. The cells do not show well in preserved specimens, but in their place we find a pair of membranous nucleated sacs in the same position, which bend in posteriorly and join on the middle line to a short chitinized tube, which opens by a median *salivary pore* on the oral face of the labrum.

I have attempted to show, in previous papers, that anal respiration is typical of Crustacea. I did this in ignorance of the completeness of my case; for Claus, whose knowledge of the class is far above rivalry, ascribes, in his 'Crustaceen-System,' to his "Protophyllopora" (the supposed Crustacean ancestor) a short muscular rectum, suspended to the body-wall and opening by dilator muscles into widely opening ("klaffendem") lumen. In his 'Polyphemiden,' p. 10, however, published a year later, he expressly denies, chiefly against Weismann, the respiratory significance of the process, as "regelmässig und normal für die Erhaltung des Organismus." After repeated observations of

\* Vernet describes a peculiar valve which I cannot identify, and ascribes a great part in this circulation to a dilatation and contraction of the stomach, forgetting the physical impossibility of this process without the taking up and discharge of liquid by the stomach, which does not occur, and which he does not assert.

Copepods, *Daphnia*, Polyphemids, and *Leptodora*, he finds a "powerful activity of these muscles, a rapid rhythmical expansion and contraction of the rectum, when the animal having been exposed for some time to the pressure of the cover-glass is deprived of its normal respiratory relations, or when the animal in its proper conditions has to expel a bolus of fæces. This shows," he continues, "that the action of the dilators is essential for the expulsion of the fæces, in contradistinction to Weismann's rather teleological view that the peristaltic motions would certainly suffice for the evacuation of the contents of the intestine. While the former relation, easily verified, shows that in abnormal conditions, perhaps of asphyxia, an increased activity of the dilators is excited, which *perhaps* [italicized in the original] may to some extent expose a new surface for respiration"\*. There are two objections to Claus's view of the matter—one of fact, the other of interpretation. As regards the fact, three stages may be seen on examining a *Cyclops* under the cover-glass. In the first, *with moderate pressure*, or *none at all*, the rhythmic contractions are perfectly regular; next, *with increased pressure*, they diminish, become irregular or stop; last, *under yet stronger pressure*, and especially when the animal is somewhat crushed, they become again very strong, spasmodic, giving the look of cramp. In *Daphnia*, the rhythmic contractions are best seen when the animal is quite free in a zoophyte-trough, with room and to spare to swim and to turn over; and if it has not been observed before in these Crustacea swimming freely, it is because any observer who did not wish to make out a special point would be sure to confine his specimen, to save his eyes and patience. Under similar conditions of free room I have observed this action of the rectum in three groups of Copepoda Natantia, in *Caligus* and *Argulus* among the Parasitica, *Daphnia*, *Chydorus*, *Macrocerus*, and *Moina*, and in *Apus* larvæ in the Phyllopoda, in *Gammarus* and *Asellus* of the Arthrostraca, and in the *Zoœa*-larvæ of Brachyura and Macrura. It occurs in *Cypris* and *Candona*, and is, I have no doubt, universal and normal.

Next, as regards argument. So many animals lack dilators for the anus, that it is impossible to regard them as essential to defecation. The peristaltic action which can urge the fæces down against the friction of the rectal wall is surely sufficient to expel them into the external medium, and the mere presence of the muscles accounts for their incidental employment; for how could the fæces pass without opening the valves? Moreover, the greater number of muscular slips serve rather to dilate the cavity of the rectum than to open the valves.

It is a noteworthy fact, and altogether against Claus's view, that the rhythmic action † is interrupted for some considerable time just when the lower part of the intestine is filled with fæces; and comes into play with increased activity immediately on their expulsion, just as a man will pant after holding his breath for a short time. Whatever be the case as regards *Cyclops* breathing by the surface of the body, and especially by the pleura, it is hard to see how such a respiration would suffice for a thick-skinned animal like *Caligus*, where the cuticle is dense everywhere and separated by a thick hypoderm from the coelomic liquid. This is a far more serious obstacle to respiration than the thin walls of the rectum chitinized though they be.

\* Strangely enough, this was published just a year before my first note "On the Anal Respiration of *Cyclops*," though I only saw the paper recently.

† See my further remarks on anal respiration in treating of the relation of Copepoda.

## THE KIDNEY.

The organ (Pl. III. fig. 7) to which this term applies has been described by Huxley as "a coiled tube with colourless contents." It is a simple tube lying at the sides of the carapace in the region of the maxillæ and maxillipeds, just above the reflection of the pleura, into which it does not extend. The numerous coils lying partially one over the other will be found, by careful focussing, to show the arrangement figured; the shading is inserted to guide the eye in following the coils. At (2) the tube bends horizontally inwards behind the lower part of the dorsal flexor of the outer maxilliped; it then bends downwards, forming a small irregular dilatation at the base of this limb, and finally opens into a depression at the hinder and inner edge of the limb, between the extensor and the flexors of the third joint. This course may be followed in transverse sections, and in specimens of which the soft parts have been dissolved by ammonia.

The coils are best seen in the living animal on its side, under a fairly high power; the horizontal part of the duct and its opening may sometimes be seen too in the live animal, supine, under the right amount of pressure, with the limbs in suitable positions—a matter rather of chance than skill. The other end of the tube, turning inwards at (1), is seen in transverse sections to run horizontally parallel to the duct, and opens apparently by a wide trumpet-shaped mouth into the œlom. The arrangement of the coils figured is, I believe, general in *C. brevicornis*, and occurs but slightly modified in some specimens at least of *C. tenuicornis*, *C. coronatus*, and *C. serrulatus*. The histology of the tube is very simple, a cuticularized tube, suspended by connective tissue in which I have been unable to detect any specialization. This organ, first described as opening near the mouth, and probably a poison-gland, by Zenker, was identified by Claus and Leydig with the "Schalendrüse" of Phyllopoða; Claus showed, in successive papers, that this gland opened on the base of the outer part of the second maxilla in Phyllopoða proper, and behind the single maxilla in Cladoocera; he also showed its opening at the base of the outer maxilliped in some parasitic Copepoda. But I believe that this is the first demonstration of its course and aperture in the swimming Copepoda. Among the *Calanidæ* a similar gland is known in the freshwater *Diaptomus*, but has been denied to marine Copepoda. Sections of *Calanus finmarchicus*, Leach, and a *Pontellina* have revealed it in its proper position, but much simpler, indeed a simple loop, of which one end opens on the outer maxilliped. I have also found it in the "youngest *Cyclops*-stage" of *Canthocamptus*, to which it has been alternately ascribed and denied, and in *Sapphirina*.

Claus describes in the Nauplius Copepod larvæ (*Diaptomus*, *Cyclops*) a similar tube forming a loop, of which the two ends lie in the region of the second limb (*al'*). This is the case; the loop extends far back, about two thirds the length of the Nauplius, lying below the dorsal retractors of the limbs. The two ends lie close together, one coiled and the other nearly straight, in the base of the antenna on the ventral side, internal to and ventrad of the "masticating hook." In the youngest Nauplius I was uncertain of an aperture; in the next stage with one pair of appendages added, the straighter limb in the antenna abuts clearly against the surface, and possibly opens there; while the other coiled limb is continued back again to an irregularly triangular mass of protoplasm, vacuolated, and containing refractive globules (Pl. III. fig. 9).

It seems probable, from a comparison of the oldest Nauplius with the youngest Cyclops-stage, that the gland is the same structure in both, but that its opening has acquired different relations in the metamorphosis. In the Phyllopod Nauplius, Claus describes an "antennary gland" in the same position as in the Copepod Nauplius, and opening below the masticatory hook. This he identifies with the "antennary gland" of the Malacostraca, and describes as disappearing soon. In the meantime appears the proper shell-gland of the adult, having its aperture, as in *Cyclops*, at the outer segment of the second maxilla. Claus lays great stress on the presence of two pairs of excretory tubes as indicative of Annelidan affinities. But in the absence of any fuller account of the development there remains the possibility that here, as well as in *Cyclops*, the two glands are really one in origin, and that the connection with the antenna is only replaced by that with the second maxilla. In this case it is interesting to note that the primitive relation of the duct to the antenna is retained in the Malacostraca, in which the "shell-gland" proper, with its duct opening in the second maxilla, is apparently never developed\*.

This is interesting, as showing the archaic relation, seen only in the larva of the ancestral group of Entomostraca, preserved and functional in the more recent Malacostraca.

#### THE NERVOUS SYSTEM AND SENSE-ORGANS.

*Central part.*—This is composed, as in all Arthropods, of a *prooesophageal ganglion* or *brain*, two *parasophageal cords*, one on each side of the gullet, and a *ventral cord*, which extends here to the anterior boundary of the sixth thoracic segment, where it bifurcates.

*Brain* (Pl. IV. figs. 3, 4).—This is an irregular mass, squarish in both sagittal and transverse section; but while in the latter its edges are respectively superior, inferior, and lateral, in the sagittal plan the square is, as it were, tilted, so that its somewhat hollow postero-inferior face rests on the lower half of the upper limb of the gullet, and its anterior angle abuts against the median eye. The cellular elements form everywhere a thick superficial layer, in front occupying half the thickness of the brain, and showing here a distinctly paired grouping. They are scanty in front, next the eye; and they are absent from the postero-inferior face and the part of the brain in front of this, being the great transverse commissure, and showing consequently a fine molecular structure in sagittal section, sharply marked off from the other nucleated part. In dissections and horizontal sections the arrangement of these fibres can be seen. The hinder set are transverse and go from one parasophageal commissure to the other; the next are oblique, and connect the one side of the brain with the parasophageal commissure of the other side; the anterior set are transverse, and connect the two sides of the brain †. The brain gives off

\* Except that a looped gland with openings at *ma*" occurs in *Elaphocoris* and *Acanthosoma* larvæ of Sergestids (Claus, Crust. p. 36, t. iv., 1, fig. 12, p. 37).

† These are well seen in some dissections I have made of *Calanus*, and coincide on the whole with Claus's figure of the brain of *Calanella* (Freil. Cop. t. vii. p. 9), except that he does not figure or notice in the text the posterior transverse commissure. The grouping of the nuclear elements into three paired sets, as seen in *Calanus* and *Calanella* (Claus), cannot be made out in the brain of *Cyclops*, so much more consolidated.

in front the very short optic nerves, above and external to which are the two short frontal nerves, and further back the nerves to the antennules, which rise in distinct triangular lobes or widenings out, with the apex outwards and forwards, marked by the large and distinctly triangular nerve-cells they contain.

From its upper surface it gives off two superior frontal nerves, and from its ventral angle a median *azygos nerve* to the epistoma and labrum, forming an *azygos ganglion* before breaking up. The lower part of the brain is perforated by two pairs of the muscles from the angle of the gullet.

*Parasophageal Cords*.—These pass obliquely downwards and backwards; they are elliptical in section and nucleated on their outer surface, the inner part next the gullet being simply connective\*. As is well known, the nerves to the antennæ are given off from these, rather towards their anterior termination, a point to which I shall revert. Behind and above the antennary nerves, a short pair of cutaneous nerves come off and run a short course obliquely outwards, forwards, and upwards to end in a ganglion below the hypoderm, just behind and dorsad of the antenna.

*Ventral Cord* (Pl. IV. figs. 1, 2, 9; Pl. III. fig. 1, *nc.*).—This is a cord of ovoid section, extending back from the back of the gullet to the end of the fifth thoracic segment, or beginning of the sixth, where it bifurcates or is continued by two branches which, giving off branches, finally end in the furcal processes. Its depth is greatest immediately behind the gullet, and diminishes posteriorly, so that its lower side is convex in the cephalon. Beyond the second segment it is suddenly flattened from above downwards. It does not narrow much from side to side before the third thoracic segment, where it suddenly contracts; beyond this, it forms a rhomboidal enlargement towards the posterior end of the fourth segment, and another slight one just before its bifurcation. There are no distinct ganglia save these, in which, indeed, I have only sometimes been able to ascertain the presence of cellular elements. The cord is, of course, slightly splayed out laterally at the origins of the nerves, but that is all. The ordinary rounded nuclear elements of the central nervous system are exclusively peripheral and, indeed, chiefly confined to the dorsal and ventral surfaces. A few occur on the anterior edge, where the cord abuts against the gullet; only a few very fine elongated nuclei, possibly representing the neurilemma, are found beyond the middle of the second thoracic segment (except a very few, four or five, more rounded, sometimes observable in the ganglion of the fourth segment), where the dorsiventral flattening takes place, so that in the next segment the cord is tape-like.

In the third segment are given off the nerves to the fourth limb, and a nerve to the side of the fifth segment; from the ganglionic(?) enlargement in the fourth segment are given off the nerves to the great flexor muscles, to the fifth appendage (first rudimentary foot), and to the sides of the sixth thoracic segment. From just before the bifurcation of the cord a nerve is given off, of which part goes to the sixth thoracic limb (genital valve) and part to the inner side of the vulva of the female.

I have found it almost impossible to fully trace the nerves from the anterior part of the

\* I use the term *cord* advisedly, because 'commisure' or 'connective' would imply the absence of ganglionic elements and has, probably, led to much erroneous reasoning.

cord; the mandibles and paragnathæ receive nerves that run outwards and forwards, and the nerves to the next appendages are almost transverse; but by the time we get to the third segment they are markedly oblique, running backwards to the appendage of the next segment. The parietal cutaneous nerves appear everywhere to come off, as in the two last thoracic segments, from the segment anterior to that which gives nerves to the limb. This arrangement is, perhaps, explicable on the hypothesis that the segments were originally mesoblastic, and that each intersegmental septum received both an anterior and posterior nerve, which passed from it to the body-wall, and that with the tendency to centralization of the body the anterior nerve alone persisted.

To this account of the nerves it is necessary to add that in each segment a pair of nerves are given off to the trunk-muscles, and that there appears to be a fine muscular nerve, distinct from the large sensory, to some at least of the appendages. The sensory nerves appear to spring from the ventral face of the cord, the muscular from a higher level. The ventral nerve-cord is perforated in the maxillary region by two holes\* for the retractor muscles of the postoral bar. Most of the fibres constituting the great bulk of the ventral cord are longitudinal; but both vertical and transverse commissural fibres occur, the latter at short intervals. The cord is traversed by distinct longitudinal lacunæ of rounded section, which in transverse section are seen to be laterally symmetrical, and can be traced in sagittal section for a considerable distance; these would doubtless favour the osmotic changes required for the active life of the cord.

The branches of the bifurcation of the ventral cord run at first below and then alongside the intestine, giving off branches. In the third abdominal segment each splits into a dorsal branch for the fourth segment and the anus &c., and a ventral one running to the furca, both branches presenting those ganglionic enlargements, to be referred to hereafter, characteristic in Invertebrata of sensory nerves near their termination, as shown by Leydig.

We are now in a position to note critically the morphological peculiarities of this nervous system. Paired ganglia never occur in the ventral cord of the Copepoda; the ganglia and their connectives are strictly median, when distinguishable, as in the *Calanidæ*. In these the ventral cord forms, according to Claus †, a ganglionated chain (though in *Diaptomus* and *Calanus* nerve-cells exist also in the constricted or commissural intervals). This is the typical arrangement, according to Claus:—two nearly fused ganglia in the region of the oral appendages, a third behind the maxillipeds, a fourth and fifth behind the first and second thoracic appendages respectively, and a sixth and seventh close together at the hinder part of the third or beginning of the fourth segment. The nerve to the first oar-foot comes from the ganglion behind the

\* The perforations of the central nervous system by muscles connected with the gullet is very puzzling, and I am at a loss to give any morphological explanation of this singular state of affairs, repeated in *Calanus* and *Diaptomus*, and probably common to the order. Can the short commissure immediately behind the gullet in Phyllopods represent the part of the metæsoophageal ganglion in front of these perforations? A puzzling monstrosity occurred in one live specimen of *Cyclops* I examined; the ganglion of the fourth thoracic segment was pierced completely from above downwards by a large oval hole, occupied by nothing, but a mere solution of continuity.

† Freil. Cop. p. 41.

maxillipeds, and so on. It will be seen, then, that the condition of the cord in *Cyclops* corresponds fairly to this, only with a more complete fusion of the ganglion. In *Euchaeta*, as in *Cyclops*, no cells are said to be found beyond the second thoracic segment\*.

The single cord found here is not only characteristic of Copepoda†, but is the earliest condition in Crustacea generally. Even in *Apus* and *Branchipus* the resolution into the ladder-arrangement is ontogenetically secondary, and the want of complete distinction between connective and ganglion occurs in some, at least, of the Annelida (Oligochaeta), and I shall revert to it again.

Another point is the presence of ganglion-cells in the periesophageal cords. Claus, who noted the origin of the nerves of the antennæ from these cords, which he calls "commissures," both in Copepoda and in the Phyllopods (including Cladocera—it is quite obvious in *Moina*), inferred the innervation of these appendages from the sub-oesophageal ganglion, a view strongly taken up by Lankester‡. With the recognition of the 'central' (i. e. ganglionated) and not commissural character of these cords, the superstructure founded on the misconception falls, and we are led to the admission that the antennæ are morphologically what they are physiologically in the Nauplius, *adoral* or *peristomial*, not *metastomial* appendages; and the antennules, which are always uniramous in larval forms, provided, as they are, with special sense-hairs, may be again regarded as belonging to the præstomium.

From this digression we return to the nervous system and consider its histology. As we found no sarcolemma, so a neurilemma seems completely absent; the nerves are quite naked. The *nerve-fibres* are exceedingly fine, and the only structure in the larger nerve-trunks is this fibrillation, with, occasionally, a few of the fine elongated nuclei already noted in the posterior part of the ventral cord.

The inside of a bifurcation is always rounded, owing to recurrent fibrils, but contains no nuclei, only dark granules.

*Ganglionic Elements.*—It is most difficult to determine the relation of ganglionic cells to nerve-fibres. What stain and are, in appearance, nuclei, usually seem to lie in clear spaces, representing presumably cell-cavities; but then these nuclei, instead of being spheroidal, are most irregular in shape§, though nearly uniform in size in the central nervous system. Such nuclei (?) extend for some distance into the cephalic nerves. Stellate cells, however, are distinctly seen in the cerebral dilatations at the base of the antennular nerves.

A little before the termination of the sensory nerves, each primitive fibre enlarges into an ovoid bipolar cell containing a large ovoid nucleus with a distinct reticulum. As these bipolar cells lie close together on the adjacent fibres of the same nerve, the effect

\* Balfour, 'Embryology,' i. pp. 433, 434; Claus, Bau u. Entw. von *Branchipus stagnalis* u. *Apus cancriformis*.

† "On *Apus*," Quart. Journ. Microsc. Sci. 1881, p. 374.

‡ In the *Copepoda*, as in *Caligus* and the Parasitica generally, the nervous centres are condensed into a thick periesophageal ring surrounding the gullet and giving off posteriorly two cords, which supply branches to the thoracic appendages and the hinder part of the body.

§ This irregularity is probably due to the post-mortem contraction of the protoplasm round the nucleus. In the living animal all nuclei visible are regularly spheroidal or ovoidal.

is that of a ganglionic enlargement. This is well seen in the living animal at the base of the antennule (animal prone), in the posterior end of the abdomen (where both of the terminal branches of the abdominal cord swell into elongated ganglia of this kind (animal lateral), or especially at the base of the fifth thoracic appendage (with the animal supine); with care it may be detected also at the sides of the carapace (animal lateral).

*Sympathetic System.*—The only trace of this I have been able to find is in the azygos nerve running down from the inferior angle of the brain, which gives rise to a ganglion in front of the mouth; but its fibres seem to be exclusively distributed to the hypoderm of the ventral face of the epistoma and labrum and the front wall of the mouth.

#### *The Nerve-terminations.*

*Motor.*—It is very difficult to trace these in most parts; but one pair are most conspicuous, that of the nerves from the fourth ganglion to the great flexors, seen readily in the living animal (supine). The end is a typical *Doyèrian hill*, containing several small irregular refractive bodies, which are possibly nuclear. In one of my dissections (gold chloride), I have found such a hill raised from its muscle (great flexor) in an anterior thoracic segment, and the base of the hill appears to run out at each end into a striated muscular fibril.

*Sensory.*—The ordinary ganglionic enlargement of the sensory nerves before its termination has been already described; the fibres then run to the hypoderm, where they are apparently lost. In some of my osmic-acid specimens I have detected, in surface view, a fine reticulum in the hypoderm, recalling the finest corneal network; but though this may be nervous, I have been unable to satisfy myself that it is not a mere coagulation-product. However, we usually find that everywhere in the neighbourhood of the entrance of a nerve into the hypoderm the cuticle bears a number of circumvallate setæ. A group of these lies in the forehead, between the corneal facets: these are the equivalents of the well-developed "frontal organ" found in so many Entomostracans, as well as in some Malacostracan larvæ; and this fact confirms their interpretation as sense-organs everywhere. In the abdomen the symmetrical arrangement of the circumvallate setæ makes them conspicuous under high powers (living), a pair on the supraanal plate being easiest to find.

A second form of cutaneous end-organ is the hair proper. Every plume and hair of the antennule receives a fibre which has passed through a bipolar ganglion-cell; and probably the same is the case with all the hairs, hooks, and spines of the body, though not the teeth and ordinary fine fringing setæ. The majority of the hairs and the circumvallate setæ seem endowed only with ordinary tactile sensibility, and that this sense should require special extensions of the skin is only natural in an actively swimming animal frequenting the mazes of aquatic vegetation.

Besides these, the above-described lancets and pale hairs found on the antennules, especially of the male, and on some of the oral appendages, appear to be olfactory or gustatory in function; for there is no real difference between these senses in an aquatic animal. Their presence on the antennule is universally characteristic of the Crustacea, and their better

development in the male is an argument often used in support of their olfactory character.

The pore-canals (described on p. 20) are probably also sense-organs. In support of the *auditory* character I have ascribed to concretions found at one time constantly at the base of the fifth thoracic appendage of the male of *C. brevicornis*, I cite an observation of Claus\* :—"Possibly a peculiar structure in the brain of *Calanella* belongs to the category of auditory organs. There are two spherical spaces, like otcysts (Taf. vii. fig. 9), in whose clear contents a ball of concretions is visible. Whether this differentiation be constant or not, I have unfortunately been unable to determine." My concretions occurred singly, or in an aggregate of two or three, in a little clear vesicle on a vacuolated mass lying on the outside of the ganglionic dilatation of the nerve, just below the base of the limb. I believe that the vacuolated mass was the pore-canal which lies in this position, but my knowledge then was insufficient to carry me so far. The very inconstancy of these organs is, strangely enough, a point of identity with Claus's suggested otcysts; and that they should occur in the pore-canal cell, instead of in the brain, is by no means an unparalleled occurrence. Indeed, if we admit their auditory function, we get a side-light on the meaning of the two-fold condition (closed and open) of the auditory organ of the Malacostraca. It may well have arisen from the confluence of a number of pore-canal cells, perhaps originally sunk in a special pit. I offer this as a suggestion to others.

#### *Sense-Organs.*

*Eye* (Pl. II. figs. 7, 8; Pl. IV. figs. 4, 6, 7, 8, 15).—The eye of *Cyclops* is situated in the frontal region, resting immediately on the anterior end of the brain. In brief, it consists of three spheroidal *ocelli*, two *lateral* and an *infero-median* (the latter, as usual, first detected by Claus), imbedded in sockets lined with pigment in a central supporting mass. Each ocellus is composed of a number of bluntly fusiform bacilli, placed radially and containing a nucleus distal to their centre; the ocellus receives the very short optic nerve posteriorly at its *outer surface*, so that the optic elements are reversed, as in the eye of *Dendrocaelum lacteum*†. The central mass is divided into three *blocks* by fine membranous partitions—one *superomedian sagittal*, separating the blocks which receive the two lateral ocelli, and one *infero-horizontal* separating these from the block for the inferior ocellus. A similar posterior partition separates the central mass from the brain, and is quite imperforate by nerves. Each of these blocks contains at least one nucleus, probably two, an anterior and a posterior. The tapetum consists of fine reddish granules, lying on the face of the block, and giving a brilliant metallic lustre by reflected light or dark-ground illumination.

The *median ocellus* is nearly spherical, containing about eight peripheral and one central bacillus. It is connected with the rostrum by two fine slips of fibres, diverging

\* Freil. Cop. p. 56, Taf. vii. fig. 9.

† See the paper by Justus Carrière, Archiv für mikros. Anat. 1882. *Sagitta* has, according to the Hertwigs, a pair of similar eyes, each of three inverted ocelli with an internal "lens," possibly equivalent to the "block."

right and left from its centre, of whose real nature I am in doubt, though it is natural to compare them to the muscular slips which move the eye of *Diaptomus*, which would lose their muscular character in an immovable eye like that of *Cyclops*. The median eye looks directly down on the rostrum, which probably serves as a cornea. The *lateral ocelli* are much more flattened and contain more bacilli—at least eight to ten peripheral and three central. They face outwards and forwards. In front of each is a nearly circular corneal facet, forming a slight depression in the frontal region, where it escapes notice in almost every view, being best seen in a dissection of the fresh animal treated with ammonia\*. In the inner limb of each bacillus is an oblong body (probably a rhabdome), staining deeply with osmic acid, hæmatoxylin, &c.

This account is not so satisfactory as I could wish, owing to the extreme difficulty of dissecting out and treating under the cover so minute an organ; while in imbedding, cutting and clearing, shrinkages take place; and a natural anxiety as the razor approaches the important place often spoils the median section. Not one in ten of my series shows the eye satisfactorily. But all the above points are *clearly* made out.

In both *Cyclops* and *Calanus* I have traced a few fibres along the septum, between the blocks of the lateral ocelli. That they do not enter the bacilli I am positive; I believe they pass on to the frontal region, or ends in the nuclei of the blocks. The strongest confirmation of this view is to be found in the structure of the eyes of Corycæidæ and Pontellidæ.

#### REPRODUCTIVE SYSTEM.

The *reproductive organs* consist in both sexes of a median egg-shaped reproductive gland, situated in the tergal region of the first thoracic segment (*i. e.* under the hinder part of the carapace), with its pointed "embryonic" † part posterior, and sometimes bent down and forwards, and giving off at its wide anterior end two ducts, which turn downwards and backwards to end, each under a genital valve, in the fifth thoracic segment. In both sexes the gland, though supported by a sort of mesentery, can scarcely be said to have a proper investment. The first origin of the gland is by two large nucleated cells ‡,

\* From the difficulty of finding these corneæ under ordinary conditions they have been noticed by Claus alone in *Cyclops tenuicornis* (Freil. Cop. p. 45, Taf. ii. fig. 17). They probably exist throughout the genus. Grenacher describes the eye of *Calanella* very differently (Schorg. d. Arthropoden, p. 63, Taf. v. fig. 36, Taf. vi. figs. 37, 38). He describes central cells, which are evidently part of what I term the blocks; he also figures the nerve-fibres as entering on the proximal side of the bacilli, stating that he has followed them *certainly, though with extreme difficulty*. I have examined the eye of *Calanus* in old spirit-specimens, which, however, were in fair condition, both by dissections and sections; this evidently is on the same type as that of *Calanella*, differing from *Cyclops* in the fact of the blocks not extending backwards, so that they leave a space at their hinder end, into which the optic nerve enters before breaking up into a ventral and two lateral branches. I cannot speak positively as to the ventral branch. The lateral branches unquestionably do not enter the inner ends of the bacilli. A discussion as to the morphological importance of this eye will be found in the concluding section "On the Systematic Position of the Copepoda."

† Gruber's paper (see *ante*, p. 1, note) revolutionized our knowledge of these organs in the Copepoda. It has been a most valuable guide to me.

‡ I find that Frič has anticipated me in this (Zool. Anz. 1882).

budded off from the subhypodermal connective tissue on each side the rectum, in the Nauplius of the second stage (with rudimentary maxillæ).

### *The Female Organs.*

The *ovary* (Pl. II. fig. 1, *or.*) appears, at first sight, as a nucleated syncytium at its hinder end; but treatment as aforesaid with oil of cloves for dissection determines enough shrinkage to prove that each nucleus has its proper investment of protoplasm. While in *Cyclops* I have been unable to trace the formation of the ova, a dissection of *Calanus* has shown me karyokinetic figures, and evident multiplication of nuclei at the hinder free end of the ovary, and there only. The latter statement certainly holds good for *Cyclops*. Towards the middle of the gland a clear space appears round the reticulated nucleus, the "*germinal vesicle*," which becomes larger. The body of the ovum becomes filled with spheroidal food-yolk granules, and the ova increase in size as they pass into the oviduct. The oviducts (Pl. II. figs. 1, 6, *od.*) seem to be outgrowths from the ovary; even in young examples with an incomplete number of joints (eleven) to the antennules and three segments to the abdomen, they may be traced to the place where the vulva is seen afterwards to open; but in one with only two abdominal segments I failed to trace it down to the fifth thoracic nerve. At this stage it has already begun giving off those uterine processes (Pls. II. fig. 1, & III. fig. 5, *u.*) so conspicuous a little later by the dark colour the ova which fill them assume. The uterine processes are as follows:—A pair, each of which bifurcates, runs forward to the head; a second runs back next the dorsal median line to the second or third thoracic segment; these are given off from the oviduct near its origin. Besides these, the oviduct itself, full of ova, first bends down obliquely back and then passes parallel to the latter pair, between the great extensors and flexors, and internal to the motors of the oar-feet, to the fourth segment, giving off a short blind ventral uterine process in each intersegmental space; beyond the fourth segment it contains no ova, and forms an elongated dilatation in the sixth segment before the vulva. Owing to the dark colour of the ova, the body of the pregnant female is elegantly banded. The wall of the oviduct seems composed of a fibrillated coat, in which I have sought in vain for a distinct arrangement of muscles; it is lined by very short granular nucleated cells with a look of hypoblast. Its uterine part doubtless secretes food-yolk, while its lower part, as first shown by Grube, is filled with a cement-substance (forming a stained coagulum in prepared specimens), which sets in water. Often, by opening the fresh animal, the masses of ova become surrounded by a membrane, which can only proceed from this cement, so that possibly the uterine parts also secrete it. Each vulva is a transverse lateral slit behind the genital valve; it receives on its inner side the short *sperm-duct* (Pl. II. fig. 6, *sp.d.*) from the spermatheca.

The *spermatheca* (Pl. II. figs. 1, 6; Pl. III. fig. 1, *sp.th.*) is a sac in the dilated ventral side of the sixth thoracic segment, and extending into the first abdominal segment aneelyosed with it. It is superficial to the trunk-muscles (flexors). It forms a double bag, its two lobes being anterior and posterior, nearly equal, transversely oval, and united by a short isthmus; into the base of the upper lobe leads upwards and forwards a short

median "vagina" from the *copulatory pore* (Pl. II. fig. 6, *spp.*) lying at the boundary of the thorax and abdomen. The sperm-ducts are short tubes, extremely difficult to make out exactly in this species. I have, however, satisfied myself that they lead from the posterior and outer part of the anterior lobe of the spermatheca. Each has a kink pointing forward, which, as suggested by Grube, acts as a valve to prevent the exit of the contents of the spermatheca.

I have shown above that one muscle of the sixth appendage might raise the lower edge of the vulva, rectify the kink of the sperm-duct, and effect the passage of the sperm to the vulva. The spermatheca, like the ducts, have all a chitinous lining; they are not formed till the last moult; they contain in the virgin female an irregular coagulum-looking mass, in the fertilized female a mass of swollen polygonal spermatozoa.

In oviposition the eggs, which have no vitelline membrane, and are polygonal by mutual pressure in the body, pass out with the cement of the oviduct and spermatozoa. The cement serves not only to attach the mass of eggs to the vulva, but by its coagulation to give both a general investment to the eggs, chambered by partitions, and a special investment to each egg. From 70-90 is a common number for the eggs in each mass, which in this species has a real narrowly oval form, about 20 eggs long to 3 or 4 wide at the widest. The length of time for incubation varies chiefly, I believe, with the temperature, for I never fail in getting a brood of Nauplii within 48 hours by keeping a female bearing egg-sacs in a corked "Bolton's tube" half full of water in my waist-coat pocket.

#### *The Male Organs.*

The *testis* (Pl. II. fig. 2, *te.*) resembles the ovary in form, position, and structure. Its hinder end is a syncytium, containing rather large nuclei, some of which may be seen dividing and showing karyokinetic figures (Pl. IV. fig. 13): about the middle the nuclei are well formed and large (male ova or spermatospores), in front they divide again, and form the spermatozoa, apparently about 32 to each spermatospore, for 16 nuclei are visible in a single view: I have not followed the full details of this process, which shows even moderately well in only a few of my specimens. It is evident that other methods must be resorted to than those given above for a full investigation on spermatogenesis, and I would recommend the investigator to select a much larger and more transparent form, such as the pelagic *Calanus* and *Calanella*, or perhaps even the Parasitica. The paired vasa deferentia may be divided into four segments, which we may term respectively *vas efferens*, *epididymis*, *vas deferens* (sensu restricto), and *vesicula seminalis*.

The *vas efferens* (Pl. II. fig. 2, *v.e.*) is simply a short thin-walled tube running obliquely down and back for a short distance from the anterior end of the testis.

The next section or *epididymis* (Pl. II. fig. 2, *ep.*) forms a loop arched upwards and inwards, the two limbs close together, and approaching one another on the median dorsal line, the bight posterior, at about the middle of the third thoracic segment; the lower and inner limb continues the vas efferens; while the upper outer limb at its end bends down to form the vas deferens proper. The lumen of the epididymis is very small, but

its epithelium is large, columnar, vacuolated, and spongy-looking. There is hardly any membranous wall, and where the two limbs are in contact their epithelial cells dovetail in with one another in this as in most species of *Cyclops*. The second limb a little before its end undergoes the change to the characters of the *vas deferens* (Pl. II. fig. 2, *v.d.*), which after running to the junction of the *vas efferens* and first limb, bends at an acute angle, and runs obliquely downwards and outwards for a short distance and then backwards, following nearly the same course as the oviduct, but is rather more wavy. It opens on the inner side of the large reniform *vesicula seminalis* (Pl. II. figs. 2 & 5, *v.s.*) which, with its fellow, fills the ventral enlargement of the sixth thoracic segment.

The *vas deferens* has a very thin membranous wall lined by tabular cells; within this it contains a structureless membrane, the *wall of the spermatophore*, forming a tube closely packed with spermatozoa, intermixed with deep-coloured nuclei in stained specimens, and extending back to the end of the third thoracic segment, beyond which it narrows greatly. The substance forming the wall of the spermatophore seems to be extensile; a segment of it must come down bodily into the vesicula seminalis, whereof it follows the reniform contour of the cavity.

The *vesicula seminalis* is reniform, and occupies with its fellow the ventral part of the last thoracic segment. Its wall is thin and chitinized inside.

The contents of the spermatophore are of three kinds:—1. A substance in which the spermatozoa are apparently imbedded, which swells up in water, becoming at the same time richly vacuolated. 2. The ordinary spermatozoa, rod-like bodies, slightly wavy, not readily stained, but in water swelling up into disks, which show a refractile streak, staining in watery logwood dye (Draper's ink, formerly recommended in the Q. J. M. S.). 3. Rounded bodies, which in water swell up, showing a clear space round a nucleus, distinctly reticulated (after staining with logwood). In the mature spermatophore these balls, at first mixed with the spermatozoa, become concentrated (by migration?) into a layer lining the wall, and by their swelling contribute to, if they do not effect, the expulsion of the spermatozoa into the spermatheca. What, then, are these bodies? It is evident that they correspond with the large nuclei seen in the *vas deferens*, and they must be either elements formed in the epididymis, or, as Gruber (who does not seem to have employed reagents) suggests, a second form of spermatozoa, which he justifies by a comparison with the dimorphic spermatozoa of the Isopoda. A confirmation of this view is my observation that, on staining after the action of water, in both epididymis and vesicula seminalis, we are able to make out a stained nucleus which has taken no share in the swelling of its unstained envelope, which before was closely applied to the nucleus. In this case the cells of the epididymis must supply the nutriment to bring about this enlargement of some of the spermatozoa, as no such differentiation is observable in the testis. The intermediate substance, of which a distinct plug is found at the mouth of the spermatophore, is probably a secretion of the epididymis, for it invests the spermatozoa in the *vas deferens*\*.

I have never been able to observe closely the union of the sexes. From the accounts

\* Movement has been denied to spermatozoa in all Crustacea save Cirripeds. I have seen them distinctly and actively undulating in the body of a male *Cypris*, half crushed by the cover.

given by Jurine (whose book I only know at secondhand), Claus, and especially Vernet, the following is the process:—The male seizes the female in the clasping-joint of his antennules by her fourth pair of oar-feet, the ventral surfaces of the two animals towards one another. The male then pulls itself up, so that its genital openings come to a level with the copulatory pore of the female, and expels its spermatophores, which become fastened to the pore, each presumably undergoing a torsion in expulsion, so that the apex, which looked towards the middle line, now turns forwards and adheres to the pore of the female. The globular elements of the spermatophores then swell up and drive the spermatozoa out into the spermatheca. The two empty sacs of the spermatophores remain attached for a short time to the female; there they swell up and become rounded. As is well-known, *Cyclops* is never parthenogenetic, but one fertilization suffices for many broods of ova.

#### THE POSITION OF THE COPEPODA IN THE CRUSTACEAN PHYLUM.

In my work, lasting as it has done over a considerable time, it has been constantly in my mind to trace out morphological relations; and the conclusion to which I have been led, that the Copepoda actually represent the ancestral form of the Crustacea, is one which carries to me the greater weight in view of Balfour's opinion that they "are undoubtedly among the lowest Crustacea which are free, or do not lead a parasitic existence," and that "they may claim to be very primitive forms, which have diverged to no great extent from the main line of Crustacean development," assigning as reasons their retention of:—

(a) "The median frontal eye as the sole organ of vision," which I would put thus:—*The plasticity of the eye, derivable from the triune inverted eye of the Nauplius, and the absence of eyes of the paired compound type found in other Phyla, which we may term the "Phyllopod eye."*

(b) "The simple biramous" swimming-legs, and indeed the character of the appendages generally, and "other characters" of which I give a list.

(b') *The plasticity of the maxillæ.* (To be considered with b.)

(c) *The small development of the pleura, never enclosing the body, nor limiting infra-pleural epimera.*

(d) *The absence of gills, and the functional anal respiration.*

(e) *The plasticity of the fore part of the alimentary canal.*

(f) *The circulation.*

(g) *The general form of the body.*

Under each heading I propose to make a few remarks before sketching out what seems to be a not impossible phylum of the Crustacea.

(a). *The eye of the Copepoda* is, with few exceptions, derivable from the type of *Cyclops* or *Calanella*. In Pontellidæ the several ocelli are separated, their number often augmented, and lenses sometimes superadded; in Corycæidæ the lateral eyes are widely separated from the median, and peculiar in many ways, but contain "inverted" bacilli, the nerve entering on their distal side, as first noticed by Claus and confirmed by Grenacher\*. Now this eye, which we may term the "Nauplius eye," is found, scarcely varying from its typical condition (so far as one can judge from figures and specimens), in almost all

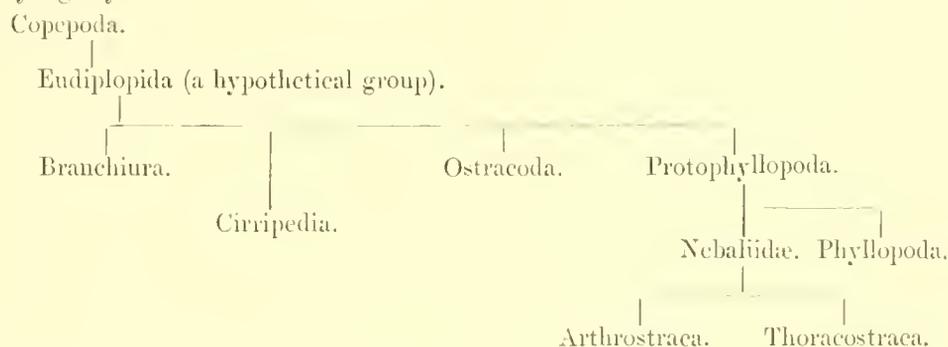
\* *Op. cit.* p. 66, t. vi. figs. 39-43.

groups of the Crustacea except the Arthrostraca\*, if not in the adult, at least in the larva, and contemporaneous with or anterior to the paired compound eye.

The ordinary paired Crustacean eye exists often side by side with the Nauplius eye, constantly in all the Malacostraca, in most Phyllopoda, in *some* Ostracoda (Cypridinidae, &c.), in the Branchiura (*Argulus*), in the Cirriped pupa, but not in the Rhizocephala.

We may infer that the Nauplius eye is *primitive*--in Copepoda proper it is *functional*, and hence susceptible of a degree of variation of which it is incapable when superseded and reduced to a mere larval organ. We may also infer that the compound and paired eye of Crustacea appeared later, in a stock which was ancestral to those which have it. But *Argulus* and the Cirripedia and Rhizocephala have distinct Copepodan affinities. We may conclude, then, that the stock which first acquired this form of the organ, and was ancestral to the rest of the Crustacea, was itself a descendant of the Copepoda.

Again, a recently acquired organ would be less constant than one long possessed; and we find just in these groups of puzzling affinities the inconstancy we might expect on this hypothesis: Cirripedian pupæ have the compound eye, Rhizocephala lack it; in Ostracoda the Cypridinidae alone possess it. This reasoning would lead us to the following phylogeny:—



(*b* & *b*<sup>1</sup>). Condition of appendages.

1. *Antennules*.—As mentioned, this pair is always uniramous—the *primitive larval condition*.
2. *Antennæ*.—In some groups biramous, in others uniramous by loss of exopodite.
3. *Mandibles*.—Possessing in some groups their *primitive biramous palp*, never more than uniramous in other adult Crustacea.
4. *Maxillæ I*.—Most plastic; showing every transition from the primitive masticatory blade with a biramous palp to the closest approach to the type of the Phyllopod limb, in which all Lankester's divisions, except, perhaps, the "bract," may be made out.

I dwell the more on this appendage, because I think, with Claus †, that the biramous condition is primitive, and that if, as is almost certain, the oral thoracic appendages of Malacostraca have passed through a Phyllopod stage, that stage is phylogenetically secondary to the biramous condition; while there is no proof that the abdominal limbs have been at all Phyllopod-like in ontogeny or phylogeny. On the contrary, those

\* Giard has shown that even in this group the larva of *Eutoniscus* has a Nauplius eye.

† Crustacean-System, p. 17. Considering this and other things, I cannot see why he calls the primitive Crustacea "Protophyllopoda." I use the term in a restricted sense, as will be seen from the above phylogeny.

of *Nebalia* approach a rudimentary Copepod condition, the two hindermost possessing a true sternal coupler. And in the Phyllopods themselves the limbs pass through a bifid condition, equivalent to the same embryonic stage of the Copepod foot or maxillæ in its second state.

A glance at the figures of maxillæ of various Copepods will show what I mean. The only conjecture possible is that a metamorphosis similar to that which the maxillæ are undergoing in this group has extended backward to a variable number of segments in the Protophyllopoda to adapt them to their limicolous life, and to make a stronger nutritive current for their bodies, as they become more and more enclosed by the prolongation upwards of the pleural groove in the thoracic region, and possibly its ultimate conversion into a bivalve shell.

5. *Maxillipeds*.—The complete separation of the two rami is comparable to that of the same and the preceding pair of appendages in the Phyllopoda proper, where, however, they are very much reduced.

6–9. *Thoracic Limbs*.—These are, I believe, very primitive, and derived, like all the others, save perhaps the antennules, from the limb of the Chætopod \*, pushed down by the extension of the tergal region, so that the notapodium becomes the exopodite, and the neuropodium the endopodite. The couplers are purely Copepodan, reappearing, however, in the hindermost abdominal legs of *Nebalia* (Claus). This is surely a strong confirmation of the above stated view of the gradual extension of the “phyllopodization” of the limbs from before backwards.

10–11. *Rudimentary Feet*.—These are two pairs, sometimes used as accessory genital organs, which remain in a very embryonic condition; they serve as an index to the process by which the abdomen has lost its appendages to make it a more efficient rudder. As mentioned above, the coincidence in the position of the genital aperture here with that of the female Leptostraca and Malacostraca brings the latter groups directly under the succession of the Copepoda, putting the Phyllopods on one side, out of the direct pedigree of the Malacostraca.

12. *Furca*.—This, as I have already suggested elsewhere, is possibly a modification of a pair of limbs. It is not present in the youngest Nauplius, but appears as a pair of *ventral* outgrowths after the first moult. These are, perhaps, not developed in all Crustacea, but exist, much reduced, as part of the Astacine “telson.” It is interesting to note their immense size in *Nebalia*.

(c). The Copepoda may have their bodies flattened, with the pleuræ straight out; but, so far as I know, no member of the group has the pleural groove prolonged so far up the body as to mark out an epimeral region between the reflection of the pleura and the sternum. The development of the pleural cavity, when carried to an extreme, results in the formation of the bivalve shell; and we have seen how in Ostracoda, and presumably in the bivalve Phyllopods &c., the adductors really represent the suspensors of the entosternite, which we know to be so primitive a structure as to be found in Arachnida (including

\* In the free-swimming pelagic Chætopod *Tomopteris* the parapodia are well marked off from the body so as to have a distinct protopodite; and the hinder part of the body is tapering, with much reduced appendages, recalling or, better, foreshadowing the Crustacean body.

Pöccepilopoda) on the one hand, and *Palæmon* among the Decapoda on the other! Using this character a phylum may be constructed differing from the former only in the addition of a new group "Bathypleuræ."

This at once shows how the Branchiura (*Argulus*) come to be so close to Copepoda; they are a very slightly modified group that has come down from the time of the Eudiplopida, before further divergence had taken place from the Copepod stem.

(d). *The Retention of the Anal Respiration, and the Absence of Gills.*—I regard this as of capital importance. In almost all the Malacostraca the gills, or at least the podobranch, can be traced to the Phyllopod or Leptostracan type. Here we find nothing of the kind. In Cirripeds and Ostracods the gills are of totally different origin, and it is just these two orders that we saw are referable to an archaic type intermediate between the Copepoda and the Phyllopoda. If we substitute in our last phylum "Podobranchiata" for "Protophyllopoda" it will express the facts thoroughly.

The suggestion has occurred to me that the rectal part of the intestine was primitively connected rather with the nephridial system than with the (then aprocæous) gut, an arrangement actually persisting in *Platyelmia* and some Rotifers (*Asplanchna*). In confirmation of this view it is to be noticed that in some pelagic Mollusca, besides the anal respiration as mentioned by Gegenbaur, a similar respiration takes place by the adjacent renal organ, as (first indicated by Huxley, I believe) shown by Joliet, who has conclusively disproved the taking-up of the water into the blood ('Comptes Rendus,' 1883). What seems likely is that this renal opening, adjacent to the primitively blind end of the intestine, has fused more or less with it, and furnished it with an outlet, which in Crustacea (and Annelida) has lost all connexion with the kidney, while in the Mollusca a separation of this rhythmical organ into rectum and kidney proper has taken place. The condition in Amphineura is strongly confirmatory of this view\*.

(e). *Plasticity of the fore part of the Alimentary Canal.*—As is well known, in the Phyllopoda the gut has two branched or simple hepatic diverticula; in Ostracods, Leptostraca, and Malacostraca, besides this, the anterior part of the stomach is chitinized.

Now we find in *Cyclops* and *Diaptomus* a chitinized anterior end of the stomach and no diverticula; in *Calanus* &c. the chitinization is limited to the gullet, and there is a median dorsal branching hepatic diverticulum. In *Temora* and *Calanella* there are paired cæca. The conclusion is that in various Copepoda we find a foreshadowing of conditions well marked in the other Crustacea†.

(f). *The Condition of the Circulation.*—The heart, when present in Copepoda‡, is a dorsal contractile sac, lying in the first or second thoracic segment, with three venous ostia, one posterior and two lateral, and a median anterior arterial ostium, sometimes continued into a short branching aorta; this corresponds with the heart of Cladocera and the cordate Ostracods. Now, while I am perfectly aware of Claus's reasons for considering

\* *Vid.* Lankester, "Mollusca," Encyclopædia Britannica.

† May not the chitinization of the gullet and stomach, with the development of an armature, be returns to a primitive condition found in so many Worms and Rotifers, and even homologous, *longo intervallo*, with the odontophore of Mollusca?

‡ Calanidæ and Pontellidæ.

the many-chambered heart of the proper Phyllopods as primitive, there seem to me equally strong ones for believing it to be rather a new development, connected with the strong segmentation of the long body, like what we find in the very aberrant Stomatopods, a group in which the similar heart cannot but be regarded as merely homoplastic with that of Phyllopods, if the Leptostraca (*Nebalia*) be the parent form of the Stomatopods. In *Nebalia* there are the above three large, well-marked venous ostia, but besides these there are smaller ones—one pair in front of the large lateral pair, and four “ganz klein” pairs, nearly dorsal, between these anterior and the posterior pairs; another lateral pair is added at the last moult, between the anterior lateral pair and the foremost of the dorsal ones. Now this shows that in *Nebalia* an increase in the number of ostia takes place just at the last moult, and the curious positions and varying size of the ostia squares with the possibility of this heart being derived from the simple heart of the Copepod and Zoæa, independent of the segmented heart of the Branchiopod. With the strong development and concentration of the cephalothorax which I ascribe to the primitive Crustacean, its heart must have been a short one, and many Zoææ show the same condition of the heart as we find in Copepoda. Moreover, if we compare Crustacea with Chætopoda, we find many a reason for believing the heart of the former to be a new structure, possibly derived from intersegmental septa or mesenteries. In that case it could only have been formed in the roomy cephalothorax, and would have had the Copepod form.

The circulation is effected in some of the Parasitic Copepoda, according to Claus, Pickering, and Dana \*, by contractile mesenteric valves; and in all of that group, which I regard as off the main line of Crustacean descent, the blood-corpuseles are said to be floating rather than wandering cells.

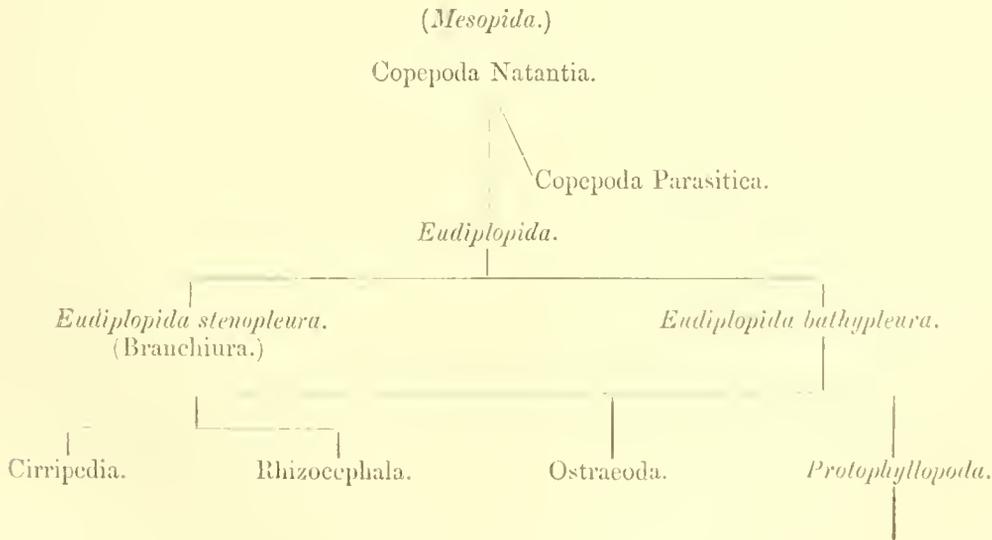
I may here note that there seems very little reason for connecting the so-called blood-system of Arthropods—at least of Crustacea—with the proper blood-system (pseudhæmal) of Annelids; the former always containing the amœboid cœlomic corpuseles, the latter special corpuseles derived from its walls, and, indeed, in this respect corresponding, as in so many others, in a measure with the blood-system of the Vertebrate embryo.

(g). *The General Form of the Body*.—If we try and figure to ourselves an ideal Crustacean, that shall combine the characters of as many groups as possible, including, too, such larval forms as Zoæa, we find that we have an Arthropod with a strong and large cephalothorax, its segments fused anteriorly, and with bifid limbs on its ventral surface, the cephalothorax appendages used for progression and apprehension of food, and the abdomen reduced to a jointed tail with ill-developed appendages, and made by the enlargement of the dorsal end into an efficient caudal rudder or fin. Of such a type are all Protozoææ, and most Zoææ, *Nebalia*, *Cuma*, and many adult Maerura; and it occurs, disguised by the shell, in many Cladocera and Ostracoda. This is the characteristic form of Copepoda generally, which, indeed, corresponds absolutely with the *Erichthys* larva of Stomatopods, save for the better-developed pleuræ of the latter, and its widely expanded telson. If we imagine how the creeping Chætopod evolved into the Crustacean, we shall see that

\* See Gerstäcker in Bronn's Thier-Reich, Bd. v. p. 656.

the elongation of the parapodia for swimming must have demanded a firmer *point d'appui*, and entailed the fusion of the anterior segments. That this has taken place may be judged from the unsegmented Nauplius, which in the egg was markedly divided into three segments, a point hitherto but little noticed. The limbs would work to better effect by being displaced ventrally, and the downward extension of the carapace into pleura, very little marked indeed in some Copepods (*Calanus*), would probably aid the action of the limbs by concentrating their action on a limited volume of water. But as in ontogeny the segments develop from before backwards, and the limbs develop only slowly and later than their proper segment, we should look for the disappearance of the abdominal appendages by a mere retardation, not by progressive abortion—*i. e.*, *pro tanto*, a retention of a young condition in that region, such as we find actually in the pelagic worm *Tomopteris*; and when once they disappeared in the adult, it would be vain to seek any traces of them in the larva. That they should reappear does not imply a new creation of parts, but just such an occurrence as the revival of suppressed parts, with which every vegetable morphologist is familiar. In *Nebalia* the hindermost abdominal feet are united by a median coupler (Claus) as in Copepoda. We are led, then, on all sides to the conclusion that *the Copepoda represent a primitive type of Crustacea*.

How, then, would the Nauplius stand? Purely as a necessary larval form, with its anterior segments fused, and in no sense ancestral; and this is the generally accepted view. Beyond Copepoda we can imagine a series of forms with progressively disjointed cephalic ends and rudimentary abdominal parapodia, and these would hardly be counted as Crustacea at all. To essay a Phylogeny:—



This table explains itself. By assuming that Cirripedia and Ostracoda come off from the parent stock soon after the development of the compound eyes, we can understand their inconstancy in the two groups—a recently acquired organ, like a new trick, being first forgotten.

One point more remains. If in any Crustacea we are to seek a common relation to the Tracheata, especially to the Arachnida, it must be the Copepoda. While I do not think

we can at present go far in this direction, we may at least note that here the intestine is in its hinder part distinctly renal in function, that as the liver is distinctly an outgrowth from the anterior digestive part, so Malpighian tubes may be developed (phylogenetically as they are in fact ontogenetically) as paired outgrowths from the hinder part. Besides this, the basal parts of the limbs are united by a median sternal process, as Lankester noted (" *Limulus* an Arachnid," Q. J. M. S. xxi. p. 638), though he regarded this in the one group as effected by the outgrowth (or rather downgrowth) of a median sternal process, and not in the other; but there seems no reason for this distinction\*.

### DESCRIPTION OF THE PLATES.

NOTE.—The great majority of these figures were drawn to scale with the Oberhäuser camera, and scarcely diagrammatized, except by the omission of unimportant details. The striation of the muscles is, however, conventional throughout. The drawings of the limbs have been finished for the engraver by Mr. J. Macpherson, and most of the others by Miss F. Thorpe, of Cork. To the actual magnification of the drawing I have subjoined the letter of the Zeiss objective under which it was originally made (B  $\frac{2}{5}$ " , C  $\frac{1}{4}$ " , D  $\frac{1}{6}$ " , E  $\frac{1}{9}$ " , J  $\frac{1}{15}$ " imm.).

The following are the letters used :—

*a.*, anus; *ap.*, apodeme; *ap.an.*, apertor ani; *ap.pm.*, postmaxillary apodeme; *ar.*, arthro-dial (cavity or ridge); *at.*<sup>1</sup>, antennule; *at.*<sup>2</sup>, antenna; *b.*, brain; *bl.*, block of eye; *bas.*, basipodite; *car.*, carapace; *c.f.*, corneal facet; *co.*, coupler; *com.*, commissure; *cox.*, coxopodite; *ep.*, epididymis; *epi.*, epistoma; *end.*, endopodite; *ent.*, free entosternite; *ext.*, exopodite; *f.*, furca; *fl.*, flexor; *g.*, ganglion; *g.az.*, azygos ganglion; *h.*, masticatory hook; *i.*, intestine; *k.*, shell-gland; *k.o.*, its opening; *l.*, labrum; *lac.*, lacuna; *lap.*, lappet of paragnatha; *m.*, muscle; *m.ab.*, abductor; *m.add.*, adductor; *m.ap.*, apertor; *m.ap.an.*, apertor ani; *m.cons.or.*, constrictor; *m.d.*, depressor; *m.ext.*, extensor; *m.fl.*, flexor; *m.l.*, levator; *m.oc.*, ocludor; *m.pr.*, protractor; *m.pl.*, pleural; *m.r.*, retractor; *mn.*, mandible; *mx.*, maxilla; *mxp.*<sup>1</sup>, outer anterior maxilliped; *mxp.*<sup>2</sup>, inner or posterior maxilliped; *mo.*, mouth; *n.*, nerve, nerve-cord: *n.az.*, azygos nerve; *n.fr.*, frontal nerve; *n.fr.sup.*, superior frontal nerve; *n.fr.i.*, inferior frontal nerve; *n.m.*, motor nerve; *n.pl.*, pleural nerve (to side-walls of body); *n.sens.*, sensory nerve; *n.th.*, thoracic nerve; *o.*, outer; *oc.*, ocellus; *oc.l.*, lateral ocellus; *oc.v.*, ventral ocellus; *od.*, oviduct; *oe.*, œsophagus; *ov.*, ovary; *p.*, palp or palpiform process; *pc.*, pore-canal; *pg.*, paragnatha; *pl.*, pleuron; *p.o.b.*, postoral bar; *p.p.*, pectinate process; *pr.v.*, prerectal valve; *r.*, rostrum; *re.*, rectum; *ri.*, ridge; *s.*, stomach; *sa.g.*, salivary gland; *sa.p.*, salivary pore; *sp.d.*, sperm-duct; *spp.*, pore of spermatheca; *su.a.p.*, supra-anal plate; *sp.th.*, spermatheca; *st.*, sternal plate; *t.*, tooth; *te.*, testis; *th.*, thoracic segment or appendage; *u.*, uterus; *v.d.*, vas deferens; *v.e.*, vas efferens; *ve.s.*, vesicula seminalis; *vu.*, vulva.

### PLATE I.

Figs. 1–10 are all magnified 150 diameters: C.

Fig. 1. Right antennule of female.

Fig. 2. Right antennule of male.

Fig. 3. Antenna.

Figs. 4, 4 *a.*—4. Left mandible, ventral aspect; 4 *a.*, posterior aspect. (The full length of the setæ of the palp is not drawn.)

Figs. 5, 5 *a.*—5. Left maxilla, posterior aspect; 5 *a.*, ventral aspect.

\* I leave this passage as it was written in 1884; but I am more and more inclined to accept the view that the Arachnida are rather connected with the Arthrostraca. *Fcb.* 1888.

- Fig. 6. Right anterior maxilliped, postero-internal face, showing renal aperture.  
 Fig. 7. Right posterior maxilliped, same face.  
 Fig. 8. Left 1st thoracic limb, posterior face; muscles of anterior side omitted.  
 Fig. 9. Right 4th thoracic limb, anterior face; muscles of posterior side of protopodite omitted; poro-canal and (in exopodite lower joints) outlines of hypoderm cells indicated.  
 Fig. 10. Section through the right coxopodite and coupler of a thoracic limb; from a horizontal section.  
 Fig. 11. Free apex of labrum.  $\times 375$ : E.  
 Fig. 12. Mouth of a live animal, from below, showing labrum, with salivary pore, preoral bar, paragnathæ (the right, *pp.r.*) turned out, and exposing its internal face.  
 Fig. 13. Paragnathæ, seen dissected out in ammonia, seen from above (oral aspect).  
 Fig. 14. Part of the sternal region of cephalon, ammonia preparation, showing inner and outer and inner arthrodial ridges, sockets, and shrivelled remains of kidney.  
 Fig. 15. Free entosternite, dorsal view, from a horizontal section; the lined parts are the retractor muscles attached to the postmaxillary apodeme, and the squarish dots are the origin of the retractors of the preoral bar seen by transparency.  $\times 125$ : D.

## PLATE II.

- Fig. 1. Adult female, seen from above; the reproductive organs and extrinsic muscles of the intestine and anus put in diagrammatically, as if the animal were transparent.  $\times 48$ : I".  
 Fig. 2. Adult male; reproductive organs diagrammatic.  $\times 48$ : I".  
 Fig. 3. Sternal region of anterior part of thorax (compiled from two sketches of the live animal): the 1st limb and coupler are seen turned back; the region of the 2nd thoracic segment is exposed by the 2nd limb (not shown) being turned forward, and the 3rd limb turned back. Part of the ventral nerve-cord shows by transparency, and the transverse direction of the nerve to the 1st limb, as compared with the obliquity of those to the 3rd and 4th, is obvious. The front of the nerve-cord is too narrow.  $\times 150$ : D.  
 Fig. 4a. Sternal region at junction of fore and hind body (4th to 6th segments) of immature female before last moult, diagrammatized from life, showing 5th thoracic limb; great flexors of body and median apodeme of their insertion, nerve-cord enlarged at hinder end of 4th and 5th segments, and bifurcating in the 6th, giving off at the former enlargement nerves to the flexors, to the 5th limb, and to the sides of the 6th segment, and at the latter nerves to the vulva and to the sixth limb (genital limb).  $\times 150$ : C and D.  
 Fig. 5. Same region of adult male, showing in addition the genital valves, vesiculae seminales, left vas deferens, and the nerve from the 4th segment to the side of the 6th.  $\times 150$ : C and D.  
 Fig. 6. Side view of same region of female combined from life and sagittal sections, showing vulva, spermatheca, and pore, 6th limb (genital valve), and terminations of pleural nerve.  $\times 150$ : C and D.  
 Fig. 7. Frontal section (from a transverse series) showing corneal facets, &c.  $\times 250$ : D.  
 Fig. 8. Horizontal section through eye and front of brain, showing left optic nerve, and (at a slightly higher level) right inferior frontal nerve.  $\times 125$ : J.

## PLATE III.

- Fig. 1. Sagittal section of adult female (nearly median), showing chief organs *in situ*; histological details diagrammatic; ganglion of fourth thoracic segment (*g. th. 4*) too large.  $\times 48$ : I".  
 Fig. 2. Sagittal section through last three segments of abdomen, showing epithelial valve at junction of intestine and rectum, median (dorsal) muscles of rectum, and ventral apertor ani, and continuation of one fork of nerve-cord to furca.  $\times 250$ : D.  
 Fig. 3. Intestine, from above (horizontal section, osmic acid and cochineal), showing the epithelium and

the incomplete circular muscles in fascicles attached at the sides of the gut, and diverging towards the upper (and lower) median line; the striation is too marked, and the longitudinal fibres are omitted. E.

- Fig. 4. Sagittal section (almost exactly median) through front of cephalon, showing relations of rostrum, epistoma, and labrum, œsophagus, and muscles of deglutition, brain with azygos nerve and ganglion, eye, and nerve-cord.  $\times 150$  : C.
- Fig. 5. Transverse section of maxillary region of male (slightly diagrammatized), and the anterior branches of the uterus, introduced from a corresponding section of a female, showing muscles of maxilla, position of entosternite with its suspensors, retractors of preoral bar, nerve-cord, stomach, and pleural muscles, &c.  $\times 150$  : C.
- Fig. 6. Horizontal section of front of cephalon of female, showing relations of mouth, &c., salivary glands, and duct.  $\times 150$  : C.
- Fig. 7. Left kidney of immature female, in natural position, from without, shaded to convey relations of its successive coils : 1, point at which it bends inwards (into œlom ?) ; 2, commencement of duct.  $\times 250$  : D.
- Fig. 8. From a transverse section in the region of the anterior maxillipeds, showing relations of kidney and duct : 1, 2 as in Fig. 7.  $\times 125$  : D.
- Fig. 9. Left kidney of *Nauplius*, 2nd stage, *in situ*, from below, with its termination (opening ?) on base of antenna, and its other end in a mass of protoplasm in the body.  $\times 525$  : J.
- Fig. 10. Series of maxillæ from various Copepoda, to show transitional forms from biramous condition to that of the Phyllopod (copied by kind permission from Brady's 'British Copepoda') :—  
*a. Calanus finmarchicus*, Gunner; *b. Metridia armata*, Bocck; *c. Pseudocalanus armatus*, Bocck; *d. Pontella Wollastoni*, Lubbock; *e. Pseudocyclops obtusatus*, Brady and Robertson; *f. Parapontella brevicornis*, Lubbock; *g. Notodelphis agilis*, Thorcell; *h. Robertsonia tenuis*, Brady and Robertson.

#### PLATE IV.

- Fig. 1. Sagittal section of anterior part of nerve-cord, traversed by retractors of preoral bar.  $\times 375$  : E.
- Fig. 2. Horizontal section of nerve-cord in region of first and second maxillæ, showing transverse fibres, slightly deeper on left side.  $\times 375$  : E.
- Fig. 3. Superficial view of brain, from a dissection (osmic acid, cochineal, oil of cloves), with origin of nerve to left antennule, forming a lateral lobe.  $\times 250$  : D.
- Fig. 4. Sagittal section of brain and eye to left of median line, showing left superior frontal nerve.  $\times 250$  : D.
- Fig. 5. Sagittal section of eye, nearly median.  $\times 525$  : J.
- Fig. 6. Slightly oblique section of eye.  $\times 375$  : E.
- Fig. 7. Horizontal section of inferior (median) ocellus.  $\times 375$  : E.
- Fig. 8. Dissection (after gold chloride) of front of brain and eye.  $\times 250$  : D.
- Fig. 9. Transverse section of nerve-cord in posterior region of first maxillæ.  $\times 375$  : E.
- Fig. 9 *a*. Section at level of posterior maxillipeds; all nerve-cells alone indicated.  $\times 150$  : D.
- Fig. 10. Portion of large nerve-trunk laid open by razor, and showing nucleoid granules.  $\times 525$  : J.
- Fig. 11. Expansion of a large nerve (sensory, below hypoderm). (From a transverse section.)
- Fig. 12. Doyerian eminence, from same section as fig. 11.  $\times 375$  : E.
- Fig. 13. A nucleus from posterior end of testis (rhachis) : *b*, dividing nuclei from a little further on, one showing the diaster stage, with spindle of achromatin fibres; *c*, male ova, or spermatospores from about middle of testis; *d*, male ova, with dividing nuclei, from a little further on. (All these taken from a dissection treated as in fig. 3.)  $\times 1050$  : J.
- Fig. 14. Expulsive bodies from a crushed seminal vesicle, slightly swollen (Draper's ink, glycerine).  $\times 750$  : E.

II. *Description of a new Genus and Species of Pyralidæ, received from the Rev. J. H. Hoeking, from the Kangra Valley, Punjab, India. By the Right Hon. LORD WALSHINGHAM, M.A., F.R.S., F.L.S.*

(Plate V.)

Read 16th June, 1887.

ABOUT seven years ago I received from my friend Mr. Hoeking\*, then residing at Dharmasala in the Punjab, a batch of cocoons with some preserved larvæ and a few specimens of a moth, to which, having regard to the evidence of its life-history, I found it difficult to assign a place in the accepted system of classification.

The following notes accompanied the specimens:—"On Jamin. Larvæ covered with a thick coating of dirty white silk; each larva in a separate compartment, great numbers of which joined together form a mass as large as a man's fist. The larvæ when young march over the leaves as processionary larvæ, covering the leaves as they go with silk, which after a little forms the outside of the compartment and is covered with frass; after a little each individual makes a compartment for itself, using the frass-covered silk, which it lines, as it draws it round itself, with a fresh covering of silk, so that there are two layers of silk with frass between them. I had worked for two years for these, and then found all the larvæ in June turned into pupæ.

"Imago during the first fortnight in July.

"A second lot found in October furnished the larvæ now brought."

The collection received at the same time contained so large a number of new and interesting species, as to induce me to indulge the hope that it might afford material for a separate work. The greater part of these, together with many larvæ admirably preserved by Mr. Hoeking, are now in the British Museum; and those which have not yet been described have become the subject of special study, with a view to publication.

Mr. F. Moore, to whom the specimens were shown, was somewhat incredulous as to the connexion between the larvæ and the perfect insects, having met with no similar series of transformations in his large experience of Indian Lepidoptera. I received no further particulars about the species under consideration until 1885, after Mr. Hoeking had returned to England and settled in Suffolk. At the risk of some slight repetition, I quote his letter, dated April 14th of that year, in full, so far as it relates to this subject:—

"I am *so pleased*, I have succeeded in getting home from India a box full of cocoons of that moth about which Mr. Moore was, and I believe still is, so sceptical. When they arrived this morning, I found, on opening the box, that there was a quantity of frass in it, showing that the larvæ had been put in before they had changed. On cutting open

\* Rev. Jno. H. Hoeking, Debenham Vicarage, Stonham, Suffolk.

one compartment, I found a dead larva, and my heart sank within me; but in the next I found a fine healthy chrysalis, and so in the others I have opened:

“You have a specimen of the caterpillar mounted. In my list it is No. 23 of 1879, and I have the following notes on it:—‘June 28. On Jamin. Larvæ covered with a thick coating of dirty white silk; each larva in a separate compartment. Had searched for two years for this; and then found all the larvæ changed to chrysalids. Moths came out first fortnight of July; ♂ and ♀ differ.’

“This I afterwards discovered was the second brood; these which I am sending you should come out soon, if the second lot should be spun up and in chrysalis state on 28th June, when I found the chrysalis in 1879. You should, I think, place them in a warm, damp air. I remember these coming out in the sweltering heat of the rains in the Kangra Valley. It is, I think, a triumph to have described this insect to unknowing people in India, and in getting home a by no means common thing just in the right state. I told my friend as nearly as possible where to find it, and told him to go on cutting open the compartments every week, until he found a chrysalis and *not* a caterpillar. And he seems to have acted up to his orders. You might, perhaps, send a clump to Mr. Moore and let him *see* the moths come out.”

The cocoons referred to in the above letter reached me safely, and were placed in a conservatory in my house in London.

The perfect insects emerged in the months of June and July, and although a large proportion of them were cripples, several good specimens were obtained. I believe that Mr. Moore also succeeded in rearing some from the clusters of cocoons which I sent to him. I am much indebted to him for an opportunity of examining some allied forms from his Indian collection, as well as for the suggestion, in which I entirely concur, that the genus is allied to the well-known European genus *Aglossa*. In proof of a somewhat similar tendency to gregarious habits in that genus, the following extract from the late Mr. Wm. Buckler's notes on the life-history of *Aglossa cuprealis*, IIb., published in the Ent. Mon. Mag., Sept. 1884, p. 76, may be referred to:—

“From the first they spin the rubbish together, making tubes much in the same way as *pinguinalis* and often making use of a straw, bean-husk, or folded leaf of *Cladium mariscus*, as a private retreat; they seem, when supplied with plenty of materials, to make the sides of their galleries of some considerable thickness, and sometimes two or three larvæ were found inhabiting the same gallery, which, however, in such a case would be noticeably longer than one occupied by a single tenant.”

This account, taken together with other evidence, is valuable as showing analogy between the habits of the two species in the larval state, and strongly supports the conclusion that some affinity exists between them.

The following is the description of a new genus and species, taken from the specimens above mentioned (figured on the Plate which accompanies this paper):—

## EPIPASCHINÆ.

## CÆNODOMUS, gen. nov.

(κοινὸς=common, δόμος=dwelling.)

Type *Cænodomus Hoekingi*, Wlsm.

*Antennæ*: ♂ bipectinate, tapering through two thirds of their length; thence laterally compressed, merely pubescent; each pectination bears a double series of fine hairs beneath; a cylindrical, erect, membranous sac, obtuse at the apex, arises out of the enlarged, globose, basal joint, and is thickly clothed with strong elongate scales; ♀ simple, slightly pubescent, with basal joint much enlarged, but without a membranous sac.

*Ocelli* none.

*Eyes* large and projecting.

*Maxillary palpi* short, porrect.

*Labial palpi* projecting about the width of the eyes beyond them, thickly clothed with closely packed coarse scales; the short apical joint almost concealed in the clothing of the second joint, which is stout and tumid, and at least seven times its length.

*Tongue* clothed at the base, thence long, naked, and conspicuously double.

*Fore wings* narrow at the base, widened outwards at the anal angle; the costa straight, apex depressed and rounded; apical margin oblique, slightly convex; dorsal margin also slightly convex near the base: *neuration*, the costal nervure extends slightly beyond the end of the cell; the subcostal nervure is divided at the upper end of the cell into two nervules, the lowest of which goes direct to the dorsal margin, the upper reaching the apex after emitting a strong branch from the middle of its lower edge to the dorsal margin immediately below the apex, and three very short slender nervulets to the costal margin; from about the lower angle of the cell four nervules are emitted to the dorsal margin, the upper or discoidal nervule closely approximate at its base to the upper of the three median nervules, which are separated from each other by an almost equal space.

*Hind wings* slightly wider than the fore wings, with evenly rounded margins.

Frenulum of the ♂ single, of the ♀ double: *neuration*, the costal nervure touches the upper of the two subcostal nervules slightly beyond the end of the cell, and in some specimens is anastomosed with it; the discocellular nervule is much angulated inwards above the middle, and below it the discoidal nervule, as in the fore wing, arises very near the upper of the three median nervules, which are separated by an equal space from each other; these, however, are all separate and distinct, differing in that respect from the genus *Aglossa*, Latr., in which the upper one is forked.

Both pairs of wings with tufts of raised scales.

*Abdomen* moderately stout, reaching slightly beyond the hind wings.

Lateral claspers broad at the base, tapering posteriorly to a depressed obtuse point.

Uncus single, obtuse, scutelliform.

*Legs*, tibiae clothed with long scales; tarsi rather slender.

The ♀ is usually a little larger than the ♂.

*Larva* with sixteen legs; the four pairs of abdominal claspers situated on segments 7, 8, 9, and 10. Living in colonies, in strong silken cases, of which several are woven together.

*CÆNODOMUS HOCKINGI*, n. sp.

*Head and face* fuscous.

*Antennæ*: ♂ bipectinate for two thirds of their length, with a pair of erect cinereous tufts arising from a hollow sac on the enlarged basal joint; ♀ simple, but with the basal joint globose; pale cinereous inclining to ochreous.

*Labial palpi* black.

*Tongue* pale cinerous-ochreous.

*Thorax* fuscous mixed with cinereous; on the underside dark fuscous, almost black.

*Fore wings* brownish grey, mottled and banded with cinerous, dark fuscous, and white, with tufts of raised brownish-cinereous and fuscous scales. The costal margin from the base to near the apex is very dark fuscous with an iridescent hue, interrupted about the middle by two narrow oblique lines of white scales, which become blended below the fuscous margin, and form an ill-defined whitish fascia, which has a pink iridescent tinge in a strong light. A similar slender waved line of white scales extends from the costa near the apex in the direction of the anal angle. Before the white fascia is an oblique raised brownish-cinereous streak margined with fuscous; and beyond the fascia the space preceding the waved whitish outer line is pale brownish cinereous. The chief accumulations of raised scales on the fore wing are immediately preceding the whitish fascia, on the basal portion of the discal cell and on the fold below it; besides a conspicuous brown tuft below the middle of the costa between the lines of white scales forming the upper part of the fascia, and a smaller one immediately beyond it, at about the same distance from the costal margin, which are both tipped with white; there is also a small tuft above it and before the anal angle.

*Underside* shining pale greyish cinereous, the costal margin inclining to fuscous; a few pale fuscous and whitish streaks and mottlings showing through both pairs of wings from the upperside.

*Hind wings*, the general colour is brownish grey, with whitish and fuscous mottlings. On the hind wings the only tuft of raised scales is placed below the middle of the wing near to the abdominal margin.

*Legs* fuscous, touched with pale cinereous.

*Abdomen* cinereous at the base, inclining to fuscous beyond it; the anal tuft cinereous, mottled with fuscous.

*Exp. al.* ♂ 38 millim., ♀ 42 millim.

First received from Rev. J. H. Hocking, from the Punjab, India, in 1880.

The larva has the head deep, dark brown; on the second segment is a yellowish-ivory coloured chitinous plate, not divided in the middle, and reaching well over to the spiracles on each side; this is flecked with about twelve small pale brown spots above and has two

ferruginous brown longitudinal stripes, one on each side of the central space. On the anterior edge of the third segment is a central brownish-fuscous spot equidistant between two also anterior lateral ones and two posterior intermediate ones of the same colour. The next segment is somewhat similarly marked, but the upper central part is re-duplicated. The fifth, sixth, and seventh segments have a pair of anterior spots near the spiracles, and a pair of posterior lateral spots above them. The sides of the segments below the black spiracles have a rugose and reticulated appearance, and the undersides of the three anterior segments are black, the feet only tipped with brown. The pale ground-colour of all the anterior segments is that of dull yellowish ivory. Behind the seventh segment the larval skin is of a uniform dusky brownish tinge without markings, and is evidently never exposed, the flattened claspers being partially aborted.

The larva is about 30 millim. in length, each tube about 40 millim.

The food-plant of this curious species, under the name of "Jámin," pronounced "Jáh-min," has been determined by Mr. Carruthers as *Eugenia jambolana*, Lam.\* Mr. Hocking writes that it is as large as a shrub, having a shiny semitransparent leaf, and that the natives make their ploughs of its wood.

The larvæ are gregarious, living in strong tubes of white silk, of the consistency of stout cardboard; these are open at both ends, and from three to fifteen or more are agglomerated together, the heads of the larvæ projecting from one or other end, according to the position of the leaves of their food, to which the whole mass of tubes is attached by stout silken threads consisting of many strands. The walls of these tubes are double and are very curiously constructed, their whole thickness being not less than from two to three millimetres. The inner lining of white silk is smooth and rather shining; the outer layer, which has a slight yellowish tinge, is much stouter and stiffer than the inner lining, and, although smooth, has an uneven surface; this is caused by the interposition of a layer of the larval excrement between the double silken wall. A more perfect arrangement for keeping off heat from the body of the larva could scarcely be devised. The silk at the ends of the tube is frayed out, and has been apparently used for attaching them to the leaves and twigs, or for changing the position of the common dwelling, according to the feeding requirements of its various inmates. When three or four tubes only are found agglomerated together, these are usually parallel to each other; but when the mass consists of a larger number they are placed, apparently without system, crossing and recrossing each other at all sorts of angles, with their apertures thus pointing in many different directions.

I have compared specimens with the following allied genera described by Mr. F. Moore and others:—

*Taurica sikkima*, Moore, has the antennæ slightly tufted at the base, and strongly pubescent on both sides throughout. *Cœnodomus* differs from this in having the antennæ bipectinated for two thirds of their length only.

*Sterieta*, Led., = *Glossina*, Gn., has a membranous process arising from the basal joint of the antennæ and turning back over the thorax.

*Sarama*, Moore, has a similar process clothed with thick scales, reminding one in

\* Mr. Thos. Christy, F.L.S., has been good enough to supply the specimen figured in the Plate.

appearance, though not in structure, of the American genus *Acrotophus*, Poey, and its allies.

*Scopocera*, Moore, and *Pannucha*, Moore, are also allied genera, with somewhat similar structural peculiarities on the basal joint of the antennæ, but differing from *Cænodomus* in the degree of pectination or pubescence on the remaining joints of these organs.

*Titanoceros*, *Catamola*, and *Astrapometis*, all described by Meyrick (Trans. Ent. Soc. 1884, pp. 61 *et seq.*), are also allied genera.

#### DESCRIPTION OF PLATE V.

- Fig. 1. *Cænodomus Hockingi*, ♂. 1 *a.* Head, front view. 1 *b.* Head, side view. 1 *c.* Portion of antenna of ♂, magnified.
- Fig. 2. *Cænodomus Hockingi*, ♀. 2 *a.* Portion of ♀, magnified.
- Fig. 3. A colony of larvæ in agglomerated cases among leaves of *Eugenia jambolana*, Lam. 3 *a.* Section of agglomerated empty larval cases. 3 *b.* Single larva extracted from its case. 3 *c.* A group of three cases, heads of the larvæ protruding. 3 *d.* Magnified section of silken wall of larval case.
- Fig. 4. Neuration of fore wing. 4 *a.* Neuration of hind wing.

III. *The Zoology of the Afghan Delimitation Commission.* By J. E. T. AITCHISON, M.D., C.I.E., F.R.S., F.L.S., Naturalist attached to the Mission, and Secretary to the Surgeon-General, Her Majesty's Forces, Bengal.

(Plates VI.–XIV. and two Maps.)

Read 3rd February, 1887.

Introduction . . . . .	By J. E. T. AITCHISON.
Mammals . . . . .	By OLDFIELD THOMAS, F.Z.S.
Birds . . . . .	By R. BOWDLER SHARPE, F.L.S., F.Z.S.
Reptiles . . . . .	By G. A. BOULENGER, F.Z.S.
Fishes . . . . .	By ALBERT GUNTHER, M.D., F.R.S.
Arachnida, Chilopoda, and Crustacea . .	By R. L. POCKOCK.
Coleoptera and Diptera . . . . .	By C. O. WATERHOUSE.
Hymenoptera and Orthoptera . . . . .	By W. F. KIRBY.
Gall Insects . . . . .	By G. B. BUCKTON, F.R.S., F.L.S.

#### INTRODUCTION.

IF the zoological collections which I have made do not answer the expectations of all, the difficulties which I have had to encounter in my work must be taken into consideration. On being appointed to the Mission, I was called upon to undertake the general duties of a naturalist, in addition to my more special calling of botanist. Previously to this I had never collected zoological specimens, and, owing to the very short notice of departure given to me, I failed in obtaining collectors, the Afghans, in this respect, being useless. Griffith remarked, fifty years ago, "Afghans will not collect;" and I can vouch for it they are still unchanged. Luckily for the undertaking, Mr. Wood Mason, of the Calcutta Museum, sent me two native taxidermists, who although useless as collectors, were invaluable in the honest way they worked as taxidermists and, in addition, arranged, labelled, packed, and sorted my various impedimenta, so as to allow of my having more time to devote to zoology.

I am greatly indebted to Lieut. Rawlins and Capt. C. E. Yate, both of whom liberally supplied me with birds whenever they had the opportunity, and I must here thank various members of the Mission who assisted me by procuring specimens, and who may not have been personally named elsewhere in this paper.

My collections comprise 290 species belonging to 210 genera, of which 32 species have been described as new.

Of Mammals I collected 16 species belonging to 13 genera, in addition to which 7 other species, belonging to 7 genera, were seen, of which I was unable to obtain specimens. The most interesting, as being the least known of these, as I learn from Mr. Thomas,

is *Ellobius fuscicapillus*, the original specimens of which were obtained many years ago near Quetta. The next point of importance is the extension of the geographical range of *Felis tigris* in Afghanistan as far east and north as Bala-morghab, and that of the Hunting Leopard (*Felis jubata*) to the valley of the Hari-rud; while the Egyptian Fox (*Vulpes famelica*) was obtained as far north and east as Kushk-rud and Kin, in the basin of the Harut river.

Of Birds, I collected 123 species, belonging to 82 genera, besides recognizing about 14 other species, specimens of which I failed to procure. Amongst these there are only three new species, namely, a Woodpecker (*Gecinus gorii*, Hargitt), a Sparrow (*Passer yatii*, Sharpe), and a Pheasant (*Phasianus principalis*, Selater). With few exceptions all the birds observed were migratory, the exceptions being the Pheasant, Raven, Rook, Carrion-Crow, Jackdaw, Sparrow, Starling, the Sky-Lark (*Alda arvensis*), the Large-crested Lark (*Galerida cristata*), the Bokhara Lark (*Melanocorypha bimaculata*), the Wall-creeper (*Tichodroma muraria*), the Bittern (*Botaurus stellaris*), an Owl, several of the *Raptors*, the Black-breasted Sand-Grouse (*Pterocles arenarius*), and a Red-legged Partridge (*Caccabis chukar*).

As spring advances, birds are seen to arrive, following each other very rapidly, such as *Aedon familiaris*, *Sylvia*, *Saxicola*, *Motacilla*, *Lanius*, *Pastor*, *Merops*, *Coracias*, &c., &c. The various Ducks are then leaving, except the Brahminy (*Casarca rutila*), which breeds there and is resident throughout the year. The largest number of species occur in the genera *Saxicola* (8), *Lanius* (6), *Sylvia* (5), *Motacilla* (5), and *Emberiza* (4).

Of Reptiles there are 35 species, comprising Tortoise (*Testudo*), Lizards (*Lacertilia*) 21 species, of which 3 are new, Ophidians 13 species, of which 1 is new. The collections of Lizards Mr. Boulenger considers interesting, as much on account of good and numerous specimens as of the number of genera represented. Amongst the Ophidians there are fine specimens of the little-known *Naia oxiana*, heretofore only recognized from young and undeveloped specimens.

Of Batrachia there are only two species, *Rana esculenta* and *Bufo viridis*. Feeding on the latter was found a Leech (*Aulostomum gulo*).

Of Fishes I only managed to procure 7 species, belonging to 6 genera, 3 of which prove to be new. The most interesting species amongst them, owing to its geographical distribution, is *Schizothorax intermedius*, first found by Griffith in the Cabul river, an affluent of the Indus, and again by the Second Yarkand Mission in the great eastern drainage of Eastern Turkestan at Tang-i-hissar. The specimens obtained by myself were found in the tributaries of the Bala-morghab river, which drain to the north and west towards the Caspian.

The new species of *Schizothorax* described by Dr. Günther was collected in the Hari-rud and its tributaries only.

One hundred species of Insects were collected, of which 20 species have been described as new. The majority of these appear to be Arabian, North-African, Mediterranean, and Canarian types, some Central Asian (Turkestanian), very few Indian; but too few were collected to admit of generalization.

I made no collection of Butterflies (though a few were seen), owing to my not being

able to engage collectors. These only appeared in small numbers of the same species here and there when there was perfect stillness in the air. This stillness occurs so infrequently and at such irregular intervals that it would have required the entire devotion of one's time to collecting these insects alone. When the wind rose they were driven about like so many leaves, and seemed with difficulty to gain shelter. I never, to my knowledge, saw a perfect specimen, all were battered (one may say) to pieces, their wings becoming deeply irregularly fringed from continuous fractures and injuries.

Thanks to the courtesy and assistance of Professor Flower, the Director of the Natural History Museum, and to the kindness of Dr. Günther, I was enabled to exhibit the collections at the Natural History Museum, South Kensington.

I am indebted to the several officers of that Museum who have identified and described for me the species of which each has made a special study, namely:—

The Mammals, Mr. Thomas; the Birds, Mr. Sharpe; the Reptiles, Mr. Boulenger; the Fishes, Dr. Günther; the Insects, Mr. Kirby and Mr. Waterhouse; and the Spiders and Crustacea, Mr. Pocock. To Mr. G. B. Buckton, F.R.S., I am obliged for his description of a gall-insect.

I alone am responsible for the localities with the references and remarks enclosed within brackets and initialed J. E. T. A.

## MAMMALS.

By OLDFIELD THOMAS, F.Z.S.,  
Assistant in the Zoological Department, British Museum.

[Since the following notes on the Mammals of Afghanistan, brought home by Dr. Aitchison, were written, I have received a paper by Dr. J. Scully "On the Mammals and Birds collected by Captain C. E. Yate, C.S.I., of the Afghan Boundary Commission" (J. A. S. B. lvi. pt. ii. p. 68, 1887), and therefore practically a paper on an almost precisely similar set of Mammals to those here described. Thirteen species are there referred to, two being new; of these, one (*Spermophilus bactrianus*) is not represented in Dr. Aitchison's collection, while the other (*Ellobius intermedius*) is evidently the same as my No. 11.—O. T.]

### 1. FELIS TIGRIS, L.

a. Skin and skull. Karaol-khana.

This Tiger has the rich coloration of Bengal specimens, and shows no approximation to the greyer and longer-haired type found further north.

[Blanford, Eastern Persia, ii. p. 34.

Afghans call the Tiger *Báber*; Turkomans *Yúlbars*.

During the march of the Afghan Delimitation Commission from India to Khusan, the question whether we were ever likely to meet with a Tiger was often discussed,

and I think the general view was against the assumption. However, on Sir Peter Lumsden, G.C.B., and his party joining our camp at Khusan, our views began to change, as we heard from them that they had seen the *pugs* (footprints) of Tigers in the valley of the Hari-rud; and the native report was that we were in the land of Tigers. On the 19th January, 1885, at our camp at Bala-morghab the body of a female Tiger was brought to the General. It had been caught in a trap by the neck, then shot, and frequently stabbed, as the skin was a good deal injured by knife-cuts. It was evidently an old animal, the teeth being broken and much worn away. It measured 8 feet  $4\frac{3}{4}$  inches from the tip of the nose to the end of the tail, the tail alone measuring 36 inches; and from the spine above the shoulder to the base of the second claw on the fore foot measured 3 feet 8 inches. The skin was in good condition, and in no way mangy, which was remarkable, considering the age of the animal and its worn away teeth. It was killed near Karaol-khana, between that and Mara-ehak on the Bala-morghab river. The arrival of this Tiger in camp settled, beyond mere hearsay and impressions, the fact that Tigers exist as far east as the Bala-morghab. On the 5th May, at the Chashma-sabz pass, at an elevation of 5000 feet, I came across the playground evidently of a pair of fine animals, which, from the very recent condition of their *pugs*, must have been close in our neighbourhood. Again near Toman-gha, on the Hari-rud, I saw their markings plentifully. During summer, owing to there being so much suitable cover for Tigers, they wander over the great rolling plains of the Badghis, ascending to higher altitudes with the increase of heat, depending for their food on Pig, Oorial, and even Ibex. In winter they resort to the Tamarisk and grass thickets of the larger streams and main rivers, to which their usual food, the Pig, also retires. The Turkomans say that an old and toothless Tiger is especially destructive to sheep, hunger and inability to obtain other food making him very bold and cunning. They assert that such a Tiger will follow a man on horseback, wait until he has taken his food, and has lain down to rest, and will then attack him in preference to his horse.

At Bandar-i-ghaz, the port of Astrabad, on the Caspian, there was a fine Tigress in captivity, some six or seven months old, which was said to have been caught on the Hari-rud between Sarakhs and Pul-i-katun: this I purchased, and after many difficulties managed to place safely on board an English steamer at Batoum, bound for England. It is now in the Zoological Gardens of London, having been presented to the Zoological Society by the Government of India in Council.

The above data confirm Ferrier's statements, that Tigers exist in the thickets of the Hari-rud, and extend their geographical area as far east as the Bala-morghab river. —J. E. T. A.]

[*FELIS JUBATA*, Schreber.

Blanford, *tom. cit.* p. 35.

A pair of young Hunting Leopards were obtained by Sir Peter Lumsden's party in their journey through Persia towards Afghanistan, in the watershed of the Hari-rud river, on the southern slopes of the mountains that separate the waters of the Zroabad

from those of the Turbat-shaikh-jami river. These I saw when only two or three weeks old. Their general colouring, the extreme length of their tails in proportion to their bodies, and their soft woolly fleece, led me to conclude that they were the young of *Felis uncia*. I therefore strongly urged their owner, my friend Nawab Mirza Hassain Ali Khan, to send them by the very first opportunity to England. They arrived safely at Quetta, where one died; I have since seen the second, grown a splendid animal, at the Zoological Society's Gardens in London.—J. E. T. A.]

## 2. FELIS CAUDATA, Gray.

a. Skin. Bala-morghab.

This specimen, a bad skin without a skull, agrees very fairly with the type of Gray's "*Chaus caudatus*" (P. Z. S. 1874, p. 31, pls. vi. & vii.) from Bokhara. Its bad state, however, prevents any further light being thrown by it on the doubtful question of the distinctness of *F. caudata* from *F. chaus*, Güld.\*

[The skin of this Cat was obtained almost fresh, so that it must have been killed in the vicinity of our camp at Bala-morghab.—J. E. T. A.]

## 3. FELIS DOMESTICA, L.

a. Bala-morghab, 31 I, 85.

[CANIS LUPUS, L.

Blanford, *tom. cit.* p. 37.

Local names *Ghurk*, *Gurg*.

On the 9th November at Karez-dasht, South-west Afghanistan, with my glasses I distinctly recognized a Wolf. In the Badghis during winter Wolves are said to be common, but I neither obtained skins nor did I ever see one.—J. E. T. A.]

[CANIS AUREUS, L. ?

Blanford, *tom. cit.* p. 37.

Local name *Shakal*.

Jackals were occasionally heard, but are not generally common, as in my journal for the 30th June I note, "Last night heard a few Jackals, the first time I do not remember since when." In Khorasan Capt. Griesbach gave me a young one, but it was in such an unhealthy condition that I had to shoot it. The skin was not worth keeping.—J. E. T. A.]

## 4. VULPES PERSICA, Blanford (?) †.

Blanford, *tom. cit.* p. 39, pl. ii.

a. Bala-morghab.

This skin, like that of *Felis caudata*, was purchased in its present state in Bala-

\* The same is also unfortunately the case with the specimen referred to by Dr. Scully, *t. c.* p. 69.

† This is probably the same Fox that Dr. Scully refers to *V. montana*, Pears.

morghab, and is without a skull. It is therefore almost impossible to decide for certain to which of several nearly allied races of Foxes it should be referred.

5. *VULPES FAMELICA*, Rüppell.

*a.* Skin and skull. Between Kushk-rud and Kin, November 3, 1884.

The discovery of the Egyptian Fox in Afghanistan is of some interest, as it confirms Mr. Blanford's determination of the Bushire Fox, in his work on Persia \*, and at the same time extends the known range of the species to a very considerable extent. The skin obtained by Dr. Aitchison agrees in every respect with Rüppell's description †, and I have little hesitation in referring it to *V. famelica*, although it is just possible that a direct comparison of the skulls of the two forms might show them to be distinct.

[Foxes (local name *Roba*) were commonly seen all over the route traversed. On the Helmand they were most numerous, and there get the credit of disturbing graves to such an extent that the relatives have to place various objects on them to frighten off these pests by their noise or motion. Sometimes smouldering fires are even kept up for the same purpose.—J. E. T. A.]

6. *PUTORIUS SARMATICUS*, Pallas.

*a.* Skull. Gulran.

Capt. Hutton (J. A. S. B. xiv. p. 346, 1845) has given an excellent account of the habits of the Mottled Polecat, as observed by him at Kandahar.

[*URSUS*, sp.

Blanford, *tom. cit.* p. 47.

At Bala-morghab several persons who lived between that and Maimana told me that in the hills between these two places are to be got two kinds of Bears, one red (called locally "*Khirsā*") and one black (called "*Kul*"). I saw no skins, nor could I obtain any.—J. E. T. A.]

7. *ERINACEUS ALBULUS*, Stoliczka.

*a.* Tirphul, 7/4/85. *b.* Bala-morghab. *c.* No history.

This species was hitherto only known from Yarkand, where several specimens were obtained by the two Indian Yarkand Expeditions (*cf.* Blanford, 2nd Yark. Miss., Mamm. p. 14, 1879). *a* is an excellent specimen, in spirit, caught alive by Dr. Aitchison; *b* and *c* are dried and headless skins, and were picked up in their present state.

[A Hedgehog seems to be very common over the whole Badghis, for pieces of the spine, bearing portions of the skin, were daily picked up. I, however, only succeeded in getting one live specimen, an adult. The local names are "*Khar-pusht-ak*" and "*Khal-posh*."—J. E. T. A.]

\* Zool. Geol. Eastern Persia, ii. p. 41 (1876). See also Selater, P. Z. S. 1875, p. 420.

† Atlas, Zool. pl. v. p. 15 (1826).

7\*. [*Spermophilus bactrianus*, Scully, *l. c.* p. 70, may be added in here as an additional species.]

8. GERBILLUS ERYTHRURUS, Gray.

*a.* Gulran, 25 2 85. *b.* Between the Hamun of the Helmand and Khusan.

[Blanford, *tom. cit.* p. 70.

The obtaining of the above two specimens extends the area of the range of this *Gerbillus* northwards to Bala-morghab, and gives a link between Kandahar and Shiraz.

—J. E. T. A.]

8\*. [Insert *Mus bactrianus*, Bly., as an additional species (Scully, *l. c.* p. 72).]

9. CRICETUS PILEUS, Pallas.

*a.* Bala-morghab, 23 1 85.

Blanford, *tom. cit.* p. 58.

10. ARVICOLA MANDARINUS, Milne-Edwards (?).

*a, b.* Gulran, 13 3 and 1 1 85.

These two Voles quite agree with the Afghan specimen doubtfully referred to *A. mandarinus* by Mr. Blanford in his paper on the Arvicolæ of this region (J. A. S. B. l. t. ii. p. 108, 1881). The following are their measurements, in spirit :—

	Head and body. millim.	Tail. millim.	Hind foot. millim.	Forearm and hand. millim.	Ear (above crown). millim.
<i>a.</i> ♂ . . . .	87	24	16·0	23	6·0
<i>b.</i> ♀ . . . .	94	26	16·1	23	6·5

Foot-pads 5-6. Mammæ 2-2=8.

10\*. [Insert *Arvicola guentheri*, Danf. & Alst., as an additional species (Scully, *l. c.* p. 72).]

11. ELLOBIUS FUSCICAPILLUS, Blyth †.

*a, b.* Gulran, 19 3 and 1 4 85. *c.* Bala-morghab, 15 1 85. *d.* Karaol-khana, 15 2 85.

This species is by far the most interesting of the Mammals found by the Commission, as it was hitherto only known from the type specimens obtained more than forty years ago at Quetta, and described as *Georychus fuscocapillus* by Mr. Blyth ‡, who later § formed a special genus, *Myospalax*, for their reception. In order to find out the true

† Dr. Scully (*l. c.* p. 73), than whom there is no better authority on such a point, describes this animal as a new species, under the name of *B. intermedius*. The cranial and dental characters he gives, however, although at first sight they would naturally appear to be of specific importance, prove to be so variable within the present series that I feel I must still adhere to the above determination, despite the advantage Dr. Scully has of me in being able directly to compare the Afghan specimens with Blyth's original types.

‡ J. A. S. B. xi. p. 887 (1842).

§ J. A. S. B. xv. p. 141 (1846).

relations of this so-called "Quetta mole," Mr. Blanford, when working out the North-Indian Voles in 1883\*, obtained one of the typical specimens from Calcutta, and showed that the species really belonged to the genus *Ellobius*, giving at the same time excellent figures of its skull and dentition. No other specimens seem ever to have been obtained, and these four well-preserved spirit-specimens, the only ones in Europe, are therefore of considerable value for the elucidation of the species. The following are their measurements, which are, of course, far more trustworthy than any taken from dried skins:—

	Head and body. millim.	Tail. millim.	Hind foot. millim.	Forearm and hand. millim.
<i>a.</i> ♀ . . . . .	127	16·0	20·5	35·0
<i>b.</i> ♀ . . . . .	98	14·0	21·0	33·0
<i>c.</i> ♂ . . . . .	103	12·0	19·4	31·0
<i>d.</i> ♂ . . . . .	115	16·0	20·6	34·5

The ear-conch is not so entirely aborted as in the Spalacidae, but forms a small triangular projection some two or three millimetres long. The soles are smooth and ungranulated, and the pads, of which there are 5 on the fore and 6 on the hind feet, are low and little prominent. The mammary formula is 2—1=6.

The other characters of this species, being observable in skins as well as in spirit-specimens, have been fully described in Mr. Blanford's paper above referred to.

[This curious bull-dog headed, mole-like Rat, with enormous incisor teeth for its size, was said by the natives to be common, but that it was rarely seen unless dug out of its burrows. The whole of the Badghis was, in many places, perforated like a sponge from the burrowing of this as well as other rodents, species of which were not obtained, owing to the restrictions placed upon my work and my having no men with me who had been trained as collectors. Owing to these burrows, in many places the country was very unsafe to ride over, as on our marches on the 21st, 22nd, and 23rd February, 1885, between Islim and Gulran. On these marches I saw what I believe to have been Marmots, but was not lucky enough to procure specimens.]

The Badghis is just the country for small rodents, from the loamy, sandy, soft soil, easily worked in, and the numerous plants with large tuberous roots, ready to supply them with food and drink.—J. E. T. A.]

## 12. ALACTAGA INDICA, Gray.

*a, b.* Sim-koh, 18/5/85. *c.* Between the Hamun of the Helmand and Khusan.

Measurements in spirit:—

	Head and body. millim.	Tail. millim.	Hind foot. millim.	Forearm and hand. millim.	Ear (above crown). millim.
<i>a.</i> ♀ . . . . .	105	161	54·5	26	38
<i>b.</i> ♀ . . . . .	102	165	50·0	26	35

\* J. A. S. B. 1. p. 118, pl. ii. (1881).

[These specimens supply a link between Shiraz and Afghanistan to the east of the Hamun of the Helmand, besides extending the range of this Jerboa as far north as the Sim-koh hills. See Blanford, *l. c.* p. 77.—J. E. T. A.]

13. *LEPUS TIBETANUS*, Waterhouse\*.

Blanford, Second Yark. Miss., Mamm. p. 63 (1879).

*a*, ♂, weight 3 lb. 4 oz., De-kamran, 26/10/84. *b*, ♂, weight 3 lb., Tirphul, 9/4/85. *c*, *d*, ♂, weight 3½ lb., and young, Gulran, 23/2 and 9/3/85.

[Hares were met with along our entire route, and all apparently of one species. They were small; the heaviest I have noted was procured on the 23rd February, and weighed 3 lb. 8 oz. Except on the march between Kushk-rud and Kin, they were never seen in any numbers. Owing to the reports of the natives of these parts, it was considered unsafe to eat their flesh, and hence a general aversion arose to doing so in camp. I do not believe a single one was eaten, though many of the natives looked for a time as if they could have eaten anything.—J. E. T. A.]

13\*. [Insert *Lagomys rufescens*, Gray, as an additional species obtained by the Commission (Scully, *l. c.* p. 75).]

[*EQUUS HEMIONUS*, Pallas?

Blanford, Eastern Persia, ii. p. 84.

Locally called *Gor-khar*, and by the Turkomans *Gulam*.

We were certainly in the country of the Wild Ass. They were first seen on the march between Tut-i-chi and Aftao on the 30th of November, 1884, where, owing to a cavalry brigade of the Afghan army marching some little distance from us they drove to us, or we to them, herds of these as well as Wild Sheep and Gazelles. The two combined camps, with their long string of impedimenta, had disturbed a country of game, over which but seldom any human being had traversed for many years back. The excitement was great, but, alas! no specimens were obtained. We next met with the Wild Ass on our last march into Gulran, on the 23rd February, on which occasion one was come upon suddenly in the dark, as if he were standing fast asleep, but he was off into the distant darkness long before he could be shot at. They occupied the country in the vicinity of Gulran, as they were known to have attacked and injured some Mules and Donkeys that had been turned loose to graze. On the 16th March a small herd, probably of a dozen, were seen close to our camp, at our second Gulran encampment.

In my march from Gal-i-cha to the base of the Kambao Pass, on the 29th of April, 1885, I had to cross the northern end of a great plain called "*Gulam-i-maidan*," or the plain of the Wild Ass. At the time I crossed it, it was one great field of the most splendid verdure, consisting chiefly of grasses and *Umbelliferae* in their spring clothing, of herbs and shrubs, probably not one over four feet in height, not a tree to be seen to break the

\* Dr. Scully refers this hare to *Lepus lehmanni*, Severtz., but there can be little question that Severtzoff's species, of which we have in the Museum specimens from the original locality, is not really separable from the earlier described *L. tibetanus*, Waterh.

landscape, but simply a great plain extending for some thirty miles and ending by being lost in the outer hills of the Barkut and Siah-koh ranges. This was the great historic plain of the Wild Ass. My guide took me to a slight elevation, and from it pointed out to me where I was to look for the animals: for some time I could see nothing; at last, whilst using my glasses, I noticed clouds of dust, like the line of smoke left in the track of steamers. This was what the guide wished to attract my attention to, and what he wished me to look for; these several lines of dust-cloud were caused by herds of Asses, galloping in various directions over the great plain. One herd came well within a mile's distance; from its extent, I am even now of the opinion which I then held, that the herd consisted of at least 1000 animals. I counted sixteen of these lines of dust-cloud at one time on the horizon. My guide said that at this period of the year the Wild Asses are always united in great herds on that plain, owing to the mothers having their foals at foot, but that in a few weeks the great herds would break up, and the animals would spread themselves all over the country in parties of ten to twelve. This is the season at which the young are caught, by riding them down; usually, the mother will not leave, viciously attacking men and horses upon their coming near her foal. It is a very rare circumstance to get a foal unless by shooting it.

This splendid open country, covered with the most excellent fodder, chiefly fine grasses, which occur as an earlier and later grass, a sufficiency of water, with great saline plains in the vicinity, impressed one greatly as to its value for the purposes of horse-breeding.

We came across a piece of ground over which a herd of these animals had recently passed, in all probability that morning; the soil was soft, and it had been covered with a fine crop of grass; over this the herd had left a track, as wide as an ordinary road, which was seen to extend, like a road, for some distance. Between Karez-dasht and Sher-baksh, to the south-east of the Do Shakh range, we were informed was a locality for the Wild Ass, also the country between Kushk-rud and Zagin, still further south, but I did not hear of any having been seen by members of the Mission.

No specimens of this animal were obtained.—J. E. T. A.]

[HYSTRIX, sp.

Blanford, *tom. cit.* p. 80.

Locally called *Shogle*; by the Turkomans *Kara-kosh* and *Sikh-aol*.

On two occasions the remains of a Porcupine were picked up, and once one was sent to me by Captain Maitland, in the Badghis: frequently their quills were found at the mouths of their burrows, but no specimens were secured. The natives say that they are not uncommon; their flesh is used medicinally, as well as being regularly eaten by a class of people called *Shaufi*, who live near Teheran.—J. E. T. A.]

[SUS SCROFA, L. ?

Locally called *Khuk*, *Khanzir*.

A Wild Hog was found to be very common, from the Hari-rud through the Badghis

to Bala-morghab. On the march between Ab-i-shora and Tor-shakh we came upon the carcass of an old Boar that had just been killed; it had attacked and killed a Camel and injured a man. I took its measurements, it was 64 inches from the tip of its nose to the end of its tail, and 37 inches from the hair on its fore foot to the top of its shoulder. In addition to the usual bristles and coarse hair, it had a thick matting of shorter and soft, *pashmina*-like wool. It was a great fat brute of a dirty white colour all over. This, with the remains of one which must have been a giant amongst its race, that lay on our route close to our camp at Kalla-i-maur, 18th February, 1885, were the only two specimens with which I came in contact. The hair and bristles on the latter were deep black.

On one or two occasions Pigs were ridden at and killed (speared) by some of the party, and frequently they were seen in great herds; but owing to the religious prejudice relative to this animal, I was unable to obtain specimens for Museum purposes, although several good opportunities occurred for doing so.

These Pigs were a great pest to those shooting Pheasants at the nearest locality to our camp at Bala-morghab, as they were heard grunting and blowing in the dense cover close to the shooter, who was never very certain whether they might not rush out and make an attack on him. During the early summer they wander over the whole country, as then there is abundance of water from the melting snows in the valleys leading down from the hills, as well as quantities of fresh food, in the form of roots and bulbs. They regularly hunted for the bulbs of an *Arum* that grew at the base of bushes in the valleys of the low ranges of hills. I used often to follow their tracks to see what roots they chiefly dug up. During summer there is plenty of cover for them all over the Badghis. Often we came across their remains in localities over which one would never expect they would wander, until a season's experience of this country had opened out one's ideas. In winter they keep to the great stream-bed, and hide in the dense Tamarisk and grass thickets. Where there is cultivation they are a perfect nuisance to the cultivator, especially in the way they attack fields of melons. Amongst these the owners build small walled enclosures with loop-holes, from which to fire on them at night. Until summer came I could not make out what these miniature fortifications could possibly be intended for.—  
J. E. T. A.]

#### 14. OVIS CYCLOCERUS, Hutton.

*a.* Head; Gulran. *b, c.* Skulls, with horns; Gulran. *d.* Head of young; Kambao, 1/5 85. *e, f.* Heads; Khusan, 22/11/84. *g-i.* Heads; Bala-morghab, 12/84. *j.* Immature skin; Chasma-sabz Pass, 27/11/84.

These specimens all agree very closely, and are of the most pronounced *cyclocerus*-type, none of them approaching the Sha-poo (*O. vignei*), from which, however, many zoologists think that *O. cyclocerus* is hardly separable. The finest horns are those of specimen *a*, which measure 36 inches in length round the curve, and 23 inches from one horn to the other, between the most distant points of their outer edges.

[Blanford, *tom. cit.* p. 87.

Locally named, the male *Mal*, female *Mesh*.

This Wild Sheep (or *Oorial* of the Punjab) is very numerous on the higher ground and lower ranges of hills throughout the Badghis, from 2000 feet and upwards. I saw a skull and horns at a *Ziarat* or Shrine, on the 2nd December, 1884, between Karakainta and Kushk. These horns, although both tips were broken off, measured 36 inches. Sir Peter Lumsden made over to me at Khusan a very fine head, in which the horns are entire, and of which Mr. Thomas has given the measurements.—J. E. T. A.]

#### 15. CAPRA SIBIRICA, Pallas.

Blanford, Second Yark. Miss., Mamm. p. 87 (1879).

*a.* Skull and horns; Bala-morghab. *b, c.* Heads; Bala-morghab, 12/84.

[Locally named, the male *Thakka*, the female *Burz-i-kohi*.

The Ibex was very numerous, and frequently seen on the more rocky parts of the Badghis, although only one was shot by any of the members of the Mission, and that was at a drive, on the 23rd December, 1884, at the Kara-jungle Peak, and at which I was not present. I am indebted to Major Rind for one of the above heads. The Ibex occurs, along with the *Oorial*, on ground where one would never expect them; but to understand their peculiarities here, one must study the country. There are, of course, the great extending rolling downs, varying in elevation from a few feet to a thousand, where these waves suddenly come together, and a little more cover is formed by blocks of sandstone having been clean washed, of all their loam; here the *Oorial* are very common, and extend more or less along the sides of the more precipitous downs. The rocks in localities such as the Sim-koh country and Kambao Pass, suddenly spring out distinct from the rolling plains on all sides to a few hundred feet in height; these sudden perpendicular ridges are the ordinary haunts of the Ibex, but they are continually seen wandering between such localities, making from one to another, and in doing so have to cross over the ordinary *Oorial* ground. I once met a herd which I tried to ride down, and almost succeeded. The total absence of human beings over the country I traversed is no doubt the reason why these animals were so numerous, and occurred on such different ground from that on which they usually resort. The largest flock of Ibex I saw was on the Doshakh range, close to the Puza-gish stream, upon precipitous limestone rocks up which no human being could possibly have climbed.—J. E. T. A.]

#### 16. GAZELLA SUBGUTTUROSA, Gldenstadt.

*a.* Head and feet, ♀; Gulran, 29/11/84. *b.* Horns; Khusan. *c, d.* Two pairs of horns, and a large number of odd feet, taken from a temple at Gal-i-cha.

The separate head (specimen *a*) has a nearly perfectly white face, but there seems to be no reason to suppose that this is more than an individual variation.

[Blanford, Eastern Persia, ii. p. 91.

Locally named *Ahu*; the male *Thakka-i-Ahu*, the female *Burz-i-Ahu*.

This animal, or a closely allied species, was occasionally seen along our whole march from Quetta to Khusan, but no specimens were procured. From a shrine at Gal-i-cha, in Baluchistan, on the 13th October, 1884, I got some horns and feet, which Mr. Thomas thinks belong to this species, as well as the head of a Doe that Major Durand shot in the Badghis, about the 30th November, 1884. The markings on this head were very pale originally.

In the low hills and great gravel plains of the valley of the Hari-rud I have seen them everywhere, but I never got within shooting distance of them. They are very cautious and wary, usually in groups of three or four, feeding at short distances from each other; on being alarmed they close together and gallop off; as one alarmed herd was seen to move off, others in their vicinity did the same. On the 30th November, between Aftao and Tut-i-chi, owing to the immense line of our camp, and at some little distance that of the Afghan cavalry, the country was accidentally driven. The consequence was that large numbers of the small herds became united, and thus in place of seeing them in fours or fives, several members of the Mission told me that they had seen herds numbering hundreds of individuals flying between the two moving camps. About the 2nd June, 1885, at Chinkilok, to the north-west of Herat, some 20 miles between the Khotal-sangi Pass and Herat, I picked up a young female Gazelle of this species; it was a day old; at Turbat-i-haidri, Khorasan, I got a pair (male and female) of the same age as my first one, and at Meshed the Nawab gave me another young male. I brought these four alive to England; they are now in the Zoological Gardens in London, and look well and healthy; the males have fine horns.—J. E. T. A.]

[CERVUS MARAL, Ogilby\*.

Blanford, *tom. cit.* p. 95.

At a shrine between Kara-kainta and Kushk, on the 2nd December, 1884, I saw a magnificent pair of very old horns, which in all probability were those of this species of Stag, which had been brought as a votive offering many years ago, when the geographical area of this animal may have extended much further east than it now does.—J. E. T. A.]

\* Dr. Scully refers an antler from the banks of the Oxus, near Balkh, to *Cervus cashmirianus*. Falc.

## BIRDS.

By R. BOWDLER SHARPE, F.L.S., F.Z.S.,  
Assistant in the Zoological Department, British Museum.

[The collection of Birds has been determined for me by my friend Mr. R. Bowdler Sharpe, of the British Museum, who has added such synonymy of the species as bears upon their distribution in Afghanistan and neighbouring parts of Central Asia. My own notes on localities and habits are placed within brackets\*. The sex of each specimen was carefully noted by me at the time of skinning it.—J. E. T. A.]

## Order ACCIPITRES.

## Fam. FALCONIDÆ.

## 1. CIRCUS CYANEUS.

*Circus cyaneus* (L.) ; Sharpe, Cat. Birds, i. p. 52 (1874) ; Scully, J. A. S. Beng. lvi. p. 77.  
*Strigiceps cyaneus*, Severtz. Turkest. Jevotn. p. 63 ; Dresser, Ibis, 1875, p. 109.

1. ♀, juv. Bala-morghab, Badghis. 11th January, 1885.
2. ♂, juv. „ „ 23rd December, 1884.

Cf. Blanford, Eastern Persia, ii. p. 110, note under *C. macrurus*.

## 2. CIRCUS ÆRUGINOSUS.

*Circus æruginosus* (L.) ; Sharpe, Cat. Birds, i. p. 69 ; Blanford, Eastern Persia, ii. p. 110 (1876) : C. Swinhoe, Ibis, 1882, p. 100 ; Scully, *t. c.* p. 78.

*Circus rufus*, Severtz. Turkest. Jevotn. p. 63 ; Dresser, Ibis, 1875, p. 109.

1. ♂, juv. Mara-chak, Badghis. 15th February, 1885. (Head only.)
2. Young specimen without locality or date. [I believe this was got at Bala-morghab.—J. E. T. A.]

## 3. BUTEO FEROX.

*Buteo ferox* (Gm.) ; Sharpe, Cat. Birds, i. p. 176, pl. 8 (1874) ; Blanf. *t. c.* p. 113 ; Wardlaw-Ramsay, Ibis, 1880, p. 47 ; C. Swinhoe, Ibis, 1882, p. 99 ; Scully, *t. c.* p. 78.

*Buteo leucurus*, Severtz. Turkest. Jevotn. p. 63 ; Dresser, Ibis, 1875, p. 103.

1. ♀. Between Sha-ismail and Salian. 9th October, 1884.
2. ♂. Between Koaja-palounda and Karez-darra, Badghis. 6th December, 1884.
3. ♂. Gulran, Badghis. 11th March, 1885.
4. ♀. „ „ „ „

No. 2 is of the dark fuliginous form found in the Punjab. The others are of the ordinary type.

## 4. NISAETUS FASCIATUS.

*Nisaetus fasciatus* (Vieill.) ; Sharpe, Cat. Birds, i. p. 250 (1874).

*Aquila fasciata*, Blanf. *t. c.* p. 112.

1. ♂. Bala-morghab, Badghis. 21st December 1884.

An adult bird, with white breast.

\* [An important paper on the Birds of Southern Afghanistan, by Lieut.-Col. Swinhoe, will be found in the 'Ibis' for 1882, pp. 95-126.—ED.]

## 5. HIEROFALCO SAKER.

*Hierofalco saker* (Gm.); Sharpe, Cat. Birds, i. p. 417 (1874).

*Falco sacer*, Severtz. Turkest. Jevotn. p. 63; Dresser, Ibis, 1875, p. 106; Blanf. *t. c.* p. 104.

1. ♂. Bala-morghab, Badghis. 14th December, 1884.

A somewhat young bird with the head rather dark rufous, and approaching the plumage of the Lanner (*Falco feldegyii*). The generality of Saker Falcons in the dark or juvenile stage have the head pale, sometimes almost white; but the Hume collection contains specimens which match this one.

## 6. CERCHNEIS TINNUNCULUS.

*Cerchneis tinnunculus* (L.); Sharpe, Cat. Birds, i. p. 425 (1874); Severtz. Turkest. Jevotn. p. 63; Dresser, Ibis, 1875, p. 108; Barnes, S. F. vol. ix. 1880, p. 214.

*Tinnunculus alaudarius*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 13 (1854); Blanf. *t. c.* p. 105; C. Swinhoe, Ibis, 1882, p. 99; Scully, *t. c.* p. 79.

*Falco tinnunculus*, Wardlaw-Ramsay, Ibis, 1880, p. 47.

1. ♀. Between Kushk-rud and Kin. 3rd November, 1884.
2. ♀. Khusan. 18th November, 1884.
3. ♂. Khusan. 16th April, 1885.
4. ♂. Tirphul. 23rd April, 1885.

## Fam. STRIGIDÆ.

## 7. CARINE BACTRIANA.

*Athene noctua orientalis*, Severtz. Turkest. Jevotn. p. 63; Dresser, Ibis, 1875, p. 110.

*Carine plumipes*, Sharpe, Cat. Birds, ii. p. 137 (1875).

*Carine bactriana* (Hutton); Barnes, S. F. 1880, vol. ix. p. 215; C. Swinhoe, Ibis, 1882, p. 100; Scully, *t. c.* p. 79.

1. ♂. Padda-sultan. 25th October, 1884.
2. ♀. Koaja-palounda. 6th December, 1884.
3. ♂. Bala-morghab, Badghis. 1st February, 1885.

## 8. ASIO OTUS.

*Asio otus* (L.); Sharpe, Cat. Birds, ii. p. 227 (1875); Scully, *t. c.* p. 79.

*Otus vulgaris*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 79 (1854); Blanf. *t. c.* p. 116.

*Ægolius otus*, Severtz. Turkest. Jevotn. p. 63; Dresser, Ibis, 1875, p. 112.

1. ♀. Bala-morghab, Badghis. 1st February, 1885.
2. ♀. Mara-chak, Badghis. 16th February, 1885.

## 9. ASIO ACCIPITRINUS.

*Asio accipitrinus* (Pall.); Sharpe, Cat. Birds, ii. p. 234 (1875).

*Ægolius brachyotus*, Severtz. *t. c.* p. 63; Dresser, Ibis, 1875, p. 111.

*Otus brachyotus*, Blanf. *t. c.* p. 116.

1. ♂. Bala-morghab, Badghis. 26th December, 1884.

## Order PASSERIFORMES.

## Fam. CORVIDÆ.

## 10. TYMPANOCORAX FRUGILEGUS.

*Corvus frugilegus*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 557 (1856-58); Severtz. *t. c.* p. 43; Dresser, Ibis, 1875, p. 237; Blanford, *t. c.* p. 263; C. Swinhoe, Ibis, 1882, p. 111; Scully, *t. c.* p. 85.

*Tympanocorax frugilegus* (L.); Sharpe, Cat. Birds, iii. p. 9 (1877).

1. ♀. Bala-morghab, Badghis. 1st January, 1885.
2. ♂. " " 9th January, 1885.
3. With white patch under bill.
- 4, 5, 6. No dates or localities.

Three fully adult birds with bare face. One has the throat bare, but the nasal plumes still adhering. Two, including the white-chinned specimen, are in young plumage with feathered face.

[Rooks were first seen between De-doda and Ibrahim-abad, on the 28th October, 1884, in large flocks; they increased in number as we got to the Hamun: from this Rooks were more or less common in the vicinity of our camp wherever we were stationed, especially during the winter at Bala-morghab, where Jackdaws and the Hooded Crow mixed freely amongst the Rooks, with an occasional pair of Ravens.—J. E. T. A.]

## 11. COLÆUS COLLARIS.

*Colæus collaris* (Drum.) ; Sharpe, Cat. Birds, iii. p. 27 (1877).

*Colæus monedula*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 562 (1856-58).

*Corvus monedula*, Severtz. *t. c.* p. 63; Dresser, Ibis, 1875, p. 237; Blanford, *t. c.* p. 263; C. Swinhoe, Ibis, 1882, p. 111; Scully, *t. c.* p. 85.

1. ♂. Bala-morghab, Badghis. 23rd December, 1884.
2. ♂. " " " "
3. ♀. " " " "

[Jackdaws were seen at the Hamun in some numbers, and were common on the Hari-rud and in Badghis.—J. E. T. A.]

## 12. CORONE CORNIX.

*Corone cornix* (L.); Sharpe, Cat. Birds, iii. p. 31 (1877).

*Corvus cornix*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 553 (1856-58); Severtz. *t. c.* p. 63; Dresser, Ibis, 1875, p. 237; Blanford, *t. c.* p. 262; C. Swinhoe, Ibis, 1882, p. 111.

1. ♀. Khusan, Hari-rud. 21st November, 1884.
2. ♂. Bala-morghab, Badghis. 8th January, 1885.
3. No ticket or locality. [This specimen was no doubt collected at the Hamun, where these birds were first seen, and where they were very common.—J. E. T. A.]

These Hooded Crows belong to the pale form which breeds in Siberia, and visits India in the winter.

## 13. PICA PICA.

*Pica pica* (L.); Sharpe, Cat. Birds, iii. p. 62 (1877).

*Pica bactriana*, Horsf. & Moore, Cat. B. Mus. E.-1. Co. ii. p. 550 (1856-58).

*Pica caudata*, var. *bactriana*, Severtz. *t. c.* p. 64; Dresser, Ibis, 1875, p. 238.

*Pica rustica*, Blanf. *t. c.* p. 264; Wardlaw-Ramsay, Ibis, 1880, p. 63; Barnes, Str. F. 1880, ix. p. 218; C. Swinhoe, Ibis, 1882, p. 111; Scully, *t. c.* p. 85.

1. ♀. Koaja-palounda, Badghis. 5th December, 1884.

2. ♀. Ab-i-kamarra, Badghis. 9th December, 1884.

These belong to the white-rumped ordinary form, and not to the black-rumped *P. bactriana*.

## 14. PICA LEUCOPTERA.

*Pica leucoptera*, Gould; Sharpe, Cat. Birds, iii. p. 66 (1877).

1. ♀. Khusan, Hari-rud. 20th November, 1884.

The presence of this Magpie on the Hari-rud is certainly interesting. It was procured on the west side of the Paropamisus, which separates the Badghis territory from the Hari-rud valley. To reach this latter locality one must suppose that the Turkestan Magpie migrated across the desert of Merv, and then followed the valley along the Hari-rud, as the Badghis specimens might have been naturally expected to be *Pica leucoptera*, instead of being identical with ordinary *Pica pica*.

## Fam. MUSCICAPIDÆ.

## 15. MUSCICAPA GRISOLA.

*Muscicapa grisola* (L.); Sharpe, Cat. Birds, iv. p. 151 (1879); Severtz. *t. c.* p. 67; Dresser, Ibis, 1876, p. 188; Blandford, *t. c.* p. 143; C. Swinhoe, Ibis, 1882, p. 104.

*Batalis grisola*, Wardlaw-Ramsay, Ibis, 1880, p. 53.

1. ♀. Between Chil-gaz and Sim-koh, Badghis. 17th May, 1885.

## 16. MUSCICAPA PARVA.

*Muscicapa parva*, Bechst.; Sharpe, Cat. Birds, iv. p. 161 (1879); Severtz. *t. c.* p. 67; Dresser, Ibis, 1886, p. 188.

*Erythrosterma parva*, Blandford, *t. c.* p. 144; Scully, *t. c.* p. 80.

1, 2, 3. ♂. Gulran, Badghis. 23rd March, 1885.

4, 5, 6. ♂. Tirphul, Hari-rud. 12th April, 1885.

7. ♂, imm. „ „ 19th April, 1885.

8. ♀. Kambao, Badghis. 1st May, 1885.

No. 7 is in brown (female) plumage, but has the throat washed with red, much brighter than in any female. This shows that the male does not gain his full plumage in the first year.

## 17. PRATINCOLA MAURA.

*Pratincola maura* (Pall.); Sharpe, Cat. Birds, iv. p. 188 (1879); Wardlaw-Ramsay, Ibis, 1880, p. 55; C. Swinhoe, Ibis, 1882, p. 106; Scully, *t. c.* p. 80.

*Pratincola rubicola* (nec L.); Severtz. *t. c.* p. 65; Dresser, Ibis, 1875, p. 337.

1. ♂. Gulran, Badghis. 5th March, 1885.
- 2, 3. ♀. „ „ 7th March, 1885.
4. ♂. „ „ 9th March, 1885.
- 5, 6. ♂. „ „ 11th March, 1885.

No. 4 has a slight amount of white at the base of the tail, showing an approach to *P. hemprichi*.

This bird was usually seen on reeds (*Arundinaria*), and was common.—J. E. T. A.]

## 18. PRATINCOLA CAPRATA.

*Pratincola caprata* (L.); Sharpe, Cat. Birds, iv. p. 195 (1879); Blanford, *t. c.* p. 144; C. Swinhoe, Ibis, 1882, p. 106; Scully, *t. c.* p. 80.

1. ♂. Tirphul, Hari-rud. 12th April, 1885.
2. ♀. „ „ 13th April, 1885.
3. ♂. Khusan, Hari-rud. 13th April, 1885.
4. ♀. Kambao, Badghis. 29th April, 1885.

## Fam. TURDIDÆ.

## 19. SYLVIA NISORIA.

*Sylvia nisoria* (Bechst.); Seebohm, Cat. Birds Brit. Mus. v. p. 6 (1881); Severtz. *t. c.* p. 65; Dresser, Ibis, 1876, p. 79; Blanford, *t. c.* p. 174.

1. ♀. Kumani-bhest, Hari-rud. 14th May, 1885.

Blanford, *t. c.* p. 174, gives Shiraz as the most eastern locality from which this bird had previously been recorded. It is, however, known to extend to Central Asia, and several specimens were procured by Dr. Stoliczka during the second Yarkand Expedition, in addition to Dr. Severtzoff's record of its appearance in Turkestan.

## 20. SYLVIA JERDONI.

*Sylvia jerdoni* (Bl.); Seebohm, Cat. Birds Brit. Mus. v. p. 16 (1881); Blanford, *t. c.* p. 172; C. Swinhoe, Ibis, 1882, p. 109.

1. ♀. Kambao, Badghis. 1st May, 1885.
2. ♂. Nihal-sheni, Badghis. 14th May, 1885.

The above localities would point to the probable occurrence of this bird in North-east Persia.

## 21. SYLVIA MINUSCULA.

*Sylvia minuscula*, Hume; Seebohm, Cat. Birds Brit. Mus. v. p. 20, pl. i. (1881); C. Swinhoe, Ibis, 1882, p. 109; Scully, *t. c.* p. 80.

*Sylvia curruca* (nec L.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 344 (1854).

1. ♀. Gulran, Badghis. 19th March, 1885.
2. ♂. Tirphul, Hari-rud. 6th April, 1885.
- 3, 4. ♂. „ „ 12th April, 1885.
5. ♀. Khusan, „ 26th April, 1885.
6. ♀. Tirphul, „ „ „

## 22. SYLVIA MYSTACEA.

*Sylvia mystacea*, Ménétr.; Seebohm, Cat. Birds Brit. Mus. v. p. 20 (1881); Severtz. *t. c.* p. 65; Dresser, Ibis, 1876, p. 80; Scully, *t. c.* p. 81.

*Sylvia rubescens*, Blanf. East. Persia, ii. p. 77, pl. xii.

1. ♂. Gulran, Badghis. 23rd March, 1885.

The discovery of this species so far to the eastward of its previously known habitat is very interesting.

## 23. SYLVIA NANA.

*Sylvia nana* (Hempr. et Ehr.); Seebohm, Cat. Birds Brit. Mus. v. p. 26 (1881); Blanf. *t. c.* p. 178.

*Atraphornis aralensis* (Eversm.); Severtz. Turkest. Jevotn. pp. 65, 124; Dresser, Ibis, 1876, p. 80.

- 1, 2. ♂. Gulran, Badghis. 12th March, 1885.
3. ♂. „ „ 19th March, 1885.
4. ♂. Tirphul, Hari-rud. 11th April, 1885.

## 24. SYLVIA FAMILIARIS.

*Sylvia familiaris*, Ménétr.; Seebohm, Cat. Birds Brit. Mus. v. p. 36 (1881); Scully, *t. c.* p. 81.

*Aedon galactodes*, var. *familiaris*, Severtz. *t. c.* p. 65; Dresser, Ibis, 1876, p. 80.

*Aedon familiaris*, Blanford, *t. c.* p. 210; C. Swinhoe, Ibis, 1882, p. 107.

1. ♂. Tirphul, Hari-rud. 12th April, 1885.
2. ♂. „ „ 19th April, 1885.
3. ♂. „ „ 21st April, 1885.
4. ♀. „ „ 28th April, 1885.
5. ♂. Kambao, Badghis. 1st May, 1885.

[This Warbler was very numerous in the Tamarisk-groves by the sides of streams; in spring it was in great song, almost equalling that of the Nightingale.—J. E. T. A.]

## 25. PHYLLOSCOPUS NITIDUS.

*Phylloscopus nitidus*, Blyth; Seebohm, Cat. Birds Brit. Mus. v. p. 43; C. Swinhoe, Ibis, 1882, p. 109.

- [1. ♂. Locality not known, the label being lost; but certainly procured subsequent to our reaching Khusan during the summer of 1885.—J. E. T. A.]

## 26. PHYLLOSCOPUS TRISTIS.

*Phylloscopus tristis*, Blyth; Seebohm, Cat. Birds Brit. Mus. v. p. 63 (1881); Horsf. & Moore, Cat.

B. Mus. E.-I. Co. i. p. 336 (1854); Blanford, *t. c.* p. 180; Wardlaw-Ramsay, *Ibis*, 1880, p. 59; C. Swinhoe, *Ibis*, 1882, p. 108.

*Ficedula fulvescens*, Severtz. *t. c.* pp. 65, 126; Dresser, *Ibis*, 1876, p. 82.

1. ♀. Banks of the Helmand, between 18th and 26th October, 1884.
2. ♂. Tirphul, Hari-rud. 12th April, 1885.
3. ♀. Khusan, „ 26th April, 1885.

### 27. HYPOLAIS LANGUIDA.

*Hypolais languida* (Hempr. et Ehr.); Seebohm, *Cat. Birds Brit. Mus.* v. p. 80 (1881); Blanford, *t. c.* p. 183; C. Swinhoe, *Ibis*, 1882, p. 108.

*Sylvia magnirostris*, Severtz. *t. c.* pp. 65, 123; Dresser, *Ibis*, 1876, p. 79.

- 1, 2. ♂; 3, 4. ♀. Between Kambao and Shore-kaltegai, Badghis. 3rd May, 1885.

### 28. ACROCEPHALUS TURDOIDES.

*Acrocephalus turdoides* (Meyer); Seebohm, *Cat. Birds Brit. Mus.* v. p. 95 (1881).

*Acrocephalus arundinaceus* (Linn.); Blanf. *t. c.* p. 195.

1. ♂. Tirphul, Hari-rud. 20th April, 1885.

This is a decidedly eastern habitat for the species. Mr. Seebohm has named the specimen.

### 29. MERULA ATROGULARIS.

*Merula atrogularis* (Temm.); Seebohm, *Cat. Birds Brit. Mus.* v. p. 267 (1881); Scully, *t. c.* p. 81.

*Turdus atrogularis*, Severtz. *t. c.* pp. 64, 118; Dresser, *Ibis*, 1875, p. 332; Blanford, *t. c.* p. 158; C. Swinhoe, *Ibis*, 1882, p. 105.

- 1, 2. ♂ ♀. Kushk-rud to Kin. 3rd November, 1884.
3. ♀. Bala-morghab, Badghis. 13th January, 1885.
4. ♂. „ „ 17th January, 1885.
- 5, 6. ♂ ♀. „ „ 29th January, 1885.
7. ♀. „ „ 29th January, 1885.

[This bird was very numerous in the Badghis during winter, especially in the Pistacio-forests; they were very shy and difficult to get near.—J. E. T. A.]

### 30. MERULA MERULA.

*Merula merula* (L.); Seebohm, *Cat. Birds Brit. Mus.* v. p. 235 (1881).

*Merula vulgaris*, Scully, *t. c.* p. 81.

*Turdus merula*, Severtz. *t. c.* p. 64; Dresser, *Ibis*, 1875, p. 332; Blanford, *t. c.* p. 157.

1. ♀. Khusan, Hari-rud. 22nd November, 1884.
2. ♂. Bala-morghab, Badghis. 14th December, 1884.

The male has the wing 5.25 inches, so that it is a little in excess of the dimensions of *M. merula* as given by Mr. Seebohm (*l. c.*), but is not quite so large as the measurements of *M. maxima* (*cf.* Seebohm, *l. c.* p. 405).

[This specimen was shot by Capt. Yate. One or two others were seen, but they were very shy.—J. E. T. A.]

## 31. ERITHACUS CÆRULECULUS.

*Erithacus cæruleculus* (Pall.) ; Seebohm, Cat. Birds Brit. Mus. v. p. 308 (1881).

*Cyanecula suecica*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 310 (1854) ; Blanford, *t. c.* p. 169 ; Wardlaw-Ramsay, Ibis, 1880, p. 58 ; C. Swinhoe, Ibis, 1882, p. 108 ; Scully, *t. c.* p. 82.

1, 2. ♂. Tirphul, Hari-rud. 11th April, 1885.

3. ♂. „ „ 25th April, 1885.

4. ♂. Gulran, Badghis. 23rd March, 1885.

[This form of blue-throated Warbler, having a chestnut spot in the centre of the blue throat, was very common in Tamarisk-groves by streams.—J. E. T. A.]

## 32. MONTICOLA SAXATILIS.

*Monticola saxatilis* (L.) ; Seebohm, Cat. Birds Brit. Mus. v. p. 313 (1881) ; Blanford, *t. c.* p. 156.

*Petrocichla saxatilis*, Severtz. *t. c.* p. 65 ; Dresser, Ibis, 1875, p. 335.

1, 2. ♂. Gulran, Badghis. 12th March, 1885.

3. ♀. Tirphul, Hari-rud. 11th April, 1885.

4. ♂. „ „ 12th April, 1885.

5, 6. ♂. Khusan, Hari-rud. 13th April, 1885.

7, 8. ♀ ♂. „ „ 16th April, 1885.

9. ♂. „ „ 20th April, 1885.

10. ♀. Toman-agma, Hari-rud. 27th April, 1885.

[This bird was very common in the Badghis in summer. It had much the habit of a Thrush, and was seen feeding on Lizards (*Eremias velox*, Pallas), one of which was taken out of the throat of one of the above specimens.—J. E. T. A.]

## 33. MONTICOLA CYANUS.

*Monticola cyanus* (L.) ; Seebohm, Cat. Birds Brit. Mus. v. p. 316 ; Blanford, *t. c.* p. 155 ; C. Swinhoe, Ibis, 1882, p. 105 ; Scully, *t. c.* p. 82.

*Petrocosphyus cyanus*, Wardlaw-Ramsay, Ibis, 1880, p. 54.

*Petrocichla cyanea*, Severtz. *t. c.* p. 65 ; Dresser, Ibis, 1875, p. 335.

1. ♂. Gulran, Badghis. 15th March, 1885.

[A single specimen, collected in the low hills near Gulran.—J. E. T. A.]

## 34. RUTICILLA RUFIVENTRIS.

*Ruticilla rufiventris* (Vieill.) ; Seebohm, Cat. Birds Brit. Mus. v. p. 342 (1881) ; Blanford, *t. c.* p. 163 ; Wardlaw-Ramsay, Ibis, 1880, p. 57 ; C. Swinhoe, Ibis, 1882, p. 107 ; Scully, *t. c.* p. 82.

*Ruticilla phœnicuroides*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 301 (1854).

*Ruticilla erythroprocta* (nec Gould), Severtz. *t. c.* p. 65 ; Dresser, Ibis, 1876, p. 77.

1. ♂. Sang-bar. 8th November, 1884.

2, 3. ♂. Gulran, Badghis. 18th March, 1885.

4. ♀. Tirphul, Hari-rud. 12th April, 1885.

## 35. SAXICOLA ALBONIGRA.

*Saxicola albonigra*, Hume ; Seebohm, Cat. Birds Brit. Mus. v. p. 366 (1881) ; Blanford, *t. c.* p. 153, pl. xi. ; C. Swinhoe, Ibis, 1882, p. 106.

1. ♂. Zagin. 6th November, 1884.

36. *SAXICOLA PICATA*.

*Saxicola picata*, Bl.; Seebohm, Cat. Birds Brit. Mus. v. p. 367 (1881); Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 287 (1854); Blanford, *t. c.* p. 153; Barnes, Str. F. ix. 1880, p. 217; Wardlaw-Ramsay, Ibis, 1880, p. 57; C. Swinhoe, Ibis, 1882, p. 106.

1. ♂. Gulran, Badghis. 12th March, 1885.
2. ♀. Tirphul, Hari-rud. 12th April, 1885.

37. *SAXICOLA MORIO*.

*Saxicola morio*, Hempr. et Ehr.; Seebohm, Cat. Birds Brit. Mus. v. p. 372 (1881); Blanford, *t. c.* p. 152; Wardlaw-Ramsay, Ibis, 1880, p. 55; C. Swinhoe, Ibis, 1882, p. 107; Scully, *t. c.* p. 82.

*Saxicola leucomela*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 287 (1854); Severtz. *t. c.* p. 65; Dresser, Ibis, 1875, p. 336.

1. ♂. Gulran, Badghis. 3rd March, 1885.
2. ♂. „ „ 8th March, 1885.
3. ♂. „ „ 11th March, 1885.
- 4, 5. ♂. „ „ 12th March, 1885.
6. ♀. „ „ 18th March, 1885.
7. ♂. North of Gulran. — March, 1885.
8. ♂. Gulran, Badghis. 1st April, 1885.

38. *SAXICOLA OPISTHOLEUCA*.

*Saxicola opistholeuca*, Strickl.; Seebohm, Cat. Birds Brit. Mus. v. p. 376 (1881); Blanford, *t. c.* p. 155; Wardlaw-Ramsay, Ibis, 1880, p. 57; Scully, *t. c.* p. 82.

*Saxicola syenitica*, Severtz. *t. c.* p. 65; Dresser, Ibis, 1875, p. 337.

1. ♂. Gulran, Badghis. 18th March, 1885.

[The acquisition of the above specimen brings the range of this bird nearer towards Persia than heretofore known.--J. E. T. A.]

39 & 40. *SAXICOLA DESERTI*.

*Saxicola deserti*, Temm.; Seebohm, Cat. Birds Brit. Mus. v. p. 383 (1881); Wardlaw-Ramsay, Ibis, 1880, p. 57; C. Swinhoe, Ibis, 1882, p. 107; Blanf. *t. c.* p. 148; Scully, *t. c.* p. 82.

*Saxicola atrogularis*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 287 (1854).

*Saxicola salina*, Severtz. *t. c.* p. 65; Dresser, Ibis, 1875, p. 337.

1. ♂. Tirphul, Hari-rud. 6th April, 1885.
2. ♂. Between Karez-dasht and Ser-mandcl. 9th November, 1884.

The specimen killed in November is much more rufous than the spring-killed bird. The rump is pale tawny buff, which would bring the species under the heading of *Saxicola xanthoprymna* in Mr. Seebohm's Catalogue (p. 364). The "key" given in the last-named volume for the genus *Saxicola* will require some amplification before the various plumages represented in the Hume collection can all be included.

41. *SAXICOLA MELANOLEUCA*.

*Saxicola melanoleuca* (Güld.); Seebohm, Cat. Birds Brit. Mus. v. p. 385 (1881); Blanf. *t. c.* p. 150; C. Swinhoe, Ibis, 1882, p. 107.

1. ♂. Gulran, Badghis. 6th March, 1885.
2. ♀. „ „ 19th March, 1885.
3. ♂. Desert north of Gulran. — March, 1885.

Mr. Seebohm gives Southern Persia as the eastern range of this species, but it has also been met with at Kandahar (*cf.* Swinhoe, *l. c.*), and apparently also goes to Turkestan and Yarkand.

#### 42. SAXICOLA ANANTHE.

*Saxicola ananthe* (L.); Seebohm, Cat. Birds Brit. Mus. v. p. 391 (1881); Severtz. *t. c.* p. 65; Dresser, Ibis, 1875, p. 335; Blanford, *t. c.* p. 146.

1. ♂. Gulran, Badghis. 19th March, 1885.
2. ♂. Tirphul, Hari-rud. 6th April, 1885.
3. ♂. „ „ 16th April, 1885.
4. ♀. „ „ 11th April, 1885.
5. ♀. „ „ 12th April, 1885.
6. ♂, juv. Shore-kaltegai, Badghis. 4th May, 1885.

An interesting record for the eastern range of the species, which breeds in Northern Afghanistan.

#### Fam. TIMELIIDÆ.

#### 43. MYIOPHONEUS TEMMINCKI.

*Myiophoneus temmincki*, Vigors; Sharpe, Cat. Birds, vii. p. 7 (1883); Severtz. *t. c.* p. 65; Dresser, Ibis, 1875, p. 335; C. Swinhoe, Ibis, 1882, p. 105.

*Myiophoneus caruleus*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 199 (1854).

- 1, 2. ♀. Between Palounda and Karez-darra, Badghis. 6th December, 1884.
- 3, 4. ♀ ♂. Bala-morghab, Badghis. 14th December, 1884.

Also observed by Colonel Swinhoe near Kandahar in the winter. It has been recorded by Severtzoff from Turkestan.

[This bird was very common in the Pistacio-forests of the Badghis, but very wary.—  
J. E. T. A.]

#### 44. SCOTOCERCA INQUIETA.

*Scotocerca inquieta* (Cretzschm.); Sharpe, Cat. Birds, vii. p. 213 (1883); Blanf. *t. c.* p. 207, pl. xiii. fig. 2; Barnes, Str. F. 1880, pp. 217, 455; C. Swinhoe, Ibis, 1882, p. 108.

*Atraphornis platyura*, Severtz. Turkest. Jevotn. p. 121 (1873); Dresser, Ibis, 1876, p. 80.

1. ♂. Tirphul, Hari-rud. 11th April, 1885.
2. ♀. „ „ 19th April, 1885.

#### Fam. ACCENTORIDÆ.

#### 45. ACCENTOR COLLARIS.

*Accentor collaris* (Scop.); Sharpe, Cat. Birds, vii. p. 664 (1883).

1. —. Bala-morghab, Badghis. 14th December, 1884.

This seems to be a pale eastern race of *A. collaris*, of which Mr. Seebohm has shown me some specimens from Asia Minor.

## Fam. PARIDÆ.

## 46. PARUS CINEREUS.

*Parus cinereus*, Vicill.; Gadow, Cat. Birds Brit. Mus. viii. p. 16 (1883); Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 370 (1854); Wardlaw-Ramsay, Ibis, 1880, p. 62; C. Swinhoe, Ibis, 1882, p. 110.

*Parus nipalensis*, Barnes, Str. F. 1880, p. 217.

*Parus bokharensis*, Severtz. Turkest. Jevotu. p. 66; Dresser, Ibis, 1876, p. 92.

1, 2. ♂. Between Palounda and Karez-darra, Badghis. 6th December, 1884.

## 47. ÆGITHALUS CORONATUS.

*Ægithalus coronatus*, Severtz.; Gadow, Cat. Birds Brit. Mus. viii. p. 68 (1883); Severtz. *t. c.* p. 136, pl. 9. fig. 3 (1873); Dresser, Ibis, 1876, p. 175.

1, 2, 3. ♂. Tirphul, Hari-rud. 19th April, 1885.

4. ♂. „ „ 23rd April, 1885.

## Fam. LANIIDÆ.

## 48. LANIUS MINOR.

*Lanius minor*, Gm.; Gadow, Cat. Birds Brit. Mus. viii. p. 235 (1883); Blanford, *t. c.* p. 137; Severtz. *t. c.* p. 67; Dresser, Ibis, 1876, p. 184; Swinhoe, Ibis, 1882, p. 104.

1. ♂. Tirphul, Hari-rud. 25th April, 1885.

2. ♀. Khusan, Hari-rud. 25th April, 1885.

## 49. LANIUS ASSIMILIS.

*Lanius assimilis*, Brehm; Gadow, Cat. Birds Brit. Mus. viii. p. 249 (1883).

1. ♂. Shore-kaltegai, Badghis. 3rd May, 1885.

So far as I can make out this difficult group, the single specimen obtained belongs to *L. assimilis*, judging from the birds in the British Museum.

## 50. LANIUS ISABELLINUS.

*Lanius isabellinus*, Ehrenb.; Gadow, Cat. Birds Brit. Mus. viii. p. 277 (1883); Severtz. Turkest. Jevotu. pp. 67, 144; Dresser, Ibis, 1876, p. 185; Swinhoe, Ibis, 1882, p. 104.

1, 2. ♂ ♀. Gulran, Badghis. 7th March, 1885.

3. ♂. „ „ 13th March, 1885.

4. ♂. Panjdch, Badghis. 18th March, 1885 (received from Capt. Yate).

5. ♂. Tirphul, Hari-rud. 12th April, 1885.

Mr. Seeböhm, who has examined the above series, has named them as above, but he admits that some of the specimens are intermediate between the present species and *L. phœnicuroides*.

## 51. LANIUS PHÆNICUROIDES.

*Lanius phœnicuroides*, Severtz.; Gadow, Cat. Birds Brit. Mus. viii. p. 278 (1883); Severtz. *t. c.* p. 67; Dresser, Ibis, 1876, p. 187; Swinhoe, Ibis, 1882, p. 104; Scully, *t. c.* p. 80.

1, 2. ♂. Tirphul, Hari-rud. 12th April, 1885.

## 52. LANIUS VITTATUS.

*Lanius vittatus*, Val. ; Gadow, Cat. Birds Brit. Mus. viii. p. 280 (1883) ; Blanford, *t. c.* p. 138 ; Wardlaw-Ramsay, Ibis, 1880, p. 52 ; C. Swinhoe, Ibis, 1882, p. 104.

1. ♂. Tirphul, Hari-rud. 30th April, 1885.
2. ♂. Kambao, Badghis. 1st May, 1885.

## Fam. CERTHIIDÆ.

## 53. TICHODROMA MURARIA.

*Tichodroma muraria* (L.) ; Gadow, Cat. Birds Brit. Mus. viii. p. 331 (1883) ; Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 719 (1856-8) ; Blanford, *t. c.* p. 223 ; Swinhoe, Ibis, 1882, p. 103.

*Tichodroma plumnicoptera*, Severtz. Turkest. Jevotn. p. 66 ; Dresser, Ibis, 1876, p. 176.

1. ♀. Between Kushk and Palounda. 5th December, 1884.
2. ♂. Bala-morghab, Badghis. 26th December, 1884.
3. ♂. „ „ „ „ January, 1885.

## 54. SITTA SYRIACA.

*Sitta syriaca*, Ehr. ; Gadow, Cat. Birds Brit. Mus. viii. p. 316 (1883) ; Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 721 (1856-8) ; Blanford, *t. c.* p. 223 ; Severtz. *t. c.* p. 66 ; Dresser, Ibis, 1876, p. 176 ; C. Swinhoe, Ibis, 1882, p. 103.

*Sitta neumayeri*, Barnes, Str. F. ix. 1880, p. 216.

1. ♂. Between Kushk and Palounda, Badghis. 5th December, 1884.
- 2, 3. ♂. Between Palounda and Karez-darra, Badghis. 6th December, 1884.
- 4, ♀. „ „ „ „ 6th December, 1884.
- 5, 6. ♂. Shore-kaltegai, Badghis. 3rd May, 1885.

[Was very common and characteristic of the sandstone rocks in the Badghis.—J. E. T. A.]

## Fam. HIRUNDINIDÆ.

## 55. COTILE RUPESTRIS.

*Cotile rupestris* (Scop.) ; Sharpe, Cat. Birds, x. p. 109 (1885) ; Blanford, *t. c.* p. 216 ; Wardlaw-Ramsay, Ibis, 1880, p. 48.

*Cotyle rupestris*, Severtz. Turkest. Jevotn. p. 67 ; Dresser, Ibis, 1876, p. 189 ; Scully, *t. c.* p. 83.

1. ♂. Puzah-gish, Mt. Do-shakh. 6th August, 1885.

A young bird with rufous margins to the feathers of the upper surface.

[Only in the above locality was this Martin seen, and then in small numbers.—J. E. T. A.]

## 56. HIRUNDO RUSTICA.

*Hirundo rustica*, L. ; Sharpe, Cat. Birds, x. p. 128 (1885) ; Blanford, *t. c.* p. 215 ; Wardlaw-Ramsay, Ibis, 1880, p. 48 ; Barnes, Str. F. 1880, p. 215 ; Swinhoe, Ibis, 1882, p. 100 ; Scully, *t. c.* p. 83.

*Hirundo domestica*, Severtz. Turkest. Jevotn. p. 67 ; Dresser, Ibis, 1876, p. 188.

1. Gulran, Badghis. 28th March, 1885.
2. ♂. Tomau-gha, Hari-rud. 26th April, 1885.
3. Gulrau ? [no label].

[Although I have few specimens of this species, it was very common, and remained in the Badghis during the whole winter, as whenever a storm came on they used to seek the shelter of our tents in camp in large numbers.—J. E. T. A.]

## Fam. MOTACILLIDÆ.

## 57. MOTACILLA ALBA.

*Motacilla alba*, L.; Sharpe, Cat. Birds, x. p. 464 (1885); Blanford, *t. c.* p. 232; Severtz. *t. c.* p. 66; Dresser, Ibis, 1876, p. 176; C. Swinhoe, Ibis, 1882, p. 109; Scully, *t. c.* p. 83.

1. ♂. Gulran, Badghis. 13th March, 1885.
2. ♀. „ „ 19th March, 1885.
3. ♀. „ „ 21st March, 1885.

The specimens all belong to true *M. alba*, and do not show any approach to *M. persica*.

## 58. MOTACILLA PERSONATA.

*Motacilla personata*, Gould; Sharpe, Cat. Birds, x. p. 479, pl. v. figs. 3, 4 (1885); Blanford, *t. c.* p. 232; Severtz. *t. c.* pp. 66, 139; Dresser, Ibis, 1876, p. 177; Wardlaw-Ramsay, Ibis, 1880, p. 60; C. Swinhoe, Ibis, 1882, p. 109.

*Motacilla maderaspatana*, pt., Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 347 (1854).

1. ♂. Gulran, Badghis. 7th March, 1885.

## 59. MOTACILLA CITREOLA.

*Motacilla citreola*, Pall.; Sharpe, Cat. Birds, x. p. 503 (1885); Severtz. *t. c.* pp. 67, 139; Dresser, Ibis, 1876, p. 178.

*Budytes citreola*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 352 (1854); Blanford, *t. c.* p. 235; C. Swinhoe, Ibis, 1882, p. 110; Scully, *t. c.* p. 83.

- 1, 2. ♂. Gulran, Badghis. 19th March, 1885.
3. ♂. Tirphul, Hari-rud. 12th April, 1885.
4. ♂. Khusan, Hari-rud. 16th April, 1885.

Considerable increase in the size of the black collar is to be noticed in the specimens killed in April.

## 60. MOTACILLA BEEMA.

*Motacilla beema*, Sykes; Sharpe, Cat. Birds, x. p. 521, pl. vi. fig. 6 (1885).

1. ♂. Tirphul, Hari-rud. 12th April, 1885.
2. ♂. „ „ 20th April, 1885.

The adult male agrees with the figure given by Sharpe (*l. c.*). The second male is not in adult plumage, but rather resembles that of the old hen bird.

## 61. MOTACILLA BOREALIS.

*Motacilla borealis*, Sundev.; Sharpe, Cat. Birds, x. p. 522, pl. vii. figs. 1-3 (1885).

*Budytes flava cinereocapilla*, Severtz. Turkest. Jevotn. p. 67; Dresser, Ibis, 1874, p. 178.

*Budytes cinereocapillus*, C. Swinhoe, Ibis, 1882, p. 109.

1. ♀. Band, near Nushki. 1st October, 1884.
- 2, 3. ♀. Gulran, Badghis. 11th March, 1885.
4. ♀. „ „ 17th March, 1885.
- 5, 6. ♀. „ „ 19th March, 1885.
7. ♀. „ „ 19th March, 1885.
8. ♀. Tirphul, Hari-rud. 11th April, 1885.
9. ♂. „ „ 12th April, 1885.
10. ♀. „ „ 20th April, 1885.

One of the females shot at Gulran on the 19th of March shows evident traces of a white eyebrow.

#### 62. ANTHUS CAMPESTRIS.

*Anthus campestris* (L.); Sharpe, Cat. Birds, x. p. 569 (1885); Blanford, *t. c.* p. 237; C. Swinhoe, *Ibis*, 1882, p. 110; Severtz. *t. c.* pp. 67, 141; Dresser, *Ibis*, 1876, p. 178.

1. ♀. Gulran, Badghis. 19th March, 1885.
2. ♂. Tirphul, Hari-rud. 6th April, 1885.
- 3, 4. ♀. Khusan, Hari-rud. 16th April, 1885.

#### 63. ANTHUS SPIPOLETTA.

*Anthus spipoletta* (Janb. et Barth.-Lapomm.); Sharpe, Cat. Birds, x. p. 592 (1885).

*Anthus aquaticus*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 358 (1854); Severtz. *t. c.* p. 67; Dresser, *Ibis*, 1875, p. 180.

*Anthus blackstoni*, C. Swinhoe, *Ibis*, 1882, p. 110; Scully, *t. c.* p. 84.

*Anthus spinoletta* (L.); Blanford, *t. c.* p. 236.

1. ♀. Bala-morghab, Badghis. 17th January, 1885.
- 2, 3. ♀. Gulran, Badghis. 19th March, 1885.

### Fam. FRINGILLIDÆ.

#### 64. PASSER INDICUS.

*Passer indicus* (J. & S.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 499 (1856-58); Blanford, *East. Persia*, ii. p. 254 (1876); Wardlaw-Ramsay, *Ibis*, 1880, p. 63; Scully, *t. c.* p. 85.

*Passer domesticus* (L.); Sharpe, Cat. Birds, xii. p. 307 (1888).

- 1, 2, 3. ♂. Khusan, Hari-rud. 16th April, 1885.
4. ♀. Tirphul, „ 20th April, 1885.
5. ♀. „ „ 25th April, 1885.

#### 65. PASSER HISPANIOLENSIS.

*Passer salicicola* (Vieill.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 501 (1856-58); Wardlaw-Ramsay, *Ibis*, 1880, p. 64.

*Passer salicarius*, Blanford, *East. Persia*, ii. p. 255 (1876); Severtz. *t. c.* p. 64; Dresser, *Ibis*, 1875, p. 239.

*Passer hispaniolensis* (Temm.); Sharpe, Cat. Birds, xii. p. 317 (1888); Scully, *t. c.* p. 85.

1. ♂. Between De-kamran and De-doda. 27th October, 1884.
- 2, 3. ♀; 4. ♀. Between Kar-o-bagh and Tut-i-chi. 29th November, 1884.
- 5, 6. Label lost.

66. *PASSER YATII*, sp. nov. (Plate VI. fig. 2.)

*Passer yatii*, Sharpe, Cat. Birds, xii. p. 322 (1888).

1. ♂. Between De-kamran and De-doda. 27th October, 1884. Occurring in large flocks.

This new species has been named after Captain C. E. Yate. It is closely allied to *Passer moabiticus* of Tristram, but differs in having the under surface yellow.

67. *CARPODACUS ERYTHRINUS*.

*Carpodacus erythrinus* (Pall.); Sharpe, Cat. Birds, xii. p. 391 (1888); Blanf. East. Persia, ii. p. 250 (1876); Severtz. *t. c.* p. 64; Dresser, Ibis, 1875, p. 245; Wardlaw-Ramsay, Ibis, 1880, p. 67; C. Swinhoe, Ibis, 1882, p. 114.

1. ♂. Khusan, Hari-rud. 16th April, 1885.
2. ♂. „ „ 25th April, 1885.
- 3, 4. ♂. „ „ 26th April, 1885.
5. ♀. Toman-agma, Hari-rud. 26th April, 1885.
6. ♀. Sim-koh, Badghis. 18th May, 1885.

[This species was very common. The last-named specimen was shot amongst a flock of *Emberiza luteola*.—J. E. T. A.]

68. *RHODOSPIZA OBSOLETA*.

*Erythropsiza obsoleta* (Licht.); Blanford, East. Persia, ii. p. 252, pl. xvii. (1876); Severtz. *t. c.* p. 64; Dresser, Ibis, 1875, p. 247; C. Swinhoe, Ibis, 1882, p. 114; Scully, *t. c.* p. 84.  
*Rhodospiza obsoleta*, Sharpe, Cat. Birds, xii. p. 282 (1888).

1. ♀. Khusan, Hari-rud. 16th April, 1885.

Only one specimen of this rare species was obtained.

69. *EMBERIZA LUTEOLA*.

*Emberiza luteola* (Sparrrn.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 486 (1856-58).  
*Euspiza luteola*, Wardlaw-Ramsay, Ibis, 1880, p. 66; C. Swinhoe, Ibis, 1882, p. 114; Scully, *t. c.* p. 85.  
*Euspiza brunneiceps*, Severtz. Turkest. Jevotr. p. 64; Dresser, Ibis, 1875, p. 249.

1. ♂. Tirphul, Hari-rud. 12th April, 1885.
- 2, 3, 4, 5. ♂. Tirphul, Hari-rud. 19th April, 1885.
6. ♂. Shore-kaltegai, Badghis. 3rd May, 1885.
7. ♂. Gulran, Badghis. 4th May, 1885.

[This was a very common bird over the Badghis; the male attracting attention by the brilliancy of its plumage.—J. E. T. A.]

70. *EMBERIZA HORTULANA*.

*Emberiza hortulana* (L.); Blanford, *t. c.* p. 259 (1876); Severtz. *t. c.* p. 64; Dresser, Ibis, 1875, p. 248; Sharpe, Cat. Birds, xii. p. 530 (1888).

1. ♂. Tirphul, Hari-rud. 19th April, 1885.
- 2, 3, 4, 5, 6. ♂. Tirphul, Hari-rud. 20th April, 1885.
7. ♂. Tirphul, Hari-rud. 25th April, 1885.

[The Ortolan was very common in the vicinity of Tirphul.—J. E. T. A.]

## 71. EMBERIZA BUCHANANI.

*Emberiza buchanani* (Blyth); Sharpe, Cat. Birds, xii. p. 533 (1888); Barnes, Str. F. 1880, p. 218.

*Emberiza huttoni*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 485 (1856-58); Blanford, *t. c.* p. 258 (1876); C. Swinhoe, Ibis, 1882, p. 113.

1. ♂; 2. ♀. Kambao, Badghis. 1st May, 1885.

## 72. EMBERIZA LEUCOCEPHALA.

*Emberiza leucocephala* (Gm.); Sharpe, *t. c.* p. 549 (1888); C. Swinhoe, Ibis, 1882, p. 113.

*Emberiza pithyornis*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 482 (1856-58); Severtz. *t. c.* p. 64; Dresser, Ibis, 1875, p. 248.

1. ♀. Ab-i-kamarra. December 9th, 1884.

## Fam. ALAUDIDÆ.

## 73. ALAUDA ARVENSIS.

*Alauda arvensis* (L.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 466 (1856-58); Blanford, East. Persia, ii. p. 239 (1876); Severtz. *t. c.* p. 67; Dresser, Ibis, 1876, p. 181; C. Swinhoe, Ibis, 1882, p. 116.

1. ♂. Aftao, Badghis. 1st December, 1884.

## 74. GALERITA CRISTATA.

*Galerita cristata* (L.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 465 (1856-58); Blanford, *t. c.* p. 240 (1876); C. Swinhoe, Ibis, 1882, p. 116.

*Alauda cristata*, Severtz. *t. c.* p. 67; Dresser, Ibis, 1876, p. 182; Scully, *t. c.* p. 84.

1. ♀. Bala-morghab, Badghis. 19th January, 1885.

2. ♂. Gulran, Badghis. 7th March, 1885.

3. ♂. „ „ 12th March, 1885.

4. ♀. Tirphul, Hari-rud. 6th April, 1885.

## 75. CALENDRELLA BRACHYDACTYLA.

*Calendrella brachydactyla* (Leisl.); Blanford, East. Persia, ii. p. 242; Severtz. Turkest. Jevotn. pp. 67, 141, 142; Dresser, Ibis, 1876, p. 182; Wardlaw-Ramsay, Ibis, 1880, p. 67; C. Swinhoe, Ibis, 1882, p. 115; Scully, *t. c.* p. 84.

1. ♂. Gulran, Badghis. 11th March, 1885.

2. ♂. „ „ 15th March, 1885.

3. ♂. Tirphul, Hari-rud. 7th April, 1885.

4. ♂. „ „ 13th April, 1885.

5. No label.

Not one of the specimens carries out the distinctions given by Mr. Seebohm (Hist. Brit. B. ii. p. 275), for the separation of *C. brachydactyla* and *C. pispoletta*; for the proportions of the primaries and secondaries, as points of distinction between them, are certainly not definite in any of the birds brought home by Dr. Aitchison.

## 76. MELANOCORYPHA BIMACULATA.

*Melanocorypha bimaculata* (Mén.) ; Blanford, East. Persia, ii. p. 244 (1876) ; Severtz. *t. c.* pp. 67, 143 ; Dresser, Ibis, 1876, p. 183 ; C. Swinhoe, Ibis, 1882, p. 115 ; Scully, *t. c.* p. 84.

*Calandrina torquata*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 470 (1856-58).

1. ♂ ; 2. ♀. Between Sang-bar and Karez-dasht. 8th November, 1884.
3. ♂. Zind-i-jan. 15th November, 1884.
4. ♀. Between Asia-deh and Kar-o-bagh. 28th November, 1884.
5. ♂. Between Aftao and Kara-kainta. 1st December, 1884.
6. ♂ ; 7. ♀. Bala-morghab, Badghis. 17th January, 1885.
8. ♀. Between Mara-chak and Ab-i-goshan. 17th February, 1885.
9. ♀ ; 10. ♀. Gulran, Badghis. 9th March, 1885.
11. ♀. Gulran, Badghis. 12th March, 1885.
12. ♀. „ „ 18th March, 1885.

## 77. CERTHILAUDA DESERTORUM.

*Certhilauda desertorum* (Stanley) ; Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 464 (1856-58) ; Blanford, *t. c.* p. 240 (1876) ; Swinhoe, Ibis, 1882, p. 117.

1. ♂. Zagin. 5th November, 1884.

## Fam. STURNIDÆ.

## 78. PASTOR ROSEUS.

*Pastor roseus* (L.) ; Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 539 (1856-58) ; Blanford, *t. c.* p. 267 ; C. Swinhoe, Ibis, 1882, p. 111 ; Scully, *t. c.* p. 86.

*Sturnus roseus*, Severtz. *t. c.* p. 64 ; Dresser, Ibis, 1875, p. 238.

- 1, 2, 3. ♂ ; 4, 5. ♀. Tirphul, Hari-rud. 13th April, 1885.

[The Rose-coloured Pastor was occasionally seen in immense flocks over the whole Badghis and the Hari-rud valley ; in all probability it migrates from this to Persia, where, according to Blanford, it is only met with in the north-west.—J. E. T. A.]

## 79. STURNUS POLTORATZKYI.

*Sturnus poltoratzkyi*, Finsch, Verhandl. zool.-bot. Gesellsch. Wien, 1879, p. 202 ; Scully, *t. c.* p. 86.

- 1, 2, 3. ♂. Kushk, Badghis. 5th December, 1884.
- 4, 5. ♂ ; 6. ♀. Gulran, Badghis. 19th March, 1885.
7. ♀. Gulran, Badghis. 18th March, 1885.

Dr. Scully has recorded *Sturnus vulgaris* also from Chahar Shamba. It is doubtless *Sturnus menzbieri*.

[This species was common, and noticed at Bala-morghab during the whole winter. A Starling of some kind was seen flitting about flocks of sheep and cattle in our marches near the Hamun of the Helmand ; but no specimens were obtained.—J. E. T. A.]

## Order PICARLÆ.

## Fam. CAPRIMULGIDÆ.

## 80. CAPRIMULGUS ASIATICUS.

*Caprimulgus asiaticus* (Lath.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 115 (1854).

1. ♂. Tirphul, Hari-rud. 14th April, 1885.
2. ♀. Khusan, „ 16th April, 1885.

## 81. CAPRIMULGUS UNWINI.

*Caprimulgus unwini*, Hume, Str. F. 1875, p. 407; Barnes, *ibid.* 1880, p. 215; Swinhoe, Ibis, 1880, p. 101.

*Caprimulgus europæus*, Scully, *t. c.* p. 79.

1. ♂. Khusan, Hari-rud. 12th May, 1885.

Mr. Blanford is quite wrong in placing *C. unwini* as a synonym of *C. mahrattensis*. It belongs to another group of the genus *Caprimulgus*, being merely a pale form of *C. europæus*.

## Fam. PICIDÆ.

## 82. GECINUS GORII, sp. nov. (Plate VI. fig. 1.)

*Gecinus squamatus* (nec Vig.), Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 659 (1856-58, pt.); C. Swinhoe, Ibis, 1882, p. 102.

*Gecinus gorii*, Hargitt, Ibis, 1887, p. 74.

1. ♂. Between Padda-sultan and De-kamran. 26th October, 1884.

This is a pale race of the Himalayan *G. squamatus*, and has been separated by Mr. Hargitt as a distinct form, to which he has given, at Dr. Aitchison's request, the name of Captain Gore, R.E., who shot the specimen above recorded. It differs from *G. squamatus* in its generally pale coloration, and in the barring of the wing-coverts, scapularies, and tail-feathers.

Mr. Hargitt has given the following description of the species:—

“*G. similis G. squamato*, sed suprâ dilutius viridis; tectricibus alarum et scapularibus saturatiore viridi transfasciatis; plumis corporis inferioris squamosi lineâ nigrâ intramarginali tenui ornatis: caudæ fasciis transversis albis latis, fasciis nigris angustioribus (his in *G. squamato* latissimis, illis vero angustioribus).”

“This is a desert form of *G. squamatus*, distinguished by the following characters:—Above very pale green, the wing-coverts and scapularies barred with a darker green; the squamate markings on the underparts reduced to a thread-like intermarginal line; the light bars on the quills as broad as, or even broader than, the black interspaces; the tail creamy white, narrowly barred with brownish black, these bars showing but faintly on the under surface, which is strongly washed with golden yellow.”

## Fam. UPUPIDÆ.

## 83. UPUPA EPOPS.

*Upupa epops* (L.); Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 723 (1856-58); Blanford, *t. c.* p. 130 (1876); Severtz. *t. c.* p. 68; Dresser, *Ibis*, 1876, p. 319; Barnes, *Str. F.* 1880, p. 216; Wardlaw-Ramsay, *Ibis*, 1880, p. 52; C. Swinhoe, *ibid.* 1882, p. 103; Scully, *t. c.* p. 80.

1. ♂. Gulran, Badghis. 7th March, 1885.
2. ♂. „ „ 12th March, 1885.

## Fam. MEROPIDÆ.

## 84. MEROPS APIASTER.

*Merops apiaster* (L.); Blanford, *t. c.* p. 122 (1876); Severtz. *t. c.* p. 68; Dresser, *Ibis*, 1876, p. 319; Wardlaw-Ramsay, *Ibis*, 1880, p. 49; Barnes, *Str. F.* 1880, p. 215; Swinhoe, *Ibis*, 1882, p. 102; Scully, *t. c.* p. 79.

1. ♂. Khusan, Hari-rud. 16th April, 1885.
2. ♀. Tirphul, „ 20th April, 1885.
3. ♂. Kambao, Badghis. 28th April, 1885.
4. ♀. Shore-kaltegai, Badghis. 3rd May, 1885.

[This Bee-eater was building in holes in sand-banks.—J. E. T. A.]

## 85. MEROPS PERSICUS.

*Merops persicus* (Pall.); Severtz. *t. c.* p. 68; Dresser, *Ibis*, 1876, p. 319; Wardlaw-Ramsay, *Ibis*, 1880, p. 49.

*Merops aegyptius*, Horsf. & Moore, Cat. B. Mus. E.-I. Co. i. p. 89 (1854); Blanford, *t. c.* p. 123.

1. ♀. Toman-agma, Hari-rud. 28th April, 1885.
2. ♂. Between Toman-agma and Kambao. 28th April, 1885.
3. ♂. Kumani-besht, Hari-rud. 13th May, 1885.

## Fam. CORACIIDÆ.

## 86. CORACIAS GARRULA.

*Coracias garrula* (L.); Blanf. *t. c.* p. 125 (1876); Severtz. *t. c.* p. 68; Dresser, *Ibis*, 1876, p. 319; Horsf. & Moore, Cat. B. Mus. E.-I. Co. ii. p. 571 (1856-58); Swinhoe, *Ibis*, 1882, p. 102; Scully, *t. c.* p. 79.

- 1, 2. ♂ ; 3. ♀. Tirphul, Hari-rud. 13th April, 1885.
4. ♀. Gulran, Badghis. 16th April, 1885.
5. ♀. Kambao, „ 19th May, 1885.

[This Roller was breeding at Turbat, Shaik-jami, Khorasan. A pair had a nest in a hole over the doorway of the house I lived in.—J. E. T. A.]

## Order COLUMBÆ.

## Fam. COLUMBIDÆ.

## 87. TURTUR AURITUS.

*Turtur auritus* (Gray); Blanford, *t. c.* p. 270 (1876); C. Swinhoe, *Ibis*, 1882, p. 117; Scully, *t. c.* p. 86.

1, 2. ♂ ; 3. ♀. Khusan, Hari-rud. 12th May, 1885.

[The Turtle-Dove suddenly arrived in large flocks about the 12th May.—J. E. T. A.]

#### 88. COLUMBA ŒNAS.

*Columba œnas* (L.); Blanf. *t. c.* p. 269 (1876); Severtz. *t. c.* p. 68; Dresser, *Ibis*, 1876, p. 321.

1. ♂ ; 2, 3. ♀. Karabagh, Badghis. 28th November, 1884.

#### 89. COLUMBA EVERSMANNI.

*Columba fusca*, Severtz. *t. c.* p. 68; Dresser, *Ibis*, 1876, p. 321.

*Columba eversmanni*, Scully, *t. c.* p. 86.

*Columba intermedia*, C. Swinhoe, *Ibis*, 1882, p. 117.

*Palumbæna eversmanni*, Scully, *Str. F.* 1876, p. 175.

1, 2. ♀. Tirphul, Hari-rud. 22nd April, 1885.

3, 4. ♂ ; 5. ♀. Tirphul, Hari-rud. 23rd April, 1885.

6, 7. ♂. Toman-agma, Hari-rud. 28th April, 1885.

[Found nesting on trees in the bed of the Hari-rud river in considerable numbers.—

J. E. T. A.]

One specimen shows apparent traces of a cross with a domestic Pigeon, as it has a great admixture of white in the plumage.

### Order PTEROCLETES.

#### Fam. PTEROCLIDÆ.

#### 90. PTEROCLES ARENARIUS.

*Pterocles arenarius* (Pall.); Blanf. *t. c.* p. 271 (1876); Severtz. *t. c.* p. 68; Dresser, *Ibis*, 1876, p. 322; Barnes, *Str. F.* 1880, p. 219; C. Swinhoe, *Ibis*, 1882, p. 118.

1. ♀. Kin. 3rd November, 1884.

2. ♀. Zagin. 5th November, 1884.

3. ♂. „ 6th November, 1884.

4. ♂. Karez-dasht. 9th November, 1884.

5. ♂ ; 6. ♀. Gulran, Badghis. 12th March, 1885.

[This was the common Sand-Grouse of the country, occurring in large flocks during autumn and winter, especially in the vicinity of villages; whilst breeding were seen in pairs everywhere. They were very good eating, although certainly not clean feeders.—

J. E. T. A.]

#### 91. PTEROCLES CORONATUS.

*Pterocles coronatus* (Licht.); Blanf. *t. c.* p. 272 (1876); Barnes, *Str. F.* 1880, p. 219; C. Swinhoe, *Ibis*, 1882, p. 118.

1. ♂ ; 2. ♀. Sang-bar. 7th November, 1884.

[I do not remember seeing this Sand-Grouse after we left the Baluchistan Desert.—

J. E. T. A.]

## Order GALLINÆ.

## Fam. PHASIANIDÆ.

## 92. PHASIANUS PERSICUS.

*Phasianus persicus*, Severtz. ; Seebohm, Ibis, 1887, p. 170.

1. ♂. Bander-i-ghaz, Caspian. October, 1885.

[This Pheasant was brought in for sale at Bander-i-ghaz, where it is said to be now rare.—J. E. T. A.]

Mr. Seebohm observes :—“This is an intermediate form between *P. colchicus* and *P. principalis*, having the narrow margins of the feathers of the underparts of the former, and the whiter wing-coverts of the latter, and differing from both in having the rump and upper tail-coverts suffused with purple-lake when the light falls on the bird from the back of the observer. No green can be detected on the centre of the breast and belly in any light.”

## 93. PHASIANUS PRINCIPALIS, sp. nov. (Plate VII.)

*Phasianus principalis*, Selater, P. Z. S. 1885, p. 324, pl. 22; Seebohm, Ibis, 1887, p. 171; Scully, *l.c.* p. 86.

1, 2. ♂ ; 3, 4, 5. ♀. Bala-morghab, Badghis. 29th December, 1884.

6, 7. ♂. „ „ 3rd February, 1885.

8. ♂ ; 9, 10. ♀. Karaol-khana, Badghis. 15th February, 1885.

[The specimens of this Pheasant were all got on the banks of the Bala-morghab, where it occurs in considerable numbers in the Tamarisk and Grass jungle growing in the bed of the river. More than 400 were killed on the march of 30 miles up this river. It not only wades through the water in trying to make from one point of vantage to another, but swims, and seems to be quite at home in these thickets, where there is always water to the depth of two or three feet. These swampy localities afford good shelter. In the mornings and evenings the Pheasants leave it for the more open and dry country, where they pick up their food. I believe the same species is found on the Hari-rud river, but I have seen no specimens from that locality. In February 1888 five living birds were presented by Major Peacocke to the Zoological Society of London (see P. Z. S. 1888, p. 140).—J. E. T. A.]

Mr. Seebohm's note on this species is as follows :—“It is an intermediate form between *P. persicus* and *P. shawi*. It differs from the former in having the rump and upper tail-coverts glossed with brick-red instead of purple-lake, and the dark margins and tips of the feathers both of the upper and underparts broader and more lustrous. From the latter it differs in having less green below the neck on the upper or underparts. On the centre of the breast and belly no trace of green can be detected, even when the light falls upon the bird from the back of the observer. Some examples of *P. shawi* almost, but apparently never quite, lose this trace of green.”

94. *FRANCOLINUS VULGARIS.*

*Francolinus vulgaris*, Steph.; Blanf. *t. c.* p. 273 (1876); C. Swinhoe, Ibis, 1882, p. 119.

1. ♀. Between Padda-sultan and De-kamran. 26th October, 1884.
2. ♀. Between De-kamran and De-doda. 27th October, 1884.

[The above were the only localities where we saw the "Black-Partridge" of Northern India. Numbers were shot, but, curiously enough, no male birds.—J. E. T. A.]

95. *COTURNIX DACTYLISONANS.*

*Coturnix dactylisonans*, Meyer.

*Coturnix communis*, Blanf. *t. c.* p. 278; Hume & Marshall, Game Birds of India, vol. ii. p. 133, pl. 26 (1879); Swinhoe, Ibis, 1882, p. 119; Scully, *t. c.* p. 87.

*Coturnix vulgaris*, Severtz. *t. c.* p. 68; Dresser, Ibis, 1876, p. 323.

1. ♂. Toman-agma, Hari-rud. 26th April, 1885.
2. ♂. " " 27th April, 1885.
3. ♀. Tirphul, Hari-rud. 4th May, 1885.
4. ♀. Sang-haji, Badghis. 21st May, 1885.

[A very few Quail, in pairs, were met with all over Badghis.—J. E. T. A.]

96. *CACCABIS CHUKAR.*

*Caccabis chukar*, Gray; Blanf. *t. c.* p. 275 (1876); Hume & Marshall, *t. c.* p. 33, pl. 5, fig. 1 (1879); Wardlaw-Ramsay, Ibis, 1880, p. 70; Barnes, Str. F. 1880, p. 219; C. Swinhoe, Ibis, 1882, p. 119.

*Perdix savatilis*, var. *chukar*, Severtz. Turkest. Jevotn. p. 68; Dresser, Ibis, 1876, p. 323.

- 1, 2, 3. ♀. Khusan, Hari-rud. 17th November, 1884.
4. ♂. Kar-o-bagh, Badghis. 28th November, 1884.
5. ♂. Bala-morghab, Badghis. 16th December, 1884.

[The Chukar was very numerous all over the country, and in large coveys.—J. E. T. A.]

97. *AMMOPERDIX BONHAMI.*

*Ammoperdix bonhami*, G. R. Gray; Blanf. *t. c.* p. 274 (1876); Hume & Marshall, *t. c.* p. 45, pl. 6 (1879); Wardlaw-Ramsay, Ibis, 1880, p. 70; Barnes, Str. F. 1880, p. 219; C. Swinhoe, Ibis, 1882, p. 119.

*Perdix griseogularis*, Brandt (?) (*P. bonhami*, Fras.), Severtz. Turkest. Jevotn. p. 68; Dresser, Ibis, 1876, p. 323.

1. ♂. Karez-dasht. 8th November, 1884.

[The most northern locality that I saw the "Sisi" was at Mont Do-Shakh near Kilki.—J. E. T. A.]

## Order ALECTORIDES.

## Fam. OTIDIDÆ.

98. *OTIS TARDA.*

*Otis tarda*, L.; Blanf. *t. c.* p. 287 (1876); Severtz. Turkest. Jevotn. p. 69; Dresser, Ibis, 1876, p. 326.

1. ♂. Bala-morghab, Badghis. 29th January, 1885.

[The measurements taken when the bird was fresh were:—Length from tip of bill to end of tail 3 feet 4 inches; length to point of toe (legs extended) 3 feet 8 inches; length

from tip to tip of wings extended 7 feet 4 inches. Weight 17 lbs.; weight of food in gizzard 2 lbs.

This magnificent bird was shot by Lieut. Rawlins near Bala-morghab on the 29th of January, 1885, out of a flock of seven.

On opening the bird the gizzard was found to contain a solid ball of vegetable matter, much like cooked spinach, in a mass rather larger than a cricket-ball, weighing 2 lbs.; amongst this were neither seeds nor insects.

The flesh was eaten next day and was excellent.

This flock had been seen for fully a month in the vicinity, and one had been killed by some wild animal, as we picked up the feathers in large quantities.

The flock was seen to light upon the top of a small hill that had extremely precipitous sides, which were very difficult to ascend owing to the clay being wet with half-melted snow; although there was not 100 feet to ascend, by the time Lieut. Rawlins and Capt. Drummond got to the top they were both quite exhausted. As they rested just before gaining the top, so as to get their wind, the birds rose, and Lieut. Rawlins succeeded in shooting one, but the stench of the bird was so great that he almost thought of leaving it; it was so dark that he scarcely knew what it was that he had got, and the scent was almost enough to put off any one from even a new acquisition.—J. E. T. A.]

## Order LIMICOLÆ.

### Fam. CHARADRIIDÆ.

#### 99. *ŒDICNEMUS CREPITANS*.

*Œdicnemus crepitans*, Temm.; Blanford, *t. c.* p. 288 (1876); Severtz. *t. c.* p. 69; Dresser, *Ibis*, 1876, p. 326.

1. —. Gulran, Badghis. 11th March, 1885.

#### 100. *CURSORIUS GALLICUS*.

*Cursorius gallicus* (Gm.); Blanf. *t. c.* p. 281 (1876).

1. ♀. Gulran, Badghis. 19th March, 1885.
2. ♂. Karez, Khorasan. 8th June, 1885.

[This bird was very common on the great gravel plains, but very wary, keeping well out of shot and always on the run, carefully putting every bush and tussock of grass between itself and its pursuer.—J. E. T. A.]

#### 101. *VANELLUS CRISTATUS*.

*Vanellus cristatus*, Meyer; Blanf. *t. c.* p. 280 (1876); Severtz. *t. c.* p. 69; Dresser, *Ibis*, 1876, p. 238; Swinhoe, *ibid.* 1882, p. 120; Scully, *t. c.* p. 87.

1. ♂. Between Zind-i-jan and Roznak. 16th November, 1884.
2. ♀. Bala-morghab, Badghis. 16th January, 1885.

[Common over the whole Badghis.—J. E. T. A.]

102. *ÆGIALITIS DUBIA*.*Ægialitis dubia* (Scop.).*Ægialitis curonica*, Dresser, Birds of Europe, vol. vii. p. 491, pl. 524 (1876); C. Swinhoe, Ibis, 1882, p. 120; Scully, *t. c.* p. 87.*Ægialites minor*, Severtz. *t. c.* p. 69; Dresser, Ibis, 1876, p. 328.

1. ♀. Tirphul, Hari-rud. 20th April, 1885.

103. *PHALAROPUS HYPERBOREUS*.*Phalaropus hyperboreus* (L.); Blanf. *t. c.* p. 284 (1876).*Phalaropus angustirostris*, Severtz. *t. c.* p. 69; Dresser, Ibis, 1876, p. 411.

1. ♀. Band, near Nushki. 2nd October, 1884.

## Fam. SCOLOPACIDÆ.

104. *GALLINAGO GALLINULA*.*Gallinago gallinula* (L.); Blanf. *t. c.* p. 283 (1876); Severtz. *t. c.* p. 69; Dresser, Ibis, 1876, p. 330; Swinhoe, Ibis, 1882, p. 121.

1. ♂. Between Hadj-ali and Lundi. 19th October, 1884.
2. ♂. Gulran, Badghis. 5th March, 1885.

[Jack Snipe were found in small numbers in the stream-bed which ran through Gulran, and were occasionally seen in similar localities all over the country.—J. E. T. A.]

105. *GALLINAGO SCOLOPACINA*.*Gallinago scolopacina*, Bp.; Blanf. *t. c.* p. 282 (1876); Scully, *t. c.* p. 87.

1. ♂. Between Hadj-ali and Lundi. 19th October, 1884.
2. ♀. Bala-morghab, Badghis. 17th January, 1885.
3. ♂. Gulran, Badghis. 19th March, 1885.

[This Snipe was met with in small numbers over the whole country.—J. E. T. A.]

106. *TOTANUS OCHROPUS*.*Totanus ochropus* (L.); Blanf. *t. c.* p. 285 (1876); Severtz. *t. c.* p. 69; Dresser, Ibis, 1876, p. 412; Swinhoe, Ibis, 1882, p. 122; Scully, *t. c.* p. 87.

1. ♀. Between Ab-i-kamarra and Ab-i-shora. 9th December, 1884.
2. ♀. Gulran, Badghis. 1st April, 1885.

## Order FULICARIÆ.

## Fam. RALLIDÆ.

107. *RALLUS AQUATICUS*.*Rallus aquaticus*, L.; Blanf. *t. c.* p. 288 (1876); Severtz. *t. c.* p. 69; Dresser, Ibis, 1876, p. 412; Scully, *t. c.* p. 87.

1. ♂. Between Lundi and Rudbar. 20th October, 1884.
2. ♂. Bala-morghab, Badghis. 10th January, 1885.

## 108. ORTYGOMETRA BAILLONII.

*Ortygometra baillonii* (Vicill.) ; Hume & Marshall, Game Birds of India, vol. ii. p. 203, pl. 35 (1879).

*Porzana bailloni*, Swinhoe, Ibis, 1882, p. 123 ; Scully, *t. c.* p. 88.

*Gallinula pygmaea*, Severtz. *t. c.* p. 69 ; Dresser, Ibis, 1876, p. 413.

1. ♀. Nushki. 26th September, 1884.
2. ♂. Between Gaz-i-cha and Safia. 7th October, 1884.

## 109. FULICA ATRA.

*Fulica atra*, L. ; Blanf. *t. c.* p. 289 (1876) ; Severtz. *t. c.* p. 69 ; Dresser, Ibis, 1876, p. 413 ; Swinhoe, Ibis, 1882, p. 122 ; Sully, *t. c.* p. 88.

1. —. Kalla-i-maur, Badghis. 29th March, 1885.

[This bird was sent to me by Mr. Merk.—J. E. T. A.]

## Order HERODIONES.

## Fam. ARDEIDÆ.

## 110. BOTAURUS STELLARIS.

*Botaurus stellaris* (L.) ; Blanf. *t. c.* p. 297 (1876) ; Severtz. *t. c.* p. 68 ; Dresser, Ibis, 1876, p. 325 ; C. Swinhoe, *ibid.* 1882, p. 123.

- 1, 2. ♂ ; 3. ♀. Bala-morghab, Badghis. 29th December, 1884.
4. ♂. Karaol-khana, Badghis. 15th February, 1885.

[The Bittern is very common, living in exactly the same wet localities as where the Morghab Pheasant is found, and these specimens were all shot whilst looking for Pheasants.—J. E. T. A.]

## 111. PLATALEA LEUCORODIA.

*Platalea leucorodia*, L. ; Blanf. *t. c.* p. 298 (1876) ; Severtz. *t. c.* p. 68 ; Dresser, Ibis, 1876, p. 326.

- 1, 2. Sex unknown. [The birds were cleaned and then sent to me from Kalla-i-maur, Badghis, by Mr. Merk. 25th March, 1885.—J. E. T. A.]

## Order ANSERES.

## Fam. ANATIDÆ.

## 112. BRANTA RUFINA.

*Branta rufina*, Pall. ; Hume & Marshall, Game Birds of India, vol. iii. p. 253, pl. 34 (1880).

*Fuligula rufina*, Blanf. *t. c.* p. 801 ; Severtz. *t. c.* p. 70 ; Dresser, Ibis, p. 421 ; C. Swinhoe, *ibid.* 1882, p. 125.

- 1, 2. ♂. Bala-morghab, Badghis. January 1885.
3. ♀. „ „ 23rd January, 1885.

## 113. CASARCA RUTILA.

*Casarca rutila*, Pall.; Blanf. *t. c.* p. 303 (1876); Hume & Marshall, *t. c.* p. 123, pl. 17 (1880); C. Swinhoe, *Ibis*, 1882, p. 124; Scully, *t. c.* p. 89.

*Anas rutila*, Severtz. *t. c.* p. 70; Dresser, *Ibis*, 1876, p. 419.

1. ♂. Gulran, Badghis. 6th March, 1886.

[This bird, the Brahminy Duck of India, was occasionally seen and was breeding in the cliffs overhanging the Hari-rud river.—J. E. T. A.]

## 114. SPATULA CLYPEATA.

*Spatula clypeata* (L.); Blanf. *t. c.* p. 301 (1876); Hume & Marshall, *t. c.* p. 142, pl. 19 (1880); C. Swinhoe, *Ibis*, 1882, p. 124.

*Anas clypeata*, Severtz. *t. c.* p. 70; Dresser, *Ibis*, 1876, p. 420.

1. ♂. Kalla-i-maur, Badghis. 18th March, 1885.

## 115. CHAULELASMUS STREPERUS.

*Chaulelasmus streperus* (L.); Dresser, *Ibis*, 1876, p. 419; Hume & Marshall, *t. c.* p. 181, pl. 24 (1880).

*Anas strepera*, Severtz. *t. c.* p. 70; Blanf. *t. c.* p. 300; C. Swinhoe, *Ibis*, 1882, p. 124; Scully, *t. c.* p. 88.

1. ♀; 2. ♂. Bala-morghab, Badghis. 22nd January, 1885.
3. ♂. „ „ 9th February, 1885.

## 116. CLANGULA GLAUCION.

*Clangula glaucion* (L.); Severtz. *t. c.* p. 70; Dresser, *Ibis*, 1876, p. 421; Blanf. *t. c.* p. 302; Hume & Marshall, *Game Birds of India*, iii. p. 285, pl. 38 (1880); Scully, *t. c.* p. 89.

1. ♂. Bala-morghab, Badghis. 15th January, 1885.

## 117. QUERQUEDULA CRECCA.

*Querquedula crecca* (L.); Blanf. *t. c.* p. 301 (1876); Hume & Marshall, *Game Birds of India*, vol. iii. p. 205, pl. 27 (1880); C. Swinhoe, *Ibis*, 1882, p. 124.

*Anas crecca*, Severtz. *t. c.* p. 70; Dresser, *Ibis*, 1876, p. 419; Scully, *t. c.* p. 88.

1. ♂. Bala-morghab, Badghis. 23rd January, 1885.

## 118. QUERQUEDULA FALCATA.

*Querquedula falcata* (Pall.); Hume & Marshall, *Game Birds of India*, vol. iii. p. 231, pl. 30 (1880).

1. —. Bala-morghab, Badghis. 28th December, 1884.

[One specimen of this fine Duck, a supposed male, was shot by Captain Heath, and given to me by Captain Gore, R.E. The falcated secondary wing-feathers were present on one side of the body only. This would have been an interesting specimen to dissect, in order to have seen if the organs of generation were irregularly developed. The general plumage is that of the male.

The occurrence of the bird in this locality gives a much further western area than heretofore known. Hume and Marshall state that it is unknown from Western Turkestan or the Caspian.—J. E. T. A.

## 119. QUERQUEDULA ANGUSTIROSTRIS.

*Querquedula angustirostris*, Hume & Marshall; Game Birds of India, vol. iii. p. 237, pl. 31 (1880); C. Swinhoe, Ibis, 1882, p. 124.

*Anas angustirostris* (Mén.); Blanf. *t. c.* p. 301; Scully, *t. c.* p. 88.

1. —. Between De-kamrau and De-doda. October 27th, 1884.
2. —. Bala-morghab, Badghis. Winter 1884–85.

## 120. MARECA PENELOPE.

*Mareca penelope* (L.); Blanf. *t. c.* p. 301 (1876); Hume & Marshall, Game Birds of India, vol. iii. p. 197, pl. 26 (1880); C. Swinhoe, Ibis, 1882, p. 124.

*Anas penelope*, Scully, *t. c.* p. 88.

1. ♀. Bala-morghab. 14th January, 1884.
2. ♂. Bala-morghab, Badghis. 20th January, 1885.

## 121. MERGELLUS ALBELLUS.

*Mergellus albellus* (L.); Hume & Marshall, Game Birds of India, vol. iii. p. 293, pl. 39 (1880); C. Swinhoe, Ibis, 1882, p. 125.

*Mergus albellus*, Blanf. *t. c.* p. 303 (1876); Severtz. *t. c.* p. 70; Dresser, Ibis, 1876, p. 421; Scully, *t. c.* p. 89.

- 1, 2. ♂; 3. ♀. Bala-morghab, Badghis. 29th December, 1884.

## 122. MERGUS SERRATOR.

*Mergus serrator* (L.); Hume & Marshall, Game Birds of India, vol. iii. p. 305, pl. 40, fig. 2 (1880).

1. ♀. Bala-morghab, Badghis. 21st January, 1885.
2. ♂. „ „ 30th January, 1885.

[This is the first occasion that this bird has been recorded as from Afghanistan.—J. E. T. A.]

## Order GAVIÆ.

## Fam. LARIDÆ.

## 123. LARUS RIDIBUNDUS.

*Larus ridibundus* (L.); Blanf. *t. c.* p. 292 (1876); C. Swinhoe, Ibis, 1882, p. 126; Scully, *t. c.* p. 88. *Gavia ridibunda*, Severtz. *t. c.* p. 70; Dresser, Ibis, 1876, p. 415.

1. ♀. Gulran, Badghis. 12th March, 1885.

[This bird was shot and given to me by Captain Cotton.—J. E. T. A.]

## Order STEGANOPODES.

## Fam. PHALACROCORACIDÆ.

## 124. PHALACROCORAX JAVANICUS.

*Phalacrocorax javanicus*, Horsf.

*Phalacrocorax pygmaeus*, Dresser, Birds of Europe, vol. vi. p. 173, pl. 391 (1876); Blanford, *t. c.* p. 298. *Carbo pygmaeus*, Severtz. *t. c.* p. 70; Dresser, Ibis, 1876, p. 414.

1. —. Bala-morghab, Badghis. 28th December, 1884.
2. ♀. „ „ 12th January, 1885.
3. ♀. „ „ January, 1885.

[Species of the following genera were seen, but no specimens obtained :—

A Vulture (*Fultur*, sp.), probably *V. monachus*, L.

A large pure white egg was brought me which I believe to have been that of *Gyps fulvus* (G.). These birds go by the name of “Lash-kar” or Flesh-eater. In the Badghis, on Pistacio and Juniper trees, at a height of from 6 to 8 feet from the ground, on several occasions, I came across huge nests which the natives said were those of an Eagle, whose eggs were laid during January or February, and the young hatched whilst snow was still on the ground.

A Kite (*Milvus*, sp.) was more or less common round our camp.

The white ‘Scavenger-bird’ of India (*Neophron percnopterus* ?) was only occasionally seen during summer, and its nest was found.

The Raven (*Corvus corax*) was common along our whole route.

I believe two species of Chough (*Pyrrhocorax*, sp.) were met with, one in largish flocks at the Hamun; and the second in the vicinity of Kuskh in the Badghis, and again in the hills to the south of Bezd, Khorasan, occurring in pairs.

A Cuckoo (*Cuculus*, sp.) was heard during spring all over the Badghis.

A Swift (*Cypselus*, sp.) was common, building in the cliffs overhanging the Hari-rud.

An Oriole (probably *Oriolus galbula*, L.) was common in gardens. Khorasan.

The “Kulan” of the Punjab (*Grus communis*) was in some numbers at Gulran.

The Wild Duck (*Anas boschas*) was frequently shot at Bala-morghab.

A supposed Swan was heard and seen resting at night, and was known to the natives. On the Hamun the natives kept and reared Geese, very similar to the ordinary Grey Goose of England.

The Houbara (*Otis macqueni*) was occasionally seen, but not a single specimen, to my knowledge, was obtained.—J. E. T. A.]

#### EXPLANATION OF THE PLATES.

PLATE VI. Fig. 1. *Gecinus gorii*, Hargitt.

Fig. 2. *Passer yatii*, Sharpe.

PLATE VII. Figs. 1 & 2. *Phasianus principalis*, Selater

## REPTILES and BATRACHIANS.

By G. A. BOULENGER, Assistant in the Zoological Department, British Museum.

### REPTILIA.

#### CHELONIA.

##### 1. TESTUDO HORSFIELDII, Gray.

*Testudo horsfieldii*, Gray, Cat. Tort. &c. 1844, p. 7; Blanford, E. Pers. ii. p. 308.

12 specimens. Gulran, Badghis.

[Local names *Kashif*, *Kashaf*, *Sang-toti*, *Sang-pusht*, *Lach-pusht*, *Tosh-bakke*, *Shamshatu*.

Along the entire march from Quetta to Pahir (13th November, 1884) the remains of Tortoises were seen; at the latter place the first live specimen was got, living in a dry water-course, full of limestone débris, the disintegration of the surrounding rocks and hills, in a locality utterly devoid of vegetation, as far as I could see, and where I should never have expected to find any animal. On the 23rd February, in our march from a camp without name to Gulran, numbers of the empty shells of Tortoise eggs were seen lying on the sides of several streams, as if washed there by floods, the eggs in all probability having been emptied in the first place of their contents by rats.

Whilst at Gulran early in March, numbers were noticed wandering over the great rolling plains, the warmth of spring having enticed them from their winter-quarters, and there was herbage sufficiently grown to prevent their being easily detected. It is curious to note that out of the large number I saw and collected, I only got one species. I do not recollect, nor have I noted, ever having seen a single specimen in that part of Khorasan over which I travelled.—J. E. T. A.]

#### LACERTILIA.

##### 2. TERATOSCINCUS SCINCUS (Schleg.). (Plate VIII. fig. 1.)

*Teratoscincus keyserlingii*, Blanford, *tom. cit.* p. 354.

*Teratoscincus scincus*, Boulenger, Cat. Liz. i. p. 12.

The specimen measures 200 millim., in which the tail enters for 77. Cream-coloured, with a few black spots on the back, and four brick-red longitudinal bands; three blackish vertical bars down the lips on each side.

[One specimen only of this rare Lizard was picked up, on the 17th May, 1885 (no. 325), amongst stones on the banks of the Hari-rud river near Tirphul. This would give as its known area the country between Lash-Jowain, Karman and Tirphul.—J. E. T. A.]

##### 3. STENODACTYLUS LUMSDENII. (Plate IX. fig. 1.)

*Stenodactylus lumsdenii*, Boulenger, Cat. Liz. iii. p. 479.

Snout much longer than the diameter of the orbit, or the distance between the latter and the ear; forehead very slightly concave; ear-opening vertically oval, one third the

diameter of the eye. The fore limb, stretched forwards, reaches the tip of the snout; the hind limb reaches the shoulder. Digits slender, shortly fringed laterally, with feebly tricarinate inferior lamellæ. Head covered with small granules, intermixed with enlarged ones on the vertex, the occiput, and the temples; rostral quadrangular, nearly as broad as long, with median cleft above; nostril pierced between the rostral, the first labial, and two nasals; ten upper and nine lower labials; mental trapezoid, broader than long; no chin-shields; gular granules minute. Back covered with small granules intermixed with oval, very feebly keeled tubercles, forming about twelve irregular longitudinal series. Ventral scales small, smooth, subhexagonal, imbricate. Tail cylindrical, slightly depressed, verticillate, with subequal feebly keeled scales. Sand-coloured above, with seven darker bands across the body, and dark brown bands across the tail; head marbled with dark brown; a dark brown band from the eye to above the ear; lower surfaces white.

Total length . . . . .	millim.	78	Fore limb . . . . .	millim.	16
Head . . . . .	12	Hind limb . . . . .	21		
Width of head . . . . .	7	Tail . . . . .	42		
Body . . . . .	24				

Nearest *S. orientalis*, Blanf., from which it differs by the much longer snout, longer limbs, larger and more numerous dorsal tubercles, smooth ventral scales, &c.

[One specimen only of this new species was collected in Northern Baluchistan between Nushki and the Helmand.—J. E. T. A.]

#### 4. ALSOPHYLAX TUBERCULATUS (Blanf.).

*Bunopus tuberculatus*, Blanford, *tom. cit.* p. 348.

*Alsophylax tuberculatus*, Boulenger, *op. cit.* i. p. 20.

[One specimen only was obtained on the march down the Helmand between Hadj-ali and the Hamun.—J. E. T. A.]

#### 5. AGAMURA PERSICA (A. Dum.). (Plate IX. fig. 2.)

*Agamura persica*, Blanford, *tom. cit.* p. 358; Boulenger, *tom. cit.* p. 51.

These specimens show the differences between *A. persica* and *A. cruralis*, Blanford, to be less important than was hitherto believed. The following notes are taken from the specimens collected by Dr. Aitchison:—

The fore limb being stretched forwards, the wrist reaches the tip of the snout, or half-way between the latter point and the eye; the hind limb reaches the ear, or half-way between the ear and the eye, or (in a young male) as far as the eye. Rostral twice or not twice as broad as high, completely divided into two, entering or not entering the nostril; 12 to 14 upper and 9 to 12 lower labials; mental not twice as broad as long, sometimes with a shield on each side between it and the second infralabial. The enlarged dorsal tubercles sometimes keeled and subtriangular. Numerous enlarged tubercles on the hind limbs. Male without or with two preanal pores.

[Three specimens of this species were collected on our marches along the Helmand. Four specimens between the Hamun and Khusan, and one to the north of Herat. Blanford, at page 359, in distinguishing this species from *A. cruralis*, lays stress on its distribution, "found at a much greater height above the sea" . . . "at an elevation of at least 8000 feet"; my specimens were all collected at 2000 feet, if so much.—J. E. T. A.]

6. *AGAMA ISOLEPIS*, Blgr. (Plate X. figs. 1-3.)

*Agama isolepis*, Boulenger, *tom. cit.* p. 342.

*Agama agilis* (non Oliv.), Blanford, *tom. cit.* p. 314.

5 specimens. Nushki to Helmand.

2 specimens. Helmand.

9 specimens. North of Herat.

[This Lizard was common along our route from Nushki to the Hari-rud, and was generally found to occur throughout the Badghis.

It was usually seen at the very end of a dry branch, the highest and most exposed it could find, never more than six feet from the ground; here it basked in the sun, and attracted insects towards it by the changes it produced in the coloration of its head and neck, the rest of its body resembling in colour the dry twig to which it elung. It was easily killed and collected if struck at the first blow; while dying it showed various patches of coloration from deep indigo-blue to violet and purple, over such parts of its body as were usually light-coloured.

I never met with it on the ground, although in trying to escape it always made for some hole at the root of the bush on which it was first seen.—J. E. T. A.]

7. *AGAMA SANGUINOLENTA* (Pall.).

*Agama sanguinolenta*, Boulenger, *tom. cit.* p. 343.

[One specimen only of this species was collected, and that on the 14th of March, 1885, at old Gulran, and was given to me by Mr. Chapman.—J. E. T. A.]

8. *AGAMA CAUCASICA* (Eichw.).

*Stellio caucasicus*, Blanford, *tom. cit.* p. 322.

*Agama caucasica*, Boulenger, *tom. cit.* p. 367.

[Two specimens of this very handsome species were obtained at Bezd, Khorasan. One at Chinkiloh, Afghanistan.—J. E. T. A.]

9. *PHRYNOCEPHALUS OLIVIERI*, D. & B. (Plate VIII. fig. 2.)

*Phrynocephalus olivieri*, Blanford, *tom. cit.* p. 327; Boulenger, *tom. cit.* p. 370.

2 specimens. Quetta to Nushki.

22 specimens. Nushki to Helmand.

6 specimens. Helmand.

2 specimens. Hamun to Khusan.

[Owing to this being a very bright-coloured species and common along our whole route from Quetta to Khusan, I was well supplied with specimens.—J. E. T. A.]

## 10. PHRYNOCEPHALUS ORNATUS. (Plate VIII. fig. 3.)

*Phrynocephalus ornatus*, Boulenger, Cat. Liz. iii. p. 496.

12 specimens. Nushki to Helmand.

2 specimens. Helmand.

Forehead convex and slightly sloping, with scarcely enlarged keeled scales; occipitals very feebly enlarged; supraocular scales a little smaller than median dorsals, imbricate, feebly keeled; nostril directed forwards and upwards; nasals very large and in contact mesially. Dorsal scales homogeneous, small and granular on the sides, enlarged, flat, imbricate, and feebly keeled on the back. Gular, pectoral, and ventral scales smooth or indistinctly keeled. Scales on upper surface of limbs feebly keeled. Digital fingers moderately developed, stronger on the outer side of the fourth toe than on the inner. Tibia much longer than the skull. The hind limb reaches beyond the snout. Tail nearly twice as long as the distance from gular fold to vent, strongly depressed at the base, roundish-depressed through the greater part of its length; except on the basal portion of the tail, the scales are keeled. Yellowish or yellowish grey above, with small grey or blackish specks and symmetrical markings; usually a few rose-coloured, purple-edged spots on the anterior part of the back and smaller orange ones on the hinder part; head with one or two orange transverse markings; usually a blackish or purplish-grey, straight-edged or festooned lateral band, which may be edged above with a yellowish-white band; a grey band along the hinder side of the thighs. Tail sometimes with regular elliptical brown or orange spots, above separated by a yellowish-white chain. Lower surfaces white; tail usually lemon-yellow, constantly with four or five black spots.

	millim.		millim.
Total length . . . . .	92	Fore limb . . . . .	21
Head . . . . .	9	Hind limb . . . . .	37
Width of head . . . . .	9	Tail . . . . .	53
Body . . . . .	30		

This new Lizard is allied to *P. caudivolvulus* (Pall.), from which it is easily distinguished, besides other points, by having the nasals in contact.

[This beautifully coloured small species was very common between Nushki and the Helmand, and along the Helmand on the gravel plains, and always near bushes, to the roots of which it ran for shelter. It was very difficult to catch.—J. E. T. A.]

## 11. PHRYNOCEPHALUS MACULATUS, And. (Plate IX. fig. 3.)

*Phrynocephalus maculatus*, Blanford, *tom. cit.* p. 331; Boulenger, *op. cit.* i. p. 377.

[This species was met with on the great gravel plains between Nushki and the Helmand, on the more exposed parts, where there were neither bushes nor stones. They hid by lying flat pressed upon the small gravel and sand, hoping from their coloration to evade detection.—J. E. T. A.]

## 12. PHRYNOCEPHALUS LUTEOGUTTATUS. (Plate VIII. fig. 4.)

*Phrynocephalus luteoguttatus*, Boulenger, Cat. Liz. iii. p. 497.

10 specimens. Between Nushki and Helmand.

3 specimens. Helmand.

Head much depressed; forehead convex, not sloping; upper head-scales small, obtusely keeled, not enlarged on the occipital region; nostril directed forwards and upwards; nasals in contact mesially; three or four series of scales between the orbit and the upper labials; none of the chin-shields in contact with the mental or the lower labials. Sides of head and neck with series of erect pointed scales. A fold along the flanks. Dorsal scales rather large, rhomboidal, obtusely keeled, intermixed with enlarged, flat, obtusely keeled ones; lateral scales smaller, equal. Gular, pectoral, and ventral scales smooth or very feebly keeled, ending in a point; median gulars nearly as large as ventrals. Scales on upper surface of limbs keeled. Digits strongly fringed, the fringe extremely strong on the outer side of the fourth toe. Tibia longer than the skull. The adpressed hind limb reaches the eye. Tail about as long as head and body, depressed throughout; caudal scales keeled. Yellowish brown or rufous above, with black dots and round pale yellow spots; the sides sometimes blackish; frequently a blackish streak along the outer side of the tibia; eyelids salmon-coloured. Lower surfaces white, belly sometimes pink; tail salmon-coloured, usually black at the end and with one to three black spots.

	millim.		millim.
Total length . . . . .	82	Fore limb . . . . .	22
Head . . . . .	11	Hind limb . . . . .	35
Width of head . . . . .	11	Tail . . . . .	41
Body . . . . .	30		

The nearest ally of this new species is *P. interscapularis*, Licht., which is at once distinguished by having uniform dorsal scales, and the nasals separated from each other.

## 13. OPHISAURUS APUS (Pall.).

*Pseudopus apoda*, Blanford, *tom. cit.* p. 387.*Ophisaurus apus*, Boulenger, Cat. Liz. ii. p. 280.

3 specimens. Bala-morghab.

2 specimens. Gulran.

[This snake-like Lizard was called by the natives Sag-mar (Dog snake) and Kor-mar (Blind snake). Although I collected few specimens, this Lizard was to be seen in any number during the whole summer all over the Badghis, the soft sandy loam of the country generally suiting it exactly, as well as the presence of numerous white ants which supplied it with food. I have seen it coiled near the exit of a white ants' nest devouring them as they came out, mouthful after mouthful; and as these ants were a little dilatory just as they were going to fly off, this was the opportunity for the *Ophisaurus* to sweep them into his gullet with his long tongue. The natives, though they know that it is innocuous, destroy it wherever they see it, as an "evil thing." I did not

collect it before we got to the Badghis, nor do I remember seeing it in the valley of the Hari-rud or in Khorasan. Lieut. Wright gave me my largest specimen at Balamorghab.—J. E. T. A.]

14. VARANUS GRISEUS (Daud.).

*Psanmosaurus caspius*, Blanford, *tom. cit.* p. 359.

*Varanus griseus*, Boulenger, *tom. cit.* p. 306.

[Three specimens of this well-known and very handsome Lizard were collected, all in the valley of the Hari-rud. Two at Khusan and one at Buniad-khan.—J. E. T. A.]

15. ACANTHODACTYLUS CANTORIS, Gthr.

*Acanthodactylus cantoris*, Günth. Rept. Brit. Ind. p. 73; Blanford, *tom. cit.* p. 381; Boulenger, Cat. Liz. iii. p. 60.

6 specimens. Nushki to Helmand.

1 specimen. Helmand.

[This species was collected on the hillocks of pure sand, formed by drifting, that are so numerous in Northern Baluchistan, and on the route we traversed along the Helmand.—J. E. T. A.]

16. EREMIAS GUTTULATA (Licht.).

*Mesalina pardalis* (non Licht.), Blanford, *tom. cit.* p. 377.

*Eremias guttulata*, Boulenger, Cat. Liz. iii. p. 87.

2 specimens. Quetta to Nushki.

2 specimens. Helmand.

1 specimen. Tirphul.

[From the above specimens the area of this Lizard would extend from Northern Baluchistan along the Helmand to the valley of the Hari-rud river.—J. E. T. A.]

17. EREMIAS VELOX (Pall.).

*Eremias persica* et *E. velox*, Blanford, *tom. cit.* pp. 370 & 374.

*Eremias velox*, Boulenger, *tom. cit.* p. 97.

2 specimens. Quetta to Nushki.

1 specimen. Helmand.

1 specimen. Toman-agma.

1 specimen. Gulran.

[This very bright and slowly marked species seems to extend over a very varied condition of country and climate—from the sandy, stony, and barren soil and climate of Northern Baluchistan to the verdure-covered downs of the Badghis and its damper climate. In the latter country it is the prey of *Monticola saxatilis*.—J. E. T. A.]

18. EREMIAS FASCIATA, Blanf.

*Eremias fasciata*, Blanford, *tom. cit.* p. 374; Boulenger, *tom. cit.* p. 99.

[Only one specimen of this little-known species was collected on the Helmand.—  
J. E. T. A.]

19. *SCAPTEIRA ACUTIROSTRIS*. (Plate IX. fig. 4.)

*Scapteira acutirostris*, Boulenger, *tom. cit.* p. 114.

1 specimen (young). Nushki to Helmand.

Snout conical, acutely pointed; loreal region nearly vertical. Nasals slightly swollen, lower not reaching the rostral, upper forming a long median suture; frontal grooved anteriorly; three large supraoculars, forming sutures with one another; first supraocular in contact with the first supraeiliary, the second loreal, the præfrontal, and the frontal; second and third supraoculars separated from the supraeiliaries and from the frontal by a series of granules; two or three minute granules between the first and second supraoculars; a small, band-like posterior supraocular, separated from the others by granules; interparietal pentagonal; no occipital, parietals forming a suture behind the interparietal; no enlarged scales on the outer border of the parietals; temporal scales granular, smooth; no auricular denticulation; subocular not reaching the lip, resting on the fifth, sixth, and seventh upper labials; the three anterior pairs of chin-shields in contact; collar straight, the marginal scales feebly enlarged. Dorsal scales minutely granular, smooth, equal. Ventrals equilateral or longer than broad, in oblique longitudinal series; 35 transverse series, the longest of which contains about 20 plates. A very large præanal plate, about twice as broad as long. The adpressed hind limb reaches the posterior border of the orbit; foot as long as the distance between the arm and the anterior loreal; digits flattened, smooth or indistinctly keeled inferiorly, strongly fringed laterally; the unguis lamellæ much enlarged, forming a suboval disk; a series of large, transverse subtibial shields. 15–17 femoral pores. Upper caudal scales feebly keeled. Sand-coloured above, with blackish network; head with symmetrical black markings, lower surfaces white.

	millim.
From snout to vent . . . . .	35
Head . . . . .	10
Width of head . . . . .	6.5
From end of snout to fore limb . .	15
Fore limb . . . . .	14
Hind limb . . . . .	25

This new species is allied to *S. grammica* (Lieht.); differing by the large anterior supraocular, the absence of enlarged shield on the outer border of the parietals, the large præanal, and the much larger subtibial shields.

20. *ABLEPHARUS BRANDTII*, Strauch.

*Ablepharus brandtii*, Strauch, Bull. St. Pétersb. xii. p. 367; Blanford, *tom. cit.* p. 391; Boulenger, *tom. cit.* p. 351.

[One specimen only of this species was collected on the Helmand. This extends

the range of this Seink from near Busrah \*, “on the banks of the Shat-el-Arab” (the union of the Tigris and Euphrates), to the Helmand.—J. E. T. A.]

21. EUMECES SCHNEIDERI (Daudin).

*Eumeces pavimentatus*, Blanford, *tom. cit.* p. 387.

*Eumeces schneideri*, Boulenger, *tom. cit.* p. 383.

[Of this species only two specimens are in my collection, one from the Helmand and the other got at Shore-kaltegai in the Badghis. The latter specimen was collected living with several others in hollows of rapidly disintegrating sandstone amongst the sand that lies at the bottom of these hollows. They are simply long rolls of fat, extremely inert, and what they can possibly get to live upon in the hollows they inhabit I cannot imagine. A fine series I had secured in the Badghis were lost.—J. E. T. A.]

22. OPHIOMORUS TRIDACTYLUS (Blyth).

*Sphenocephalus tridactylus*, Blanford, *tom. cit.* p. 395.

*Ophiomorus tridactylus*, Boulenger, *tom. cit.* p. 394.

[Of this curious Lizard I only obtained one specimen, which was killed by Dr. Wier and given to me by Major Durand. It was found at an old fort called Nadir Ali, between De-kamran and De-doda on the Helmand, living in a sand-drift, into which it at once began to burrow on being aware of danger. The natives said that these Lizards are collected and eaten; but I doubted their being numerous enough for that.—J. E. T. A.]

OPHIDIA.

23. TYPHLOPS PERSICUS.

*Typhlops persicus*, Blanford, *tom. cit.* p. 399.

[Only one specimen of this little *Typhlops* was obtained, the exact locality for which is rather doubtful. I believe it was got in our camp at Chinkilok, north of Herat; if not there, certainly between that and the Sang-khotal pass. The latter locality is more like Blanford's, viz. hills, north-east of Sarjan, at 8000 ft. elevation.—J. E. T. A.]

24. ERYX JACULUS (L.).

*Eryx jaculus*, Strauch, Schlang. d. Russ. Reichs, p. 29; Blanford, *tom. cit.* p. 401.

6 specimens. Bala-morghab.

1 specimen. Robot-i-turk.

[A very common species throughout the Badghis. Most of the specimens I kept were dug out of their winter-quarters in holes, in ridges between irrigation-channels, on the margins of fields. Occasionally several were found nestled together.—J. E. T. A.]

\* Blanford, *t. c.* p. 393.

25. *ZAMENIS RAVERGIERI* (Mén.).

*Zamenis ravergeri*, Strauch, *tom. cit.* p. 127 ; Blanford, *tom. cit.* p. 417.

- 1 specimen. Tirphul.
- 1 specimen. Gulran.
- 1 specimen. Chinkilok.

26. *ZAMENIS VENTRIMACULATUS* (Gray).

*Zamenis ventrimaculatus*, Günth. Cat. Col. Sn. p. 105 ; Blanford, *tom. cit.* p. 414.

[One large specimen of this species was got at Bezd, Khorasan. The body was greatly injured, only the head and tail were therefore preserved.—J. E. T. A.]

27. *ZAMENIS KARELINII* (Brandt).

*Zamenis karelinii*, Strauch, *tom. cit.* p. 110.

*Zamenis ventrimaculatus*, part., Blanford, *tom. cit.* p. 414.

- 1 specimen. Helmand.
- 1 specimen. Tirphul.
- 1 specimen. Chinkilok.
- 1 specimen. Kilki.

28. *ZAMENIS RHODORACHIS*, Jan.

*Zamenis rhodorachis*, De Fil. Viag. in Persia, p. 356.

*Zamenis ventrimaculatus*, part., Blanford, *tom. cit.* p. 414.

[One very fine specimen of this Snake, splendidly marked with a bright red broad line down its back, was obtained at our second Gulran encampment, Badghis.—J. E. T. A.]

29. *ZAMENIS DIADEMA* (Schleg.).

*Zamenis diadema*, Günth. Rept. Brit. Ind. p. 412 ; Blanford, *tom. cit.* p. 412.

*Zamenis cliffordii*, Strauch, *tom. cit.* p. 106.

- 2 specimens. Quetta to Nushki.
- 1 specimen. Nushki to Helmand.
- 1 specimen. Tirphul.

[This very handsome Snake seems to be common from Northern Baluchistan to the valley of the Hari-rad.—J. E. T. A.]

30. *LYTORHYNCHUS RIDGEWAYI*. (Plate XI. fig. 1.)

*Lytorhynchus ridgewayi*, Boulenger, Ann. & Mag. N. H. (5) xx. 1887, p. 413.

- 2 specimens. Chinkilok.

Head small, distinct from neck ; snout pointed, strongly projecting. Rostral very large, four-sided, the lower side longer than the upper, deeply concave, the lateral sides angularly emarginate, concave, with a trace of a short longitudinal cleft ; the posterior angle wedged in between the pair of frontonasals, which form a short suture. A single præfrontal, twice and a half as broad as long. Frontal large, pentagonal, a little longer

than broad, its straight anterior border twice as long as the greatest width of the supra-oculars. Parietals slightly longer than the frontal. The nostril is very indistinct; but, by pressing, fluid is expelled from the upper half of the oblique suture between the two nasals; of the latter shields the anterior is more than twice as large as the second. A small loreal. Three præoculars, upper largest and in contact with the frontal; a sub-ocular; two or three postoculars. Seven upper labials, none in contact with the eye, three posterior largest. Two anterior temporals, upper smallest; three or four temporals in contact with the parietal. Six infralabials on each side in contact with the chin-shields, the posterior pair of which is the smallest and separated by two pairs of scales. 19 rows of scales. Ventrals 174; anal divided in one specimen, single in the other; subcaudals 46 pairs. Upper surfaces pale buff, with brown, black-edged, symmetrical markings. An anchor-shaped marking on the head, the crescentic portion extending from one angle of the mouth to the other, passing through the eye and crossing the frontal and præfrontal; the longitudinal branch expands in a large spot on the middle of the parietals, and bifurcates on the nape. Large transverse spots disposed at regular intervals on the body and tail, and alternating with smaller ones on the flanks. Lower parts uniform white. Total length 425 millim.; tail 70.

[The only two specimens collected of this new species were obtained at Chinkilok on the 27th and 29th May, 1885.—J. E. T. A.]

### 31. PSAMMOPHIS LEITHII, Gthr.

*Psammophis leithii*, Günth. Proc. Zool. Soc. 1869, p. 505; Blanford, *tom. cit.* p. 421.

2 specimens. Helmand.

3 specimens. Hamun to Khusan.

[This is a curious Snake in its habit, as it lives amongst the upper branches of bushes; the only specimens I collected were first noticed in that position.—J. E. T. A.]

### 32. TAPHROMETOPON LINEOLATUM, Brandt.

*Taphrometopon lineolatum*, Strauch, *tom. cit.* p. 185; Blanford, *tom. cit.* p. 422.

4 specimens. Tirphul.

1 specimen. Zindijan.

[Obtained only in the Hari-rud valley.—J. E. T. A.]

### 33. NAIA OXIANA (Eichw.). (Plate XI. fig. 2.)

*Naja oxiana*, Strauch, Bull. St. Pétersb. xiii. p. 81; Nikolsky, Tr. St. Petersb. Soc. Nat. xvii. 1886, p. 405.

? *Naja*, sp., Blanford, *tom. cit.* p. 426.

2 specimens. Chinkilok.

1 specimen. Kara-bagh.

An adult specimen, four feet long, and two heads I regard as belonging to this rare Snake, as well as a young specimen from Gilgit presented to the British Museum by

Major Biddulph in 1880, which has been reported upon by Blanford\*. Whether *N. oxiana* deserves specific distinction from *N. tripudians* appears to me extremely doubtful, as the temporal scutellation of the latter is liable to a greater amount of variation than was believed by Strauch. Figures are given of the heads of the four specimens before me. The adult are uniform brown above, without spectacle-mark. The young show traces of the transverse bands represented on Eichwald's figure.

The adult specimen recently obtained by Nikolsky near the Russian post of Giarmak, near Geok-Jepe, is described as slaty grey, without any markings.

[Owing to the great size of this Cobra, and believing that it was the ordinary Indian species, I only preserved one entire specimen and two heads. This, with *Vipera obtusa*, is considered very destructive to Camels; both are equally called "Shutar-mar."—J. E. T. A.]

### 34. VIPERA OBTUSA, Dwig.

*Vipera euphratica*, Strauch, *tom. cit.* p. 221.

*Vipera obtusa*, Blanford, *tom. cit.* p. 428.

1 specimen. Shore-kaltegai.

1 specimen. Sang-hadji.

1 specimen. Sang-kotal.

1 specimen. Kilki.

[This Viper is said to be very common on the sandstone rocks of the Badghis, and also in the valley of the Hari-rud. The last specimen I preserved was obtained to the south of Mt. Do-Shakh, at Kilki. It causes much mortality amongst Camels; owing to its extremely sluggish habits it will not move out of the way, trusting to its colouring to escape detection; hence it is apt to be trampled upon, the result, of course, proving fatal to the trampler. It is called, as already stated, "Shutar-mar" by the natives, an honour divided between it and the Cobra of these parts. The largest one that I measured was 5 feet in length, and 6 inches in circumference at its greatest girth. The country round Chil-gaz was regarded as highly favourable to Snakes: in one night one horse died, and a second had its head so swollen up from a poisoned wound, considered to have been caused by the bite of a Snake, that the head of the poor beast looked more like that of a hippopotamus than anything else to which I could liken it. The animal lingered for several days, and I believe would have recovered, but rubbing its head, it broke the skin and flies settled on it.—J. E. T. A.]

### 35. ECHIS ARENICOLA, Boic.

*Echis arenicola*, Strauch, *tom. cit.* p. 228.

*Echis carinata*, Blanford, *tom. cit.* p. 430.

1 specimen. Nushki to Helmand.

1 specimen. Tirphul.

1 specimen. Chil-gaz.

\* Journ. As. Soc. Beng. i. 1881, p. 241.

[This Viper, called Dusha, was common from Quetta along our whole route to Klusan, specimens being daily brought to me by the camp-followers; except one specimen, I never came across it in the Badghis. The natives say that it is common near their dwellings.—J. E. T. A.]

## BATRACHIA.

## ECAUDATA.

## 1. RANA ESCULENTA, L., var. RIDIBUNDA, Pall.

*Rana esculenta*, Blanford, *tom. cit.* p. 432.

1 (Tadpole) specimen. Quetta to Nushki.

2 specimens. Turbat.

## 2. BUFO VIRIDIS, Laur.

*Bufo viridis*, Blanford, *tom. cit.* p. 434; Boulenger, *tom. cit.* p. 297.

1 specimen. Quetta to Nushki.

2 specimens. Bala-morghab.

Numerous specimens from Tirphul, Karez-badak, Kishmaru.

Numerous Tadpoles from streams at base of Mt. Do-Shakh.

[At Puza-gish I found the Frogs suffering from Leeches attached to them; this Leech, Mr. Jeffrey Bell tells me, is the common one of our own lakes, *Autostomum gulo* (*A. nigrescens*), and that the presence of this species in Lake Baikal has been already signalized by Grube (Sitzungsb. Schles. Gesell. xlix. p. 55), but he does not know that it has ever been reported to attach itself to Frogs.

The above localities extend the area of this species of *Bufo* from Northern Baluchistan to the valley of the Hari-rud, Badghis, and Khorasan.—J. E. T. A.]

## EXPLANATION OF THE PLATES.

## PLATE VIII.

Fig. 1. *Teratoscincus scincus*, Schleg.

Fig. 1 a. " " Upper view of end of snout, enlarged.

Fig. 1 b. " " Side " " "

Fig. 1 c. " " Chin, enlarged.

Fig. 2. *Phrynocephalus olivieri*, D. & B., male.

Fig. 2 a. " " female.

Fig. 3. *Phrynocephalus ornatus*, Blgr. Adult, upper view.

Fig. 3 a. " " " lower view.

Fig. 3 b. " " " upper view of head, enlarged.

Fig. 3 c. " " Half-grown, upper view.

Fig. 4. *Phrynocephalus luteoguttatus*, Blgr. Adult, upper view.

Fig. 4 a. " " " lower view.

Fig. 4 b. " " " upper view of head, enlarged.

Fig. 4 c. " " Half-grown, upper view.

## PLATE IX.

- Fig. 1. *Stenodactylus lumsdenii*, Blgr.  
 Fig. 2. *Agamura persica*, A. Dum. Female.  
 Fig. 2 a. „ „ „ ; chin, enlarged.  
 Fig. 2 b. „ „ Male.  
 Fig. 2 c. „ „ „ ; chin, enlarged.  
 Fig. 3. *Phrynocephalus maculatus*, And.  
 Fig. 4. *Scapteira acutirostris*, Blgr.  
 Fig. 4 a. „ „ Side view of head, enlarged.  
 Fig. 4 b. „ „ Upper „ „  
 Fig. 4 c. „ „ Lower view of posterior part of body, enlarged.

## PLATE X.

*Agama isolepis*, Blgr. Male, female, and young.

## PLATE XI.

- Fig. 1. *Lytorhynchus ridgewayi*, Blgr. With enlarged views of head.  
 Fig. 2. *Naia oxiana*, Eichw. Side views of heads of four specimens.

## FISHES.

By Dr. A. GÜNTHER, F.R.S.,  
 Keeper of the Zoological Department, British Museum.

## 1. CIRRHINA AFGHANA, sp. n. (Plate XII. fig. C.)

D. 13-14. A. 10. L. lat. 40. L. transv. 7/3-4.

One pair of barbels only at the angle of the mouth, which are shorter than the eye. Lower lip transverse, generally covered with a horny substance which forms a sharp edge; the snout is rather obtuse and rounded. Dorsal fin commencing in front of the ventrals, its origin being equidistant between the end of the snout and the root of the caudal fin, and opposite to the twelfth scale of the lateral line; its longest single ray is scarcely longer than the branched rays, but found to be distinctly serrated along its basal portion after the investing skin has been removed. Anal fin narrow and high, extending nearly to the caudal when laying backwards. Caudal fin deeply cleft. There are three or four longitudinal series of scales between the lateral line and the ventral fin, but sometimes the lowermost is not developed; in fact the whole of the abdominal surface, from the isthmus to the vent, is naked or covered with small rudimentary scales only on the sides. The height of the body is contained from three times and four fifths to four times and one third in the total length without caudal; the length of the head rather more than four times. Coloration uniform.

Pharyngeal teeth 4 or 5, 3, 2-2, 3, 4 or 5; compressed, slightly concave on their posterior surface, and very closely adpressed. Gill-rakers extremely small. Intestinal tract with numerous convolutions. Peritoneum deep black.

This species differs in several points from the typical *Cirrhinia*. In the latter the snout is more depressed, and the covering of the lower jaw by horny substance is the exception; of the barbels the upper ones are more frequently developed than the lower; the anal fin has a ray or two less than in the present species, and finally the nakedness of the abdomen is a character by which our species seems to differ from all the others.

Numerous specimens were collected at Nushki (N. Baluchistan), and in the small river at Kushk (N.W. Afghanistan), Badghis; they are all of small size, none of them exceeding 5 inches in length.

## 2. DISCOGNATHUS LAMTA, Hamilton Buchanan.

A considerable number of this common species, which extends from Assam into Abyssinia, were collected on the Helmand River, and in the streams at Kushk (Badghis).

## 3. CAPOËTA STEINDACHNERI.

*Capoëta steindachneri*, Kessler, Ichth. Faun. Turkest. p. 5, tab. 6. figs. 3, 4.

This species, which was discovered by Fedchenko in the Sarafsehan River, has also been met with by the Delimitation Commission at Nushki and Kushk. The larger of the two specimens is five and a half inches long, and the other only half that size.

## 4. SCHIZOTHORAX INTERMEDIUS.

? *Schizothorax intermedius*, McClell. Calc. Journ. Nat. Hist. ii. 1842, p. 579.

*Schizothorax intermedius*, Günth. Fish. vii. p. 165; Day, in 'Second Yarkand Mission,' Ichthyol. p. 5, pl. 2. fig. 1\*.

The Barbels described under this name were found :—

1. By Griffith in the Cabul River at Jellalabad, and in the Tarnuck River;
  2. During the Second Yarkand Mission in Kashgar, Tangihissar, and Sarikol;
- whilst those obtained by Dr. Aitchison came from the River Kushk (Badghis).

\* In consulting this paper, which treats of Fishes of another Central-Asiatic district, I notice two statements which I may correct on the present occasion :—

1. The author proposes to supersede the name which I gave to a species first characterized by me, viz. *Schizothorax biddulphi*, by one of McClelland's, viz. *Schizothorax chrysochlorus*. McClelland gave this name to a rude figure sent by Griffith. Any unbiassed observer who may take the trouble of examining the reduced copy of that figure which McClelland appended to his paper will come to the conclusion that the figure and the name may be applied to more than one species of *Schizothorax*, but that it certainly cannot have been taken from a fish with so small and low a head as *Sch. biddulphi*.

2. On p. 19 the same author states that "the stuffed type [of *Racoma gobioides*] presented to the British Museum from the Indian Museum, seems to have been lost or destroyed." Now there is not a shadow of evidence that a specimen of that fish was among those which were transferred from the Old India Museum to the British Museum. Nay more, McClelland himself states that the specimen of *Racoma gobioides* was one of those which, on account of their bad condition, were not transmitted from India to London (Calcutta Journ. Nat. Hist. ii. 1842, p. 575).

The latter are a skin 13 inches long, not in a good state of preservation, and three young examples in spirit, of not quite half that size. These young specimens agree very well with the types named by McClelland, and show that the strength of the barbed dorsal ray is subject to some variation. The snout is rather produced, and the præ-orbital considerably longer than deep. The anal fin, if laid backwards, does not reach the caudal. One of the specimens has the lower jaw provided with a sharp-edged horny sheath.

The larger example differs in some not unimportant points from the smaller ones; but, partly because it is not in a sufficiently good state of preservation, the snout being shrunk, with a portion of its integuments destroyed, and partly because we are at present entirely ignorant as to the extent to which the species of *Schizothorax* vary, I consider it better to refer it to the same species as the others.

The dorsal spine is very conspicuously more slender, and the anal fin extends somewhat beyond the root of the caudal. But, perhaps, the most significant point of difference is the shape of the præorbital, which is much shorter than in the smaller specimens, only as long as deep, and subtriangular in shape. Nothing can be said about the shape of the mouth and the length of the barbels, so that it would be impossible to characterize the species, if distinct it be, from this specimen.

##### 5. SCHIZOTHORAX RAULINSII, sp. n. (Plate XII. figs. A, B.)

Scales very small, in about 160 transverse series above the lateral line; those of the lateral line are rather larger and more distantly placed, about one hundred in number. There are about thirty-two in a transverse series between the dorsal spines and the lateral line, and about twenty-seven between the lateral line and the root of the ventral fin. Anal scales rather small. Mouth inferior, crescent-shaped, nearly horizontal, as broad as long; upper jaw somewhat projecting beyond the lower (lower jaw without horny sheath in any of the specimens); lower labial fold interrupted in the middle. The barbels, as far as I am able to judge from dried specimens, are about as long as the eye, the upper extending to the front margin, the lower to the hind margin of the orbit. Præorbital twice as long as deep. Origin of the dorsal fin much more distant from the end of the snout than from the root of the caudal fin, and opposite to the root of the ventrals. The osseous dorsal ray is of moderate strength and armed with barbs behind. Anal fin narrow, high, but not extending to the caudal in the adult specimen when laid backwards. The length of the head is rather less than one fourth of the total. The length of the snout exceeds that of the eye, which is one sixth of the length of the head in specimens fifteen inches long, and two ninths in examples of about one third that size. The pectoral equals the length of the head without snout, and terminates at a great distance from the root of the ventral. Caudal fin rather deeply black. Coloration uniform, without spots; sides and lower part silvery.

This description and figure A are taken from a skin fifteen inches long, which Dr. Aitchison obtained on November the 21st in the Hari-rud River, near Khusan, and the characteristics of which I cannot reconcile with any of the descriptions given by Kessler. The species which come nearest to it, like *Schizothorax argentatus*, *affinis*, &c.,

and of which I have specimens before me for comparison, have larger scales, or differ in other respects.

Beside this skin, Dr. Aitchison collected at Bezd, which lies on the Jam River, a tributary of the Hari-rud in Khorasan, Persia, four smaller specimens, from four to five inches long (fig. B), which I am inclined to refer to the same species; they must have been caught about spawning-time (15th of June, 1885), as they are covered with granules of melanotic matter.

#### 6. GOBIO GOBIO, L.

*Gobio fluviatilis* (Flem.), var. *lepidolemus*, Kessler, in Mém. Soc. d'Hist. Nat. Mosc. x. p. 15; and Ichthyology of Turkestan, p. 19.

One specimen from Kushk (Badghis).

#### 7. NEMACHILUS KESSLERI, sp. n.

D. 9. A. 7.

Scaless. Caudal fin emarginate. The origin of the dorsal fin is nearly midway between the root of the caudal and the end of the snout, and opposite to the base of the ventral. The height of the body is one eighth, and the length of the head two elevenths of the total length without caudal. The free portion of the tail is moderately broad, its width being rather more than one half of its length. Eye small, one eleventh of the length of the head. Snout shorter than the postorbital portion of the head. Pectoral not quite as long as the head, half as long as the distance of its root from the ventral. Upper margin of the dorsal fin oblique, straight, with the upper corner slightly rounded. The markings of the body are rather indistinct, and concentrated on the back into twelve somewhat irregular cross bands. A deep black spot on the base of the three anterior dorsal rays, the upper part of the fin ornamented with one or two series of black specks running parallel to the upper margin of the fin. Caudal fin with a narrow blackish cross band on the root and with two more or less indistinct, oblique, series of black specks.

Eight specimens were collected at Nushki, of which the largest is only twenty-eight lines long.

#### EXPLANATION OF PLATE XII.

Figs. A, B. *Schizothorax rautinsii*.

Fig. C. *Cirrhina afghana*.

## ARACHNIDA, CHILOPODA, and CRUSTACEA.

By R. I. Pocock,

Assistant in the Zoological Department, British Museum.

So far as it is possible to judge from the small number of specimens of the above-mentioned groups of Arthropoda that were brought home by Dr. Aitchison from the north-western border-land of Afghanistan, the fauna of the localities examined is more nearly related to the fauna of the Mediterranean district of the Palæartic Region than to that of any other area. It is true that nearly fifty per cent. of the species are new; but although new, they are allied to species that inhabit the basin of the Mediterranean; while those that are not new are referable to species that have been recorded from various parts of that district.

### ARACHNIDA.

#### ARANEIDEA.

##### 1. ARGIOPE LOBATA (Pallas).

*Argiope lobata*, Pallas, Spicil. Zool. i. p. 46, pl. iii. figg. 14, 15; Thorell, Remarks on Synonyms of European Spiders, p. 520.

A single female specimen between Hari-rud valley and Meshed.

##### 2. TARANTULA MEDICA, sp. n. (Plate XIII. fig. 1 *a*.)

*Cephalothorax* covered with greyish-green pubescence on its upper surface and bordered with a thick line of white hairs; the posterior half of the upper surface with a median longitudinal white band. Upper surface of the legs white; under surface of tarsus and of metatarsus of all the legs brown; under surface of the tibia of the anterior two pairs brown, of the posterior two pairs white; under surface of the femora of the posterior three pairs white; apex of palpi brown. Under surface of the femora of the first pair of legs white or yellow; upper surface of the palpi and of the falcæ and the region of the anterior eyes yellow. Sternum and the under surface of the coxæ white. Under surface of abdomen yellowish white; sides white, with blackish spots. On each side of the median dorsal line there is a series of oblique short white bands; in the hinder third of the abdomen the posterior end of each of the bands upon one side is connected with the posterior end of the corresponding band upon the other side by a straight white line; ground-colour of the upper surface of the abdomen greyish green.

In alcohol, when the pubescence which clothes the cephalothorax and limbs is obscured, the colour of these parts may be described as follows:—

Cephalothorax castaneous; falcæ castaneous or black; palpi ochraceous, with apical segments darker; legs castaneous above, ochraceous below, the colour becoming darker upon the distal segments; sternum and coxæ ochraceous; labium and maxillæ castaneous at the base, ochraceous towards the apex.

*Adult ♂.*—*Cephalothorax.* Thoracic portion wide, ovate, cephalic portion narrowed, its width being about equal to half the width of the thoracic portion; height of cephalic portion less than its greatest width. Anterior series of eyes procurved; the four eyes about equally separated; the two median the largest. Space between the second eyes less than the diameter of each eye. Eyes of the third series smaller than those of the second, and separated from them on each side by a space which is equal to the diameter of one of the posterior eyes. Cephalothorax equal in length to the patella and tibia of the third pair of legs; shorter than patella and tibia of first pair of legs. Femora armed with eight or nine spines above; patellæ armed with two spines, one in front, the other behind. Chelicerae furnished distally with two or three teeth in front and three behind. Tibial segment of palp simple, cylindrical; tarsal segment proximally thicker than the tibial, distally elongate and attenuate; half as long again as the tibial segment; bulbous portion bearing two teeth—one internal, directed forwards, bifid; the other external, simple, and directed backwards.

*Measurements* (in millimetres).—Total length 22; length of cephalothorax  $13\frac{1}{2}$ , width 10, width of cephalic portion  $5\frac{3}{4}$ , height  $4\frac{3}{4}$ ; length of chelicera  $5\frac{1}{8}$ , width  $2\frac{3}{4}$ ; sternum, length  $5\frac{3}{4}$ , width  $4\frac{3}{4}$ ; length of first leg  $52\frac{1}{2}$ , of second  $51\frac{1}{2}$ , of third  $46\frac{1}{2}$ , of fourth 57; of palp 16.

*Adult ♀.*—Differs from the male in being more robust; cephalic portion considerably higher; legs shorter (*cf.* measurements). Epigyne nearly circular, covered laterally and in front with hairs; posterior border prominent, rounded; marked with an elongate depression; the side margins of this depression nearly parallel; in front blending circularly and without constriction; behind terminating before reaching the posterior margin of the plate in a rounded prominence.

*Measurements* (in millimetres).—Total length 28; length of cephalothorax 16, width 11, cephalic portion, width  $7\frac{1}{2}$ , height  $5\frac{3}{4}$ ; length of chelicera 7, width  $3\frac{1}{2}$ ; sternum, length  $6\frac{1}{2}$ , width 5; length of first leg 47, of second  $46\frac{1}{2}$ , of third  $43\frac{1}{2}$ , of fourth  $53\frac{1}{2}$ .

The cephalothorax equal in length to the patella and tibia of first pair of legs, longer than patella and tibia of third pair.

Three specimens (one ♂ adult, two ♀, one adult, one immature) taken between Tirphul and Meshed in Persia.

In the adult specimens the white colour of the abdomen is more pronounced, so that the ground-colour of this part appears to be white with darker markings.

This species appears to be closely allied to *Tarantula alticeps* (Kronenberg, in Fedchenko's 'Turkestan,' Arachnida, p. 40, pl. iv. fig. 28); but according to the figure of the last named the central eyes of the anterior series are equal to the lateral eyes of the same series; moreover the epigyne has a different form.

[At Kalla-i-dast-dargarri, June 8th, amongst the brick débris of the old buildings, and running in and out of the clay fissures in the soil, this Spider occurred in large numbers, much to the horror of the natives—the Afghans and Persians holding it in great fear, as, they say, should it drop any of its excreta on the skin, the result is acute erysipelas, usually ending in death.—J. E. T. A.]

3. *DYSDERA CONCINNA* (L. Koch).

*Dysdera concinna*, L. Koch, *Kauk. Arachn.*, in *Isis*, Dresden, p. 43 (1878).

One specimen (♀) between Hari-rud valley and Meshed.

In this specimen the legs appear to be less hairy than in the one described by L. Koch; otherwise the two seem to be alike. There is a resemblance also between it and *Dysdera aculeata* (Kronenberg, in Fedchenko's 'Turkestan,' *Arachn.* p. 25, pl. iii. fig. 17), of which the male only was known; and I am disposed to think that the two may be sexes of the same species. But the spine-armature of the patellæ is different in the two forms. Thus Kronenberg's type has four spines on the outer and two on the inner side of all the patellæ, while this Afghan specimen, which I refer, though with some hesitation, to *D. concinna* of L. Koch, has no spines upon the patellæ of the first two pairs, three upon the outer and two upon the inner of the third pair, and three upon the outer and one upon the inner of the fourth pair.

4. *NEMESIA TUBIFEX*, sp. n. (Plate XIII. fig. 2.)

*Colour*.—Cephalothorax and legs castaneous; chelicerae darker; sternum and coxæ ochraceous; abdomen testaceous, ornamented above with a somewhat purplish band, which at the hinder end of the body narrows to a point and breaks up into five short, oblique bands.

*Cephalothorax* ovate, with anterior border truncate, posterior border rounded laterally, triangularly excised in the middle line. The transverse sulcus is straight and not convex forwards as in *N. cæmentaria*. Cephalic portion sharply defined by lateral grooves, somewhat high and rounded. Width of cephalothorax equal to about three quarters of its length. Anterior central eyes about as widely separated from each other as they are from the anterior lateral eyes, circular and situated slightly behind the line of the anterior lateral eyes; anterior lateral eyes the largest of the series, somewhat ovate; the posterior two eyes on each side small, circular, set close together behind the anterior lateral eyes.

*Appendages*.—Chelicerae projecting forwards; constricted above close to margin of clypeus; clothed above with shorter and finer hairs, which below anteriorly become longer and coarser, and ultimately pass into a series of long spines which overhang the proximal end of the fang; fang slender, curved, unarmed. *Maxillæ* clothed in front with long hairs, and furnished proximally on the inner side with many small, black, blunt, close-set teeth. Upper surface of palp nearly naked, under surface clothed more or less sparsely with long hairs intermixed with fewer spines; apical segment thickly clothed beneath with short, close-set hairs. First leg the longest, third the shortest, second and fourth approximately equal in length; upper surface of legs for the most part naked, under surface scantily clothed with hairs interspersed with spines; tarsi thickly clothed below with short close-set hairs; the four distal segments of the third pair of legs clothed with hair, which is particularly abundant upon the patella and tibia, patella and distal end of femur of fourth pair anteriorly clothed thickly with hairs; meta-

tarsi of the first and second pairs furnished beneath with several strong spines; tibia and metatarsus of the fourth pair of legs about equal in length.

Labium rounded, clothed in front with long hairs; coxæ of all the legs beset with coarse hairs; sternum longer than wide, wider in its posterior than in its anterior half.

*Measurements* (in millimetres).—Length (from margin of clypeus to end of abdomen)  $19\frac{1}{2}$ ; of cephalothorax 8, width  $6\frac{1}{4}$ ; length of sternum  $4\frac{1}{4}$ , width  $3\frac{3}{4}$ ; length of legs (with coxæ), first  $22\frac{1}{4}$ , second  $19\frac{1}{4}$ .

One female specimen from Gulran.

With respect to the equality in length between the tibia and metatarsus of the fourth pair of legs, this species resembles *N. badia* and *N. macrocephala*, described respectively from Corsica and Palermo by Ausserer (Verh. k.k. zool.-bot. Ges. Wien, xxi. p. 166, &c., 1871). From *N. badia* it may be distinguished by the existence of the small teeth upon the maxilla, and from *N. macrocephala* by the entire absence of spines upon the tarsi of the first and second pairs of legs.

[This Spider was found in numbers over the plains of Gulran (4th March, 1885). The entrance to its abode, consisting of a well-defined inlet about three quarters of an inch in width and without a cover, was easily seen; this was the aperture into a passage that led perpendicularly down into the soil to a depth of eighteen inches; this passage was lined with a very thin layer of a grey silk web, only of sufficient consistency to prevent the soil, which was a soft, sandy loam, from falling in and filling up the passage. The Spider was caught at the bottom of the passage, which ended abruptly, by dropping in a piece of stick the length of the tube, and then digging away the soil round it until the end of the passage was reached.—J. E. T. A.]

#### SCORPIONIDEA.

##### 5. BUTHUS PARTHORUM, sp. n. (Plate XIII. fig. 3.)

*Colour*.—Cephalothorax and abdomen fusco-testaceous; legs testaceous, palpi and tail a little darker than the legs. Eyes and hinder half of aculeus black; cephalothoracic and abdominal keels dark-coloured.

*Cephalothorax*.—Anterior border lightly concave, wider posteriorly than it is long; about twice as wide behind as it is in front; the arrangement of the keels almost resembling that of *B. peloponnensis*, C. Koch (*gibbosus*, Brullé), the granules of the anterior keels extending from the hinder portion of the ocular tubercle to the anterior margin of the cephalothorax; near the anterior border the granules decrease in size, and curving inwards meet in the middle line with those of the opposite side. The eyes are a little more widely separated than in *B. peloponnensis*, and this circumstance, in connection with the confluence in front of the granules on each side, constitutes the most noticeable difference between these anterior keels and those of *B. peloponnensis*. The area surrounded by these keels is almost smooth behind, but in front is beset with very fine granules. The area between the anterior half of each anterior keel and the lateral eyes of the same side is beset, but not closely, with granules; and behind and externally to this granular area

are two parallel rows of granules which run obliquely backwards in the direction of, but failing to reach, the median eye.

The posterior keels, slightly converging in front, are almost continuous and in the same straight line with the internal middle keels; this slight want of continuity between these two keels gives to them, when considered as one, a slightly sinuous appearance. The area which is defined laterally by these keels, and anteriorly by a transverse offshoot of granules from their anterior extremities, is depressed towards the middle line, finely and sparsely granular for the most part, but quite smooth just in the middle; this last-mentioned smooth portion stretches from the ocular tubercle nearly to the hinder margin of the cephalothorax, where it breaks up into a right and left branch; each branch, extending towards the posterior angle of the intercarinal area, constitutes with the median branch a T-shaped depression. The granules of the external middle keels are well marked, but the posterior extremity of each is not connected by a conspicuous transverse row of granules with the anterior extremity of the posterior keel of its side. The hinder half of the cephalothorax is externally granular.

*Tergites*.—Finely granular in the intercarinal and extracarinal spaces, the anterior six provided posteriorly with three finely but bluntly denticulated keels. The keels, which are very short on the first tergite, increase progressively in length, height, and coarseness of granulation from before backwards; lateral keels slightly diverging in front, and becoming almost obsolete, as, curving outwards, they pass insensibly into the granules of the lateral portions of the tergites. The median keel of the seventh abdominal tergite present only on the anterior half of that plate, the lateral keels not reaching the hinder margin of the tergite.

*Sternites*.—First abdominal sternite marked with a few conspicuous punctures; the second, third, and fourth marked in the middle of the plate on each side of the middle line with one puncture; between these punctures there is a shallow depression; the fourth sternite furnished on each side with two low keels,—one, smooth, running from the median puncture to the posterior margin; the other, finely granular, running from the inner end of the pulmonary aperture to the posterior margin. Fifth abdominal sternite furnished with four granular keels,—two lateral, in the middle of the plate, falling short of both the anterior and posterior margins, two median and parallel situated on the hinder two thirds of its length. Between the last-named keels the sternite is smooth; the rest of it is very finely granular.

*Tail* slender and long, more than five times as long as the cephalothorax, and more than one and a half times the length of the trunk, thicker at the base than at the apex. First segment with ten complete, finely and almost evenly denticulated keels; the median inferior intercarinal space smooth; the other intercarinal spaces finely and sparsely granular, the spaces becoming slightly more granular from below upwards; superior surface shallowly excavated. The second segment has the median lateral keel incomplete in front; the intercarinal spaces are almost wholly smooth, and the upper surface is less deeply excavated than in the preceding segment; the keels are evenly and finely denticulate. In the third segment the median lateral keel is absent, its place being taken by a few minute granules; the keels are evenly and finely denticulated, the superior

surface less deeply excavated than in the second segment, and the intercarinal spaces very finely and sparsely granular. The fourth segment differs from the third almost as the third does from the second and the second from the first. The fifth segment not excavated above; lateral margins of upper surface irregularly granular, or finely and bluntly denticulated in front, the granules or denticles becoming smaller behind and disappearing before reaching the posterior angle of the upper surface of the segment; lateral surface very finely and sparsely granular. The denticles of the inferior lateral keels small, but larger than those of any other keel in the tail; the denticles are blunt, vary slightly in size, and increase gradually in size from before backwards. The keels gently curved, the distance between them in front equal to the distance between them behind; but they are more widely separated in the middle of the segment. The inferior surface is divided by a complete, median, finely, bluntly, and evenly denticulated keel, between which and the lateral keels are some very fine granules and a few small tubercles. The posterior border of this surface finely and bluntly denticulated, the posterior lateral lobe of this segment undivided, but slightly roughened beneath. Vesicle oval, slender, only as wide as the distance between the posterior ends of the inferior lateral keels of the fifth segment of the tail; much narrower than the middle of the segment; granular beneath. Aculeus long, slender, gently curved; vesicle and aculeus equal in length, together as long as the fifth caudal segment.

*Chela*.—Upper surface of humerus very finely granular, bounded in front and behind by a series of blunt denticles; anterior surface bounded below by a series of denticles, and divided into an upper smooth, and a lower finely granular area, by a row of widely separated larger denticles, between which are smaller granules. Inferior and posterior surfaces finely granular, but not sharply separated from each other. Upper surface of brachium furnished with two granular keels; the anterior surface also has two granular keels; at the proximal end of each keel is a larger denticle; the inferior surface also has two granular or merely roughened keels; the posterior surface is smoothly costate, and all the intercarinal spaces of the segment are smooth. *Manus* rounded, smooth, wide, considerably wider than brachium; length of the “hand-back” greater than width of the hand. Dactyli long, slender, gently curved; the movable dactylus furnished proximally with a conspicuous lobe, which fits into a corresponding excavation in the immovable dactylus. Length of the “hand-back” equal to half the length of the movable dactylus.

*Legs*.—External surfaces furnished with granular keels; internal surfaces smooth. Three distal segments hairy; margins of coxal segments finely granular.

*Pectines* not projecting beyond the distal margins of the posterior coxæ; number of teeth 22 and 23.

*Measurements* (in millimetres):—

	Length.	Breadth.	Height.
Total . . . . .	71		
Cephalothorax . . . . .	$8\frac{1}{4}$	9	
Tail. . . . .	$11\frac{1}{2}$		
First caudal segment . . . . .	5	5	$1\frac{1}{4}$

	Length.	Breadth.	Height.
Fifth caudal segment . . . . .	$9\frac{1}{4}$	4	$3\frac{1}{2}$
Vesicle . . . . .	5	3	3
Aculeus . . . . .	5		
Humerus . . . . .	$6\frac{1}{2}$		
Brachium . . . . .	8	$3\frac{1}{4}$	
Manus . . . . .	6	4	$3\frac{1}{4}$
“Hand-back” . . . . .	$4\frac{1}{2}$		
Movable dactylus . . . . .	9		
Immovable dactylus . . . . .	$7\frac{3}{4}$		
Pecten . . . . .	$6\frac{1}{4}$		

A single specimen, probably a male, was taken between Hari-rud valley and Meshed.

This *Buthus* presents affinities with several species known to me, but appears to be different from all hitherto described. Perhaps its most noticeable peculiarity is the entire absence of keels and of a median depression on the upper surface of the fifth caudal segment—a peculiarity by which it may be recognized at a glance from such forms as *B. martensii* (Karsch) and *B. confucius* (Simon). With *B. arenicola* (Simon, Arachnides, Expl. Sci. Tunisie, p. 51, 1885), however, it is with respect to the form of this caudal segment that *B. parthorum* appears to be allied; for in *B. arenicola* this segment is said to be “*supra lævi, hand canaliculato, nec costato.*” But the cephalothoracic and caudal costæ are much less strongly developed in the Tunisian form.

Four species of *Buthus* have been recorded from the Caucasus. These are *B. eupæus* (C. Koch, Die Arachn. v. p. 127, fig. 418), *B. cognatus* (L. Koch, Kauk. Arachn. in Isis, Dresden, p. 58, pl. i. fig. 7), *B. caucasicus* (Nordmann, Voy. Russ. mérid. iii. p. 731, pl. i. fig. 1), and *B. ornatus* (Nordmann, *tom. cit.* p. 732, pl. i. fig. 2). Although analogy would perhaps lead us to expect to find a greater amount of similarity existing between the Afghan and the Caucasian species than between the Afghan species and those of any other locality, no such similarity can be traced. For *B. parthorum* may be at once separated from the above-mentioned species by sundry well-marked characters. For instance, in *B. eupæus* the fifth caudal segment appears to be without denticulations, and the vesicle is thick, with the aculeus curved and short; in *B. cognatus* the infero-lateral keels of this same caudal segment are in part strongly dentate, while in both *B. caucasicus* and *B. ornatus* the aculeus is remarkably short; the former, in addition, has thirty pectinal teeth, and the latter the complete supernumerary series of granules on the fourth caudal segment, as in *B. gibbosus* (Brullé).

#### 6. BUTHUS AFGHANUS, sp. n. (Plate XIII. fig. 4.)

This species is so nearly allied to *B. europæus*, Linn. (= *occitanus*, *tunetanus*, of authors), the common and well-known S. European and N. African form, that perhaps a comparison between the two will serve as a satisfactory diagnosis of it.

*Cephalothorax*.—Anterior keels as in *B. europæus*; the space between them quite smooth. Posterior keels converging in front, sinuous, and in contact with the posterior termina-

tions of the internal intermediate keels, and not connected by means of a conspicuous transverse series of granules with the external intermediate keels. All the keels less pronounced than in *B. europæus*.

*Tergites*.—Anterior six bearing three keels. In all the specimens of *B. europæus* that I have seen, the lateral keels are absent on the first, and absent or nearly so on the second tergite. But in *B. afghanus* they are clearly expressed on both the first and the second.

*Sternites* as in *B. europæus*.

*Tail* as in *B. europæus*, the inferior keels of the second and third segments and the infero-lateral keels of the fifth being dentate in the manner which is so characteristic of that species.

*Chela*.—Humerus and brachium as in *B. europæus*, but the terminal segments are very different. The *manus* is thicker, and the dactyli considerably shorter, the immovable dactylus being only about the length of the "hand-back." Moreover, this dactylus is furnished with a deeper basal excavation for the reception of a larger lobe on the movable dactylus.

Two specimens, probably males, between Hari-rud valley and Meshed.

In spite of the many points of resemblance between this species and *B. europæus*, three well-marked differential characters can be made out for it:—(1) The posterior thoracic keels converge and join the internal intermediate keels; (2) the first two tergites are tricarinate; (3) the "hand-back" is almost equal in length to the immovable dactylus.

The resemblance between the two species is most noticeable in the structure of the tail.

*Measurements* (in millimetres) of the type specimen:—

	Length.	Breadth.	Height.
Total . . . . .	37		
Cephalothorax . . . . .	5 $\frac{3}{4}$		
Tail . . . . .	29		
Manus . . . . .	5	3 $\frac{1}{4}$	2 $\frac{3}{4}$
"Hand-back" . . . . .	4 $\frac{1}{4}$		
Movable finger . . . . .	5 $\frac{1}{4}$		
Immovable finger . . . . .	4 $\frac{1}{4}$		

#### Genus ORTHODACTYLUS.

*Orthodactylus*, Karsch, Berl. ent. Zeits. xxv. p. 90 (1881).

*Butheolus*, Simon, Ann. Mus. Genov. xviii. p. 218 (1883).

#### 7. ORTHODACTYLUS SCHNEIDERI (L. Koch). (Plate XIII. fig. 5.)

*Buthus schneideri*, L. Koch, Naturw. Beitr. Kennt. Kaukasusländer-Kaukasische Arachnoideen, p. 61 pl. ii. fig. 4, in Isis, Dresden, 1878.

*Orthodactylus olivaceus*, Karsch, *tom. cit.* p. 91.

*Butheolus aristidis*, Simon, *tom. cit.* p. 258, pl. viii. fig. 23.

This synonymy was made out by Dr. Karsch (Berl. ent. Zeits. xxx. p. 76, 1886), and is here reproduced.

One specimen, taken between Hari-rud valley and Meshed.

This Scorpion appears to have a very wide range. The localities hitherto known for it are Sicily (*Karsch*), Nubia (*Simon*), Caucasus (*L. Koch*). And in addition to the specimen now recorded from Afghanistan, the British Museum possesses others from Egypt and Baghdad.

The width of the tail of this species varies considerably with the size of the individual, being narrower in small, wider in large specimens.

#### SOLPUGIDEA.

##### 8. *GALEODES ARANEOIDES* (Pallas).

*Galeodes araneoides*, Pallas, Spicil. Zool. ix. p. 37, pl. iii. figg. 7, 8, 9 (1772); Simon, Ann. Soc. Ent. Fr. (5), ix. p. 99 (1879).

A single specimen (male) between Roznak and Shabad.

According to Simon this species ranges from Persia and the Caucasus through Egypt to Nubia and Algeria.

[This Spider was caught at Roznak on the 5th June, 1885, in the branches of a bush. Its size and the remarkable appendages, shaped like small mushrooms, situated in a row along the lower surface of its posterior pair of legs, drew attention to it.—J. E. T. A.]

##### 9. *RHAX AUREA*, sp. n. (Plate XIII. fig. 6.)

Head-plate above ochraceo-fuscous, with a paler band running from the ocular tubercle to the posterior margin; at the sides testaceous; not sulcate; clothed with pale hairs; ocular tubercle prominent, black. Chelicerae clothed with pale hairs, testaceous proximally and becoming rufous towards the distal extremity; digits perfectly black. The movable digit with or without a minute denticle in front of the principal tooth, which is furnished on the inner side with the usual hairs; the fixed digit with two smaller teeth, or with only one, in front of the largest tooth. Behind the largest tooth there is an external series consisting of six smaller teeth, subequal in size, except for the penultimate, which is smaller and placed slightly on the inner side. The posterior internal series consists of two larger teeth in front, between which there may or may not be a smaller accessory tooth and one behind. The posterior border of the digit is furnished with one, two, or even three minute teeth. The inner surface of each chelicera is furnished with hairs interspersed with spines.

Maxillary palp testaceous, the tarsus and the proximal portion of the metatarsus only being rufous. The whole limb bearing longer and shorter pale-coloured hairs; the metatarsus armed beneath with spines in addition to the hairs; tarsus not armed with spines. First pair of feet testaceous, hairy; metatarsus furnished with darker hairs; tarsus rufous. Tibiæ of second and third feet armed above distally with a single spiniform tooth; metatarsi of the same feet armed above with a series consisting of five, six, or seven similar spiniform teeth. The fourth leg not armed above, as are the foregoing two.

Thoracic segments and abdomen entirely dirty white, although the colour of the cuticle of the abdomen may be obscured by the colour of its contents.

*Measurements* (in millimetres) of *largest specimen*.—Total length 62; length of head-plate 5, width 10; length of chelicera 12, width  $4\frac{1}{4}$ ; length of tarso-metatarsus of maxillary palp 7, of tibia 6, of femur  $7\frac{1}{2}$ .

Two gravid females between Hari-rud valley and Meshed.

One of the specimens is slightly smaller than the other, with the head-plate ochraceous and not fuscous. Moreover, it presents another feature by which it may be recognized, not only from the specimen with which it was captured, but, to the best of my belief, from all specimens of *Rhax* hitherto examined. This peculiarity, the importance of which, owing to lack of material, it is impossible to estimate, is the presence of a third and median seta occupying a position on the ocular tubercle midway between the two setæ which have been considered so important a characteristic of this genus and others. All the specimens of *Rhax* that have been described have possessed two and only two ocular setæ; yet inasmuch as these two Afghan individuals are so like each other in all those features which have been found to be of value for the determination of the species of this genus, I am unwilling to consider the smaller as specifically distinct from the larger on the strength of the existence of this median hair. Therefore, until the constancy of the occurrence of this seta can be tested by the examination of a number of individuals, it can only be looked upon as an abnormal development.

The species of *Rhax* are mostly rendered conspicuous by their colours; and this species may be at once recognized from others by its entirely white abdomen.

#### ACARIDEA.

##### 10. HYALOMMA GROSSUM (C. Koch).

*Hyalomma grossum*, C. Koch, Arch. f. Naturg. x. i. p. 220; id. Uebersicht des Arachnidensystems, iv. pl. ii. fig. 8.

Two specimens (♀) taken from a camel, between Hari-rud valley and Meshed.

#### CHILOPODA.

##### 11. SCOLOPENDRA TRUNCATICEPS, sp. n. (Plate XIII. fig. 7.)

Ochraceous or testaceous, the dorsal plates of the anterior and central portions of the body slightly olivaceous.

Antennæ composed of 19 segments, of which the four distal are bare, the rest very faintly pubescent.

Head-plate pentagonal, with straight posterior margin, meeting but not covering the anterior portion of the first dorsal plate; marked in its posterior half by two very faint anteriorly diverging sulci, not punctured. Width equal to width of last dorsal plates.

Prosternal plates of the maxillary sternum almost in contact; each plate furnished with four teeth, of which the three internal exhibit various grades of conerescence. Basal tooth simple or very slightly denticulated.

Dorsal plates, except the first and last, bisulcate; the last seven or eight with raised

lateral margins, the anterior thirteen or fourteen with simple unraised lateral margins. The first dorsal plate not marked with a transverse groove. The last dorsal plate marked with a median longitudinal sulcus.

The ventral plates, except the first and last, bisulcate; the last with slightly converging lateral margins, rounded posterior angles, and straight posterior margin; not marked with central sulcus or depression.

Anal pleuræ somewhat coarsely punctured, and furnished with a spine on the posterior margin near the dorsal plate; pleural process well developed, furnished with three stronger spines at the apex, and with two or one weaker spine nearer the base.

Femora of all the legs, except those of the 21st somite, unarmed; first tarsal segment of all the legs, except those of the 20th and 21st somites, armed with a spur; claws of all the legs, except those of the 21st somite, furnished distally with two spurs.

Femora of anal legs furnished with from 15 to 23 spines, not including those of the process. But since these spines vary both in number and position in the two specimens examined and upon the two sides of either of the specimens, their arrangement is, in this case, of but little specific value. Femoral process short, obtuse, and armed at the apex with from 2 to 5 spines.

Patella of anal leg unarmed.

Length of larger specimen 57 millim.

Two specimens of this species were taken, between Hari-rud valley and Meshed, Afghanistan.

In the collection of the British Museum there is a specimen from Bussora in which the spines of the anal femora are fewer in number and more regularly arranged than in the Afghan specimens. Their arrangement may be thus described, regarding them as set in longitudinal series:—2. 3 on the upper inner margin, 1 in the posterior portion of the inner surface, 4 or 3 in an irregular line upon the under inner margin, 3. 2 on the under outer.

## 12. HIMANTARIUM TENIATUM (Meinert). (Plate XIII. fig. 8.)

*Himantarium teniatum*, Meinert, Vid. Medd. nat. Foren. 1886, p. 149.

*Geophilus barbaricus*, Newport, Trans. Linn. Soc. xix. p. 437 (1845).

Nec *G. barbaricus*, Gervais, Mag. Zool. ix. pl. 133. fig. 3 (1835).

Between Hari-rud valley and Meshed. One specimen.

Dr. Newport appears to have fallen into error in referring to *G. barbaricus* (Gerv.) a specimen of *Geophilus* belonging to the British Museum. For Gervais (Aptères, iv. p. 325), when speaking of his species, says:—“*Le dessous sans pore sécréteur médian et marqué près de son bord externe d'une simple ligne longitudinale.*” But the specimen named by Newport has a conspicuous median porous area on each sternite (with the exception of the first and last), and, in addition, upon some of them a well-marked elliptical depression, which could scarcely have escaped Gervais's attention. In fact, the specimen named *Geophilus barbaricus* by Newport agrees well with the description of a specimen named *Himantarium teniatum* by Meinert, and I have consequently no doubt that the two are specifically identical.

The species is widely distributed. Newport's specimen was from Barbary; Dr. Meiner's from Egypt; and in addition to this Afghan specimen the British Museum possesses others from Smyrna, Bushire, and Karachi.

## CRUSTACEA.

## 13. HEMILEPISTUS KLUGII (Brandt).

Of this Isopod several examples, which were identified by the Rev. A. E. Eaton, were taken between Mnskü and Bala-morghab.

## 14. GAMMARUS PULEX (Linn.).

Specimens of this wide-ranging Amphipod were taken in the streams leading from Do-Shakh in Afghanistan.

## EXPLANATION OF PLATE XIII.

Fig. 1. *Tarantula medica*, sp. n., ♀ young, nat. size.

1 a. Ditto, ♀ adult, nat. size.

1 b. Ditto, ♂ adult, nat. size.

1 c. Ditto, face, enlarged.

1 d. Ditto, sternum, enlarged.

1 e. Ditto, epigyne, enlarged.

1 f. Ditto, palp of ♂ from below.

1 g. Ditto, palp of ♂ from the side.

2. *Nemesia tubifex*, sp. n., ♀, nat. size.

2 a. Ditto, ♀, nat. size (lateral view).

2 b. Ditto, chelicere, enlarged.

2 c. Ditto, sternum, enlarged.

2 d. Ditto, eyes, enlarged.

3. *Buthus parthorum*, sp. n., cephalothorax,  $\times 1\frac{1}{2}$ .

3 a. Ditto, manus,  $\times 1\frac{1}{2}$ .

3 b. Ditto, extremity of tail,  $\times 1\frac{1}{2}$  (lateral view).

3 c. Ditto, from below.

4. *Buthus afghanus*, sp. n., cephalothorax.

4 a. Ditto, manus.

4 b. Ditto, extremity of tail.

5. *Orthodactylus schneideri*, under surface of tail.

6. *Rhax aurea*, sp. n.: ocular tubercle with abnormal seta.

7. *Scolopendra truncaticeps*, sp. n.; anal somite from below.

7 a. Ditto, anal somite from above.

7 b. Ditto, prosternal teeth.

8. *Himantarium taeniatum*, head from above.

8 a. Ditto, head from below.

8 b. Ditto, anal somite from below.

8 c. Ditto, sternite of 50th somite.

## COLEOPTERA.

By C. O. WATERHOUSE,  
Assistant in the Zoological Department, British Museum.

### GEODEPHAGA.

1. *DICTES LEHMANNI*, Ménétr. Mém. Ac. Pét. 1849, p. 25, pl. i. f. 7.  
A local species, originally described from Kisil Koum.  
*Hab.* Badghis.

### HYDRADEPHAGA.

2. *CYBISTER TRIPUNCTATUS*, Oliv. Ent. iii. 1795, 40, p. 14, pl. 3. f. 24.  
A widely distributed Asiatic species.  
*Hab.* Hot spring, Tor-shakh, Badghis.

### PALPICORNIA.

3. *HYDROPHILUS CARABOIDES*, Linn. Faun. Suec. no. 214.  
A European species.

### LAMELLICORNIA.

#### SCARABÆIDÆ.

4. *SCARABÆUS SACER*, Linn. Syst. Nat. i. 2, p. 545.  
*Hab.* Hari-rud valley.
5. *HOMALOCOPRIS TMOLUS*, Fischer, Ent. Ross. i. p. 141, t. 13. f. 1.  
A local species, originally described from Kirgis.  
*Hab.* Badghis.

#### MELOLONTIIDÆ.

6. *LACHNOSTERNA*, sp.

A testaceous yellow species, with pitchy yellow head, thorax, and legs; about an inch long, shining; the thorax closely and rather finely punctured; the elytra moderately, closely, and finely punctured, with the usual costæ rather broad.

Two examples, male and female.

*Hab.* Badghis.

[This species was frequently found in the Badghis, stuck on thorns, the store of one of the numerous Butcher-birds.—J. E. T. A.]

#### RUTELIDÆ.

7. *ADORETUS*, sp.  
*Hab.* Badghis.

## CETONIIDÆ.

These are all European forms.

8. *TROPINOTA SQUALIDA*, Linn. Syst. Nat. i. 2, p. 556.

*Hab.* Badghis.

9. *OXYTHYREA STICTICA*, Linn. Syst. Nat. i. 2, p. 552.

*Hab.* Hari-rud valley.

10. *CETONIA FLORALIS*, Fabr. Mantissa, i. p. 31.

*Hab.* Persia; Hari-rud valley.

11. *CETONIA ARMENIACA*, Ménétr, Cat. Rais. p. 190.

*Hab.* Badghis and Hari-rud valley.

12. *CETONIA*, sp.

A single specimen of a species allied to *C. armeniaca*, but smaller (7 lines long), black, with a few white marks. ♦ This is possibly a new species, but I cannot venture to describe it from a single example.

*Hab.* Hari-rud valley.

## SERRICORNIA.

## BUPRESTIDÆ.

13. *JULODIS LÆVICOSTATA*, Gory, Mon. iv. p. 16, pl. 3. f. 14.

*Hab.* Persia; Hari-rud valley.

A Persian species.

14. *JULODIS EUPHRACTICA*, Cast. & Gory, Mon. i. p. 18, pl. 6. f. 25.

*Hab.* Hari-rud valley, Badghis, and Persia.

[Was collected on willow-branches, flying over the high walls surrounding the orchards, and lighting on the top branches of a willow, in preference to other trees. Was chiefly noticed at Turbat-shaikh-jami, Khorasan.—J. E. T. A.]

15. *JULODIS VARIOLARIS*, Pall. It. i. 1773, p. 464; Ic. p. 63, t. D. f. 2.

*Hab.* Badghis, Persia, and valley of Hari-rud.

A South-Russian species.

[This very handsome Beetle was local, and only captured when seen flying off a bush and then ridden down. It may be common enough, but is very difficult to detect, owing to its colouring.—J. E. T. A.]

16. *CAPNODIS MILIARIS*, Klug, Symb. Phys. Bupr. 15, t. 2. f. 1.

*Hab.* Badghis, Persia.

A Persian species.

17. *CAPNODIS TENEBRIONIS*, Linn. Syst. Nat. i. 2, p. 661.

*Hab.* Persia.

A South-European species.

HETEROMERA.

TENEBRIONIDÆ.

ERODIINÆ.

18. *SPYRATHUS POLITUS*, sp. n. (Plate XIV. fig. 1.)

Niger, nitidus; capite antice asperato; thoracæ disco discrete subtiliter punctato, lateribus crebrius sat fortiter punctatis; elytris nitidis, basi sat crebre punctatis, ad apicem ereberrime asperatis. Long. 9 millim.

Front of the head granular; granules moderately large and close together on the front of the epistome, gradually becoming smaller posteriorly; the extreme vertex smooth. The angles of the cheeks very slightly prominent, less so than in *S. indicus*. Thorax very convex, widest at the posterior angles, where it is three times as broad as the length in the middle, gradually (but not much) narrowed anteriorly; with a slight sinuosity in the middle of the base. The punctures on the disk are fine but distinct, separated from each other about four or six times the diameter of a puncture; on the sides the punctures are larger and deeper, and on the margin and at the anterior angles are placed close together. The anterior angles are very acute. Elytra very convex, broadest just below the shoulders, narrowed at the apex; more convex at the base, and more obliquely sloping down posteriorly than in *S. indicus*. The surface polished; the punctures not very fine, separated from each other by about four to six diameters of a puncture. Towards the sides and behind the middle the punctures are somewhat asperate, and at the apex are replaced by moderately fine granules which are placed near together. Prosternum closely and very coarsely and strongly punctured; the mesosternum coarsely and irregularly punctured. Abdomen finely transversely strigose, the basal segment with a few large punctures.

*Hab.* Between Quetta and Khusan.

ADESMIINÆ.

19. *ADESMIA FAGERGREMI*, Baudi, Deut. ent. Zeit. xix. (1875), p. 27.

*Hab.* From Quetta to Khusan, Hari-rud valley, and Badghis.

The specimens brought by Dr. Aitchison agree very well with specimens in the British Museum collection from Persia.

[All these *Adesmiæ* were noticed as working in pure sand, running in and out of holes, their habits very much resembling Ants.—J. E. T. A.]

20. *ADESMIA PANDERI*, Fischer, Bull. Mosc. 1835, p. 313, pl. 8. f. 3.

*Hab.* Hari-rud valley and Badghis.

Two examples only. This species was originally described from Turcomania.

21. *ADESMIA SODALIS*, sp. n. (Plate XIV. figs. 2, 3.)

Nigra, sat nitida; thorace transverso, convexo, parce subtilissime punctulato; elytris bene convexis, singulis in medio carina parum crenulata instructis, inter suturam et carinam seriebus duobus fovearum rotundatarum, inter carinam et marginem tuberculis 4 vel 5 perparum elevatis ornatis; tibiis posticis compressis. Long.  $5\frac{1}{4}$ –6 lin., lat. ♂ 3, ♀ 4 lin.

This species is nearly allied to *A. carinata*, but is relatively shorter and more convex, and the impressions on the elytra are different. The head is dull, without punctures posteriorly, but with the epistome rather closely punctured. The thorax has fine punctures scattered over the surface. Each elytron has a well-marked acute costa a trifle nearer to the suture than to the margin; the sutural area gently convex. Between the suture and the costa are two lines of large, shallow, somewhat round, impressions; the surface is slightly wrinkled. The space between the costa and the margin is obliquely declivous; the surface very finely rugose; in the middle there are a few small tubercles. The lateral margin is furnished with a double series of small shining tubercles. The under flanks are rather dull and very finely rugulose.

[*Hab.* Baluchistan, working amongst dry sand, their general appearance and habits very like large black Ants.—J. E. T. A.]

## BLAPTINÆ.

22. *BLAPS OMINOSA*, Ménétr. Cat. Rais. p. 198.

\**Hab.* Badghis and Hari-rud valley.

Three examples.

23. *BLAPS PRUINOSA*, Fald. Bull. Mosc. vi. 1883, p. 53.

*Hab.* Between Quetta and Khusan.

A single specimen.

24. *BLAPS PUNCTOSTRIATA*, Solier, Studi Ent. p. 329.

*Hab.* Between Quetta and Khusan.

Several examples. The species is an Indian one.

25. *BLAPS TRIDENTATA*, sp. n. (Plate XIV. fig. 9.)

Nigra, nitida, convexa; thorace modice convexo, subtiliter crebre punctulato; elytris bene convexis, obsolete striatis, subtiliter punctulatis, apice parum producto, tridentato. Long. 17 lin., lat. 7 lin.

The punctuation of the head and thorax is fine and moderately close. The apex of the elytra is tridentate; the central tooth (formed by production of the suture) is a little longer than the lateral ones.

The male has a tuft of fulvous hair at the base of the second abdominal segment; the basal segment is transversely wrinkled, and there is a very prominent tubercle at the base.

The female only differs from the male in being a little more convex in the elytra, with the apex a little narrower; the abdomen is simple.

*Variety*.—A smaller specimen (14 lines long) differs from those above described in being much more shining, the elytra more convex and very smooth.

This species closely resembles *B. ominosa* in its general form; but is at once distinguished from its congeners by the form of the apex of the elytra.

*Hab.* Between Quetta and Khusan.

26. *BLAPS FELIX*, sp. n. (Plate XIV. fig. 12.)

Nigra, parum nitida; thorace subquadrato, parum convexo, sat crebre punctato, lateribus paulo elevatis, postice levissime sinuatis, antice rotundatis; elytris modice convexis, apice cordatis, marginatis, sat fortiter irregulariter punctatis, obsoletissime striatis. Long. 18 lin., lat.  $6\frac{3}{4}$  lin

The punctuation of the head is distinct, not very close, except at the back, where it is crowded and rough. The thorax is unusually flat, gently convex on the disk, with the fine margin slightly reflexed; the punctures are moderately strong, moderately close together, but more distant on the disk. The elytra are very slightly convex at the base, a little more so posteriorly, gradually declivous at the apex; the fine margin is very conspicuous from above near the shoulders, but is lost sight of at about one third from the apex, appearing again at the apex; the apex is produced horizontally for about four millimetres. In some lights the elytra are seen to be slightly striated. The punctures are moderately strong, frequently subconfluent transversely, very slightly asperate. The tibiæ are asperate, subcylindrical.

*Hab.* Badghis and Hari-rud valley.

27. *PROSODES DIVERSA*, sp. n. (Plate XIV. figs. 10, 11.)

Nigra, subopaca; thorace basi parum angustato, subtiliter sat crebre punctulato, disco paulo convexo, lateribus deplanatis, marginibus perparum elevatis; elytris fere lævibus, dorso perparum convexo, ad latera et apicem declivis; tibiis tenuiter asperatis; tarsis bene compressis; antennarum articulo 7° lato.

♂. Angusta; pedibus longioribus. Long.  $12\frac{1}{2}$  lin., lat.  $4\frac{1}{2}$  lin.

♀. Lata. Long. 13 lin., lat. 6 lin.

The antennæ are rather short; the seventh joint about twice as broad as the preceding joint, somewhat triangular. The thorax has a slight impression at each anterior angle, and at the base there is in most of the examples a curved transverse impression at the base (interrupted in the middle), and there is a shallow impression within each posterior angle. The surface at the posterior angles is somewhat rugose. The elytra have numerous short, irregular scratches, and here and there a very small puncture may be traced. In the male the sides are almost vertical; in the female slightly turned under.

*Hab.* Badghis and Hari-rud valley.

This species is allied to *P. obtusa*, but is quite differently sculptured, and flatter on the back of the elytra, &c.

One female example has the elytra wrinkled all over, evidently from some accidental cause.

28. *DILA LÆVICOLLIS*, Gebler.

*Hab.* Badghis and Hari-rud valley.

## PIMELIINÆ.

29. *DIESIA COSTIFERA*, sp. n. (Plate XIV. fig. 13.)

Nigra; thorace opaco; elytris rotundatis, nitidis, convexis, ad suturam planatis, singulis costis tribus crenulatis vel serratis ornatis, marginibus lateralibus serratis; tarsorum articulo ultimo dilatato longe hirsuto. Long. 11-12 lin., lat. 6-7 lin.

General form somewhat that of *Pimelia angulata*. Antennæ rather long and slender, brown, sparingly hirsute, the apical joint a little longer than the tenth, narrowed at the base, broadest at about one quarter from the base, acuminate and sponge-like at the apex. Labrum brown. Thorax twice as broad as long, convex, dull, with a long shallow impression near the base; anterior angles slightly prominent and diverging. Elytra considerably broader than the thorax; shining, but more opaque at the apex, which is triangularly produced. The first costa is not much raised, crenulate; the second is more elevated, and is furnished with short acute spines: neither of these costæ reach the apex. The third costa is sublateral, very strong, and the spines are a little longer than those on the second. The interval between the suture and the first costa is nearly flat; the next interval is gently concave; the interval between the third and fourth costæ is rather broader and more concave. The anterior tibiæ gradually enlarged to the apex, moderately spinose and hairy. The posterior tibiæ are subcylindrical, spinose, and hairy at the apex. The apical joint of the tarsi is much widened at the apex, and furnished with long fulvous hairs, almost concealing the claws. The prosternal process is very prominent posteriorly, roughly sculptured. The mesosternum is dotted with small tubercles.

On the thorax there are numerous very short black bristles, each one arising from a dull black dot, giving the surface the appearance of being punctured, which, however, is not the case.

*Hab.* Sandhills, Baluchistan (between Quetta and Khusan).

30. *OCNERA GRACILIS*, sp. n. (Plate XIV. fig. 8.)

Elongata, convexa, nigra, sat nitida; antennis gracilibus, thorace minus crebre subtiliter punctato, longe piloso; elytris basi thorace vix latioribus, postice paulo latioribus, convexis, ad apicem gradatim declivis, confertim sat fortiter irregulariter granulato-asperatis, breviter pilosis; pedibus gracilibus, tarsorum posticorum articulo basali elongato. Long. 6-7 lin., lat. 3-3½ lin.

This species differs from all others known to me in the form and sculpture of the elytra, which, instead of being suddenly declivous at the apex, gradually slope down; the granules which cover the surface are somewhat large, round, and shining, placed rather near together, and are not arranged in regular lines; punctures are also scattered in the intervals between the granules. The tenth joint of the antennæ is nearly globular, shining.

*Hab.* Badghis and Hari-rud valley.

31. *OCNERA GOMORRHANA*, Reiche, Ann. Soc. Ent. Fr. 1857, p. 215.

A single specimen, which appears to be referable to this species, and of which specimens in the Museum are from Sinai and Bagdad.

*Hab.* Sandhills, Baluchistan (between Quetta and Khusan).

## 32. TRIGONOSCELIS NODOSA, Fischer, Ent. Ross. i. p. 149, t. 14. f. 3.

This species, when in good condition, has the elytra covered with a white chalky substance, leaving the granules black. It was originally described from Bokhara.

*Hab.* Badghis and Hari-rud valley.

## 33. TRIGONOSCELIS LONGIPES, sp. n. (Plate XIV. fig. 5.)

Elongata, nigra, subopaca; thorace sat transverso, convexo, crebre granulato; elytris oblongo-ovalibus, ad suturam depressis, granulis parvis parum elevatis discrete sparsis; pedibus longissimis, sat gracilibus, tarsis longe hirtis. Long. 9 lin., lat.  $5\frac{1}{2}$  lin.

Thorax relatively small for species of this genus; about one third broader than long; the anterior angles not very prominent. The granules on the surface are very small, moderately close together, but not crowded; they are less distinct on the front margin and at the sides. The elytra are flattened on the back; the shoulders are not at all prominent, as in *T. grandis*, &c. The granules are small and not much elevated; much less conspicuous, but much more numerous than in *T. grandis*. The sides are more rounded. The legs very long; the anterior tibiæ not quite so much dilated as in *T. grandis*, convex on their anterior surface, and very finely and closely asperate.

*Hab.* Between Quetta and Khusan.

## 34. SYMPIEZOCEMIS KESSLERI, Solsky, Hor. Soc. Ent. Ross. xi. p. 291. (Plate XIV. fig. 4.)

A single example of this very interesting species.

*Hab.* Badghis and Hari-rud valley.

## CISTELIDÆ.

## 35. OMOPHILUS LEPTUROIDES, Fabr. Mant. i. p. 85.

*Hab.* Hari-rud valley and Badghis\*.

A European species.

## CANTHARIDÆ.

## 36. MELOE VARIEGATUS, DONOV. Brit. Ins. t. 67.

Three examples. A European species.

*Hab.* Hari-rud and Badghis.

## 37. MELOE TUCCIUS, Rossi, Faun. Etr. i. p. 283, t. 4. f. 5.

Two examples. A European species.

*Hab.* Hari-rud and Badghis.

## 38. MYLABRIS KLUGII, Redt. Denkschr. Wien. Ak. i. 1850, p. 49.

*Hab.* Hari-rud valley.

A Persian species.

\* [Collected occurring in great hosts upon *Pistacia vera*, eating the young leaves, in May.—J. E. T. A.]

## 39. MYLABRIS VARIABILIS, Pallas, Ic. p. 81, t. E. f. 7.

*Hab.* Hari-rud valley and Khorasan.

A European species.

## 40. MYLABRIS FROLOVII, Germ.

*Hab.* Badghis.

## 41. MYLABRIS MACULATA, Oliv. Ent. iii. 47, p. 7, t. 1. f. 9.

*Hab.* Hari-rud valley and Badghis.

A European species.

## 42. CANTHARIS CONSPICUA, sp. n. (Plate XIV. fig. 15.)

Nigra; capite rude punctato, fronte gutta sanguinea notata; antennis ferrugineis, articulo basali nigro; thorace rude punctato; elytris rufis, confertim rugulosis et punctulatis, apice nigro; tarsis plus minusve ferrugineis. Long. 11-13 lin.

The punctures on the head and thorax are rather strong, but rather unequal in size, moderately close together. The thorax has a slight impression on the disk, a little in front of the middle; and there is another impression at the base. The elytra are rugulose and densely and rather finely punctured; each elytron has two dorsal and one lateral fine lines. The antennæ are a little attenuated from the third joint to the apex.

*Hab.* Hari-rud valley.

## 43. CANTHARIS GLABRICOLLIS, sp. n. (Plate XIV. fig. 7.)

Rufo-flava, nitida, corpore subtus nigro; antennis et ore nigris; capite thoraceque glabris, punctis nonnullis sparsis; elytris rugulosis, nitidis; pedibus nigris, femoribus (apice excepto) tibiisque posticis (apice excepto) rufo-flavis. Long. 6-8 lin.

Antennæ a little longer than the head and thorax; slightly thickened towards the apex. The punctures on the head and thorax are not numerous and are rather obscure. The elytra are considerably rugulose, but shining, with obscure punctures scattered over the surface; the costæ obsolete. The body beneath and the coxæ and trochanters black; the anterior tibiæ with a little red on the anterior surface.

*Hab.* Hari-rud valley.

## 44. CANTHARIS LÆTA, sp. n. (Plate XIV. fig. 6.)

Nigra, nitida; thoracis lateribus flavo-rufis; elytris cyaneis; pedibus rufo-piceis, tarsis nigro-piceis. Long. 8-9 lin.

Antennæ dull black, slightly thickened towards the apex; the basal joints in part pitchy. Head above tinted with dark steel-blue, rather strongly and moderately closely punctured, with a small red spot between the eyes. Thorax much flattened, very smooth, with a shallow impression in front and at the base. Elytra finely rugulose, with fine punctuation interspersed; each elytron with the usual three fine costæ. The head, the sides of the thorax, and the legs are clothed with rather long pile. The abdomen is delicately punctured, tinted with bronzy green.

*Hab.* Badghis.

45. *APALUS PLAGIATUS*, sp. n. (Plate XIV. fig. 14.)

Niger, opacus; capite thoraceque sat latis, confertim subtiliter punctulatis; elytris sanguineis, plaga nigra discoidali notatis; abdominis segmentis apicalibus ferrugineis.  
Long. 7 lin.

Antennæ about one third longer than the head and thorax together, slender. The second joint slightly elongate; the third joint one quarter longer than the second. Head broad and triangular; with a distinct impression on the vertex. Thorax a little narrower than the head, impressed in front, and with a longitudinal impression behind. The punctuation is fine and very dense; one of the examples has the punctures a little separated in the middle of the front, the surface here is consequently somewhat shining. The elytra are bright red, densely and finely rugulose; each elytron has an elongate black patch, which does not reach the sides, but sometimes touches the suture below the scutellum and at its posterior part.

*Hab.* Hari-rud valley and Badghis.

## LONGICORNIA.

## CERAMBYCIDÆ.

46. *PLOCÆDERUS SCAPULARIS*, Fischer, Lettre à Pander, 1821, p. 6.

*Hab.* Hari-rud valley\*.

Described originally from Bokhara. The specimens vary from 12 to 17 lines in length.

## LAMIIDÆ.

47. *AGAPANTHIA NIGRIVENTRIS*, sp. n. (Plate XIV. fig. 16.)

Sat lata, depressa, griseo-nigra, parum nitida, parce griseo-pubesecens; thorace lineis tribus, scutello, elytrorum margine anguste flavo-pubescentibus; antennis pallide annulatis; abdomine nitido parce griseo-piloso, sat crebre subtiliter punctulato.  
Long. 9 lin., lat. 3 lin.

This species has the general form of *A. kirbyi*, but the thorax is rather less convex. Head sparingly clothed with long black pubescence, the punctuation dense and fine; there is a short spot of yellow pubescence on the vertex. The thorax is broad, a little narrowed at the extreme base, constricted in front; the punctuation is very dense and rather fine. The elytra are closely and rather strongly punctured, scarcely shining, slightly tinted with bluish grey; the pubescence is very short, pale grey, and only visible in some lights; when viewed obliquely the elytra have a speckled appearance. The margin is narrowly bordered with yellow. The underside of the body is sparingly clothed with yellowish pubescence; but that on the abdomen is very scanty and pale grey. The punctuation is moderately close, consisting of extremely fine and some larger punctures intermixed.

*Hab.* Hari-rud valley.

\* Always caught in the sheathing stem-leaves of *Ferula fatida* (the Assafœtida plant)

## PHYTOPHAGA.

48. LABIDOSTOMIS HUMERALIS, Schneider, Neu. Mag. i. 2, 1792, p. 192.

*Hab.* Badghis.

A European species.

49. AGELASTICA ALNI, Fabr. ?

Possibly the specimens brought by Dr. Aitchison may be distinct from the common European *A. alni*; the only difference, however, is that they are a trifle more elongate.

*Hab.* Hari-rud valley.

## PSEUDOTRIMERA.

## COCCINELLIDÆ.

50. COCCINELLA SEPTEMPUNCTATA, Linn. Syst. Nat. ed. x. p. 365.

*Hab.* Badghis.

A European species.

## DIPTERA.

By C. O. WATERHOUSE,

Assistant in the Zoological Department, British Museum.

1. CHIRONOMUS, sp.

Two species.

[In streams in the Hari-rud valley, as at Dana-sanjiti and at Kilki, the water was full of the larva of some insect; it occurred as a very minute scarlet point, as if just a speck of blood, and gradually grew to good dimensions. These did not look well in a tumbler of water: we did our best to clear the water, but in vain; however they proved to have been harmless. They were most common where sheep had been watered in any numbers.—J. E. T. A.]

## TABANIDÆ.

2. TABANUS TROPICUS, Linn. Syst. Nat. ii. p. 1001.

*Hab.* Helmand valley.

A European species.

[Our horses were pretty severely bitten by this species at Padda-sultan on the Helmand; this fly and the large *Asilus* are well known to the natives, and called "*Sone*." These frequently cause a stampede amongst cattle, they say.—J. E. T. A.]

3. *TABANUS*, sp.

A small greyish species, three lines in length, with the sides of the two basal segments and margins of the following segments of the abdomen pale rusty yellow; the legs partially yellow; wings hyaline.

*Hab.* Hari-rud valley and Khorasan.

[Near Mt. Do-Shakh my ponies were nearly driven mad with the numbers of this very small species; although in ones or twos they did not give much trouble, when in large numbers, as I saw them, they were extremely irritating to the cattle, chiefly attacking the head and fore legs.—J. E. T. A.]

## ASILIDÆ.

4. *ASILUS*, sp.

A large black species, clothed with yellowish-grey pile; eighteen lines in length, with hyaline wings.

*Hab.* Hari-rud valley and Khorasan.

[This large species of *Asilus* was seen in the Hariab valley and also in Khorasan, Persia; its bite is very severe to horses.—J. E. T. A.]

## TACHINIDÆ.

5. *TACHINA*, sp.

Possibly this is *T. nitida* of Walker. It is six lines in length, nearly black, with somewhat smoky wings; the abdomen shining, rusty reddish yellow, with a broad median stripe and the apical segment black. The face is yellowish.

*Hab.* Hari-rud and Badghis.

[This hairy bee-like fly gave our horses much trouble on the march to Chashma-sabz from Khusan, 1884. They seemed to live at the roots of bushes in clay soil, and were disturbed in our riding through the scrub; they were very silent and quick on the wing, and always tried to land in the nostrils of the horse; it is called "*Kajak*."—J. E. T. A.]

## RHYNCHOTA.

## HEMIPTERA.

## SCUTELLERIDÆ.

6. *GRAPHOSOMA SEMIPUNCTATA*, Fabr. Syst. Ent. p. 698.

Mr. W. L. Distant, who kindly examined this and the other Rhynchota, considers the specimens collected by Dr. Aitchison to be merely varieties of the European *T. semipunctata*. The thoracic spots are smaller than is usual in this species.

*Hab.* Hari-rud valley.

## PENTATOMIDÆ.

## 7. CARPOCORIS NIGRICORNIS, Fabr.

The two examples brought do not differ from the ordinary European form.

*Hab.* Hari-rud valley and Badghis.

## LYGÆIDÆ.

## 8. LYGÆUS FAMILIARIS, Sp. Ins. ii. p. 363.

*Hab.* Hari-rud valley.

## HOMOPTERA.

## CICADIDÆ.

## 9. CICADATRA QUÆRULA, Pallas, Reisen, ii. Append. p. 83.

*Hab.* Hari-rud valley and Khorasan.

Dr. Aitchison's specimens are, I think, evidently referable to Walker's *Caphaloxys quadrimacula* (Cat. Hom. i. p. 238), although they are a little larger than the type, which is from North India. According to the British Museum collection, *C. quadrimacula* is only a synonym of *Cicadatra quærula*, Pallas.

## HYMENOPTERA.

By W. F. KIRBY,

Assistant in the Zoological Department, British Museum.

THE determination of this small collection has been attended with considerable difficulty, owing partly to the specimens having been preserved in spirit (a method peculiarly unfitted for hairy insects such as bees) and partly to many of the allied species described from Eastern Europe and Western Asia being unrepresented in the British Museum.

It has therefore been impossible to determine some of the species in the collection with certainty, owing to the unsatisfactory condition of the specimens; and in numerous other cases the determinations must remain somewhat doubtful for the present until the insects can be verified by comparison with actual specimens of those which they are believed to represent.

Most of the species exhibit well-marked African affinities, several being apparently identical with Algerian insects. Others are allied to insects collected by Fedchenko in Turkestan; but the proportion is smaller than might have been expected.

I have not ventured to describe more than one or two well-marked forms as new.

## HYMENOPTERA ACULEATA.

## HETEROGYNA.

## FORMICIDÆ.

## FORMICINÆ.

## 1. CATAGLYPHIS VIATICA, Fabr.

*Formica viatica*, Fabr. Mant. Ins. i. p. 308. n. 20 (1787).

A common species throughout Southern Europe, Northern Africa, and Western Asia.

*Hab.* Hari-rud valley.

## SPHEGIDÆ.

## 2. AMMOPHILA MANDIBULATA, sp. n. (Plate XIV. fig. 18.)

*Female.* Length 18 millim. Black, antennæ greyish, head and prothorax above and face shining, finely and thickly punctured; mandibles very large, spotted with red, sides of prothorax longitudinally striated, with a round bare elevation behind, perhaps surrounded with grey pubescence in fresh specimens; mesothorax dull, coarsely and thickly punctured; metathorax longitudinally striated; scutellum with a depression before the extremity; petiole about one third the length of the abdomen, smooth and shining, with a red spot at the extremity; abdomen polished, smooth and shining; occiput, cheeks, prothorax and front coxæ, femora and tarsi furnished with very long black bristles; all the coxæ with a large white depressed callosity before the extremity; spines on the tibiæ and tarsi short, but numerous; fore wings fusco-hyaline, hind wings subhyaline.

Very closely resembles the North-American *A. luctuosa*, Smith; but in that species the face is much more coarsely punctured, the white coxal callosities are small or wanting, and the long bristles, which are nearly wanting on the four hind femora of *A. mandibulata*, are very conspicuous on all the femora.

*Hab.* Hari-rud valley.

## NYSSONIDÆ.

## 3. STIZUS UNIFASCIATUS.

*Stizus unifasciatus*, Rad., Fedchenko's Reise, *Sphagida*, p. 39, pl. v. fig. 3 (1877).

Originally described from Samarcand.

*Hab.* Hari-rud valley.

## 4. STIZUS TERMINUS, sp. n. (Plate XIV. fig. 17.)

*Female.* Length 22 millim. Head above the antennæ and behind the eyes entirely black; scape of antennæ, nasus, clypeus, labrum, and inner orbits sulphur-yellow; antennæ (except the yellow scape, and the red second joint), tips of mandibles, and mentum black; prothorax black, hairy, broadly bordered with yellow behind; mesothorax black, the sides above, and the mesopleura, and a spot before and behind, yellow; tegulæ

reddish; scutellum and metathorax with transverse yellow spots; abdomen yellow above, black at the extreme base, the sutures marked with transverse dark bands, all connected, the first, and broadest, black, the hinder ones reddish, more or less varied with black; terminal segment entirely black; abdomen beneath reddish at base, and with a continuous reddish stripe, expanding at last suture and darkening towards the last segment; legs yellow, the coxæ, tegulæ, upperside of the femora, and the upperside of the hind legs reddish; wings strongly tinged with smoky yellow.

Allied to *S. Uljanini*, Rad.

*Hab.* Hari-rud valley.

5. *STIZUS TAGES*, sp. n. (Plate XIV. fig. 20.)

*Female.* Length 18 millim. Yellow; face clothed with grey pubescence; a black band on the vertex over the two hindermost ocelli, and projecting squarely downwards on each side to a level with the front ocellus, which is narrowly surrounded with black, especially below, where the colour projects into a point; a black spot above each antenna, and the tips of the mandibles and the extreme occiput black; antennæ reddish, scape yellow; prothorax yellow, with a round black spot in the middle in front; mesothorax black, with two short yellow lines in the middle in front, beyond the base; shoulders and scapulæ yellow; pectus black in the middle, and reddish yellow, clothed with grey hair, on the sides; scutellum yellow, with a large red oblong spot in the middle; postscutellum yellow, narrowly edged with black in front; metathorax yellow, marked with a large obtuse-angled black triangle, and bounded behind with narrow black lines; the sides reddish, clothed with grey hair; abdomen yellow, the base black; the first two sutures broadly black, the first connected with the base by a black line; the remaining sutures above and those below very narrowly black or reddish; terminal segments inclining to reddish; legs yellow; the coxæ and trochanters marked with black and reddish; hind legs slightly reddish above.

*Hab.* Hari-rud valley.

Allied to *S. lutescens*, Pall.

DIPLOPTERA.

VESPIDÆ.

6. *POLISTES HEBRÆUS*.

*Vespa hebræa*, Fabr. Mant. Ins. i. p. 292. n. 58 (1787).

Several specimens of this widely distributed and very variable species.

*Hab.* Hari-rud valley.

7. *VESPA ORIENTALIS*.

*Vespa orientalis*, Linn. Mant. Plant. p. 540 (1771).

A common species in S.E. Europe, Egypt, and N. India.

*Hab.* Helmand valley.

[This species, with *Polistes hebræus*, was obtained in old clay buildings on the Helmand, associating together, and so much mixed that at the time it looked as if they were interbreeding.

I saw no Wasps in the Hari-rud or Badghis, and no Honey-bees, except once in some mud walls at Karez-iliias. Honey is unknown except from the forest districts.—J. E. T. A.]

## MELLIFERA.

## ANDRENIDÆ.

8. *HYLÆUS TURANICUS* (?).

*Hyleus turanicus*, Mor., Fedchenko's Reise, *Mellifera*, p. 279 (1877).

*Hab.* Badghis.

A single damaged specimen.

9. *ANDRENA HATTORFIANA*.

*Nomada hattorfiana*, Fabr. Syst. Ent. p. 389. n. 6 (1775).

A common and widely distributed European species.

*Hab.* Hari-rud valley and Badghis.

## APIDÆ.

10. *CROCISA BIDENTATA*, sp. n. (Plate XIV. fig. 19.)

*Male.* Length 14 lines. Deep black, strongly punctured; face between the ocelli and labrum, occiput, prothorax, borders and two spots on hind margin of mesothorax, and upper surface of the short broad tibiæ, clothed with white pubescence; scutellum very broad, somewhat convex, the hinder angles strongly produced, and the metathorax also spinose. Abdomen bidentate at apex. Fore wings deep violet-black; hind wings subhyaline.

Allied to *C. scutellaris*, Fabr., but larger, and (in the two specimens before me) with no trace of white markings on the abdomen.

*Hab.* Hari-rud valley.

11. *EUCERA CLYPEATA*.

*Eucera clypeata*, Erichs., Walt's Reise, ii. p. 108 (1835).

Common in Southern Europe and Western Asia.

*Hab.* Hari-rud valley.

12. *TETRALONIA*, sp.

A single specimen of a black species with white pubescence, not closely allied to any previously contained in the British Museum collection.

*Hab.* Hari-rud valley and Badghis.

## 13. ANTHOPHORA ATROALBA (?).

*Anthophora atroalba*, St.-Farg. Hym. ii. p. 73 (1841).

In the British Museum, from the Canaries; it is likewise recorded from S. Europe and Algeria.

*Hab.* Hari-rud and Badghis.

[This species (and, I think, *Eucera clypeata*) was found in the sheathing leaf-stalks of the *Assafœtida* plant, in a semiunconscious state.—J. E. T. A.]

## 14. ANTHOPHORA LITURATA (?).

*Anthophora liturata*, St.-Farg. Hym. ii. p. 74 (1841).

Four specimens, apparently belonging to this species, but hardly determinable, having been soaked in spirit. *A. liturata* was originally described from Oran (Algeria), but has likewise been taken in Turkestan by Fedchenko. Not previously in the collection of the British Museum.

*Hab.* Hari-rud valley and Badghis.

## 15. XYLOCOPA HELLENICA.

*Xylocopa hellenica*, Spin. Ann. Soc. Ent. France (2), i. p. 114 (1843).

Previously recorded from the Balkan Peninsula, Kirghis Steppes, Caucasus, Asia Minor, Bagdad, and Turkestan.

*Hab.* Hari-rud valley.

In addition to the above there are several other specimens of Bees in bad condition in the collection, which I cannot at present determine.

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**ORTHOPTERA.**

By W. F. KIRBY,

Assistant in the Zoological Department, British Museum.

As in the case of the *Hymenoptera*, the species of *Orthoptera* represented in this collection belong principally to distinctly Mediterranean types, and many of them were already recorded to possess a very wide range. Few or none exhibit well-marked affinities with the Indian fauna. The materials at my disposal have not been sufficient to enable me to identify all the species with positive certainty.

## BLATTIDÆ.

## 1. POLYPHAGA (?), sp.

Four species of a very broad apterous form, possibly belonging to a new genus, but which it would be unadvisable to describe at present.

*Hab.* Collected in the Badghis and Hari-rud valley.

[These were seen usually on sandy soil where camels had been resting for the night, moving about amongst the dung.—J. E. T. A.]

## MANTIDÆ.

## EREMIAPHILINÆ.

## 2. EREMIAPHILA ARABICA.

*Eremiaphila arabica*, Sauss. Mém. Genève, xxi. p. 254, pl. vii. fig. 56 (1871).

This desert genus is represented by a specimen of one of the most widely-ranging species, which extends to the frontiers of India.

*Hab.* Collected between Quetta and Khusan, along the route of march.

## MANTINÆ.

## 3. POLYSPILOTA STRIATA.

*Mantis striata*, Stoll, Spectres, pl. xi. fig. 41 (1813).

A single damaged specimen belonging to this or to a closely allied species. *M. striata* occurs throughout Tropical Africa and its islands, and is also said to have been taken in Borneo.

*Hab.* Collected in the Hari-rud valley.

## 4. HIERODULA ROBUSTA (?).

*Hierodula robusta*, Sauss. Mém. Genève, xxi. p. 73, pl. vi. fig. 53 (1871).

A single bleached specimen, agreeing with Saussure's figure in the shape of the prothorax. Saussure obtained his type from the East Indies, without specifying any exact locality.

## 5. MANTIS RELIGIOSUS.

*Gryllus (Mantis) religiosus*, Linn. Syst. Nat. i. p. 426. n. 6 (1758).

Two specimens. Common throughout S. Europe, N. Africa, and W. Asia.

## EMPUSINÆ.

## 6. (BLEPHARIS) MENDICA.

*Mantis mendica*, Fabr. Syst. Ent. p. 275. n. 7 (1775).

An immature specimen of this widely distributed species, already known to extend from the Canaries to Syria. The generic name is preoccupied in Pisces (Cuv. 1817), and should be replaced by some other.

## GRYLLIDÆ.

7. *ACHETA AFRICANA*.

*Gryllotalpa africana*, Beauv. Ins. Afr. Amér. p. 229, pl. ii. C. fig. 6 (1805).

Two specimens. The species is common throughout Tropical Africa and Asia, and even extends to Australia and New Zealand.

*Hab.* Hari-rud valley and Khorasan.

8. *GRYLLUS CAPENSIS*.

*Acheta capensis*, Fabr. Syst. Ent. p. 281. n. 6 (1775).

One immature specimen. A still more widely-ranging species than the last, as it has been taken in all quarters of the globe.

*Hab.* Between Quetta and Khusan.

## LOCUSTIDÆ.

## PHYMATINÆ.

9. *CIROTOGONUS HOMALODEMUS* (?).

*Ommexycha homalodemum*, Blanch. Ann. Soc. Ent. France, v. p. 615, pl. xxii. fig. 4 (1836).

Agrees fairly with the insect described and figured by Blanchard from Sennaar; but its identity cannot be positively affirmed without comparing specimens from that locality.

*Hab.* Between Quetta and Khusan.

10. *PYRGOMORPHA BISPINOSA*.

*Pyrgomorpha bispinosa*, Walk. Cat. Derm. Salt. Brit. Mus. iii. p. 499. n. 8 (1870).

Four specimens. Walker's type was from S. India.

*Hab.* Badghis.

## PAMPHAGINÆ.

11. *EUNAPIUS GRANOSUS*.

*Pamphagus (Eunapius) granosus*, Stål, Bihang Svensk. Akad. Handl. iv. (5) p. 31 (1876).

Four specimens in different stages of growth. Stål's type was received from Algeria.

*Hab.* Hari-rud valley and Badghis.

## ACRIDINÆ.

12. (*ACRIDIDIUM*) *ÆGYPTIUM*.

*Gryllus (Locusta) ægyptius*, Linn. Mus. Ulr. p. 138 (1764).

Common throughout the Mediterranean district.

As *Tetrix*, Latr. (*Tettix*, Fisch.), is co-typical, and therefore synonymous with *Acrydium*, Geoffr. & Fabr., *Acridium*, auctorum, will require to be renamed.

*Hab.* Hari-rud valley and Badghis.

## 13. EUPREPOCNEMIS LITTORALIS.

*Gryllus littoralis*, Ramb. Faune Ent. de l'Andalusie, ii. p. 78, pl. vii. figs. 1, 2 (1839?).

Three specimens, apparently belonging to this species. It has previously been recorded from South Spain, Egypt, Kordofan, Rhodes, and Beyrout.

*Hab.* Between Quetta and Khusan.

## 14. ACRIDA GRANDIS (?).

*Tryxalis grandis*, Klug, Symb. Phys. ii. pl. xv. fig. 1 (1830).

A bleached specimen, agreeing fairly with Klug's figure, but exhibiting no trace of blue or red colour at the base of the hind wings. It is very doubtful how far the numerous named species of this genus are really distinct. Klug described the species from Egypt.

*Hab.* Between Quetta and Khusan.

## 15. STAURONOTUS MAROCCANUS.

*Gryllus maroccanus*, Thunb. Mém. Acad. Pétersb. v. p. 244 (1815).

A common species round the Mediterranean, and one of the most abundant and destructive locusts in Cyprus.

*Hab.* Badghis.

## LOCUSTINÆ.

## 16. LOCUSTA DANICA.

*Gryllus (Locusta) danicus*, Linn. Syst. Nat. i. (2) p. 702. n. 77 (1767).

Three specimens of another widely-ranging locust, which is met with in most parts of the Old World.

*Hab.* Between Quetta and Khusan.

## 17. SPHINGONOTUS KITTARYI (?).

*Sphingonotus kittaryi*, Sauss. Mém. Soc. Phys. Genève, xxviii. (2) no. 9, p. 207 (1884).

A single discoloured specimen, probably belonging to this species. Saussure's types were received from Turkestan and the shores of the Caspian.

*Hab.* Hari-rud valley and Khorasan.

## 18. THRINCHUS CAMPANULATUS (?).

*Thrinchus campanulatus*, Fisch. Bull. Mosc. vi. p. 378 (1833); Orth. Ross. p. 257, pl. xi. fig. 1 (1846).

Two specimens, differing from the figure chiefly in the narrower band on the hind wings. Described by Fischer de Waldheim from Georgia.

*Hab.* Hari-rud valley and Khorasan, Persia.

In addition to the previously-mentioned Orthoptera, there is a species of *Caloptenus* (?) new to the British Museum (one mature and two immature specimens), and one or two other immature specimens, which I am not at present disposed to notice further.

## EXPLANATION OF PLATE XIV.

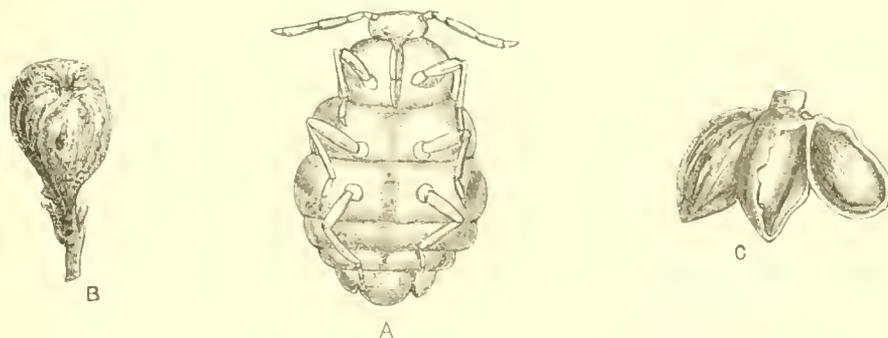
- Fig. 1. *Spyrathus politus*.  
 2. *Adesmia sodalis*, ♂.  
 3. „ „ ♀.  
 4. *Sympiezocemis kessleri*.  
 5. *Trigonoscelis longipes*.  
 6. *Cantharis leta*.  
 7. „ *glabricollis*.  
 8. *Ocuera gracilis*.  
 9. *Blaps tridentata*.  
 10. *Prosodes diversa*, ♂.

- Fig. 11. *Prosodes diversa*, ♀.  
 12. *Blaps felix*.  
 13. *Diesia costifera*.  
 14. *Apalus plagiatus*.  
 15. *Cantharis conspicua*.  
 16. *Agapanthia nigriventris*.  
 17. *Stizus terminus*.  
 18. *Ammophila mandibulata*.  
 19. *Crocisa bidentata*.  
 20. *Stizus tages*.

## GALL-INSECTS.

By G. B. BUCKTON, F.R.S., F.L.S.

WITH the collections brought home by Dr. Aitchison from Afghanistan were some galls which have been handed over to me for examination. They were gathered in 1885, on *Pistacia vera*, and were of various sizes, forms, and colours, as bright orange, purplish red, or green. When cut across they showed single, smooth, shining cavities, each of which had an exit at its base, near the peduncle, from which the insects, when mature, would have made their escape. Within the hard woody walls a quantity of excrementitious matter was found, mixed with a flocculent material, and numerous whitish bodies, numbering perhaps from thirty to fifty. These contents formed a mass at the base of the gall.



A. Larval form of *Pemphigus coccus*, parthenogenic female (enlarged). B. Natural appearance of Gall.  
 C. The same, opened.

Under a lens the grains had the appearance of grape-sugar. The substance was soaked for a short time in water, and then treated with weak alcoholic potash, which slowly dissolved the fatty matter; and then the bodies of the insects separated out sufficiently distinct for drawing.

Although the galls contained no winged forms, which would at once have certified the genus, there can be no reasonable doubt that the insects belong to the Pemphiginæ (Aphidinae), five species of which, Passerini states, infest the *Pistacia* in Italy. Four of these are of the genus *Pemphigus*; but as their chief differences seem to consist in the form and situation of the galls they raise, their claims to a distinct species may be doubted. As this Afghan species is quite blind, a better acquaintance with the insect may prove it new to science; therefore any name assigned to it now must be considered as temporary.

A short description may be here given.

PEMPHIGUS COCCUS (♀).

Larval form of the parthenogenic female. Globose, yet broadest across the abdomen; deeply ringed. Head square; antennæ five-jointed, not counting the terminal nail-like process; fifth joint the longest. Eyes none. Proboscis short, reaching to about the second coxæ. Legs stout, and furnished with a double claw. Cauda blunt, having two minute spines. Colour, when alive, probably greenish, mottled with white, and sparsely covered with silky filaments. Nectaries not visible.

Some of the galls gathered had round holes pierced in their sides. These had been doubtless the exits of parasites, for the remains of cocoons were discovered within, but no trace of the bodies of aphides.

Size of larvæ 0·0450 × 0·0280 inch.

IV. *Studies in the Morphology of the Lepidoptera.*—Part I. By W. HATCHETT JACKSON, M.A., F.L.S., Deputy Linacre Professor of Anatomy in the University of Oxford.

(Plates XV.—XIX.)

Read 21st November, 1889.

THE present paper represents a portion of an investigation which was begun some years ago but was laid aside at the time for want of material; its resumption was prevented by the claims of other and very pressing duties until the summer of the present year. The results obtained are now laid before the Society in the hope that they may prove of interest, and as a first contribution from studies which still remain to be finished. There are, however, one or two points in this first portion which will require some further elucidation; but as a year must elapse before the necessary specimens can be procured, it seems to me that it is better not to keep back what has been done, especially as the points in question are not of critical importance.

Two subjects are here dealt with. The first is the external anatomical marks by means of which the sex of a chrysalis may be determined; the second, the mode in which the azygos oviduct or vagina of the female butterfly with its accessory organs develops between the close of larval life and the assumption of the state of the imago\*.

§ 1. *The External Anatomical Characters distinctive of Sex in the Lepidopteran Chrysalis.*

After a search of some extent in the literature which deals with the anatomy of the Lepidoptera, I have come to the conclusion that none of the many authorities who have studied this order of Insecta have ever noticed the fact that the sex of every chrysalis is denoted by fixed anatomical characters †. Yet such is the case. If the dorsal aspect of a chrysalis is carefully examined, it will be seen at once that there are thirteen somites following the head, three thoracic, and ten abdominal, the last somite carrying the cremaster, which represents the anal valve of the caterpillar. The eighth somite, which has a particular connection with the object of this section, may be identified at once for

\* A preliminary account of the results of this investigation was sent to the 'Zoologischer Anzeiger' on Oct. 7, and appeared in No. 322 of that periodical for Dec. 2nd, 1889.

† My search in this connection has extended through the works of Kirby and Spence, Burmeister, Westwood, Camerano, Graber, Scudder, and various anatomists, as well as writers of special monographs such as Lyonet, Herold, and Suckow. Figures occur here and there in which the markings distinctive of sex are more or less clearly indicated, but their import has not been recognized. See Addendum, p. 145, *post*, and Zool. Anz. Jan. 27, 1890.

practical purposes without the labour of counting by the fact that its stigmata are abortive as compared with the stigmata of preceding somites. The characters which determine the sex are to be found on the ventral or sternal aspect of the ninth somite in the male, and in the corresponding region of both the eighth and ninth somites in the female. They were first recognized by myself in 1875, and I have used in succeeding years whatever opportunities have presented themselves of verifying their truth not only by the inspection of specimens but also by means of breeding and dissections.

The male sex is indicated by a linear depression in the sternal region of the ninth somite, a depression which represents the aperture of the ductus ejaculatorius of the imago. It presents itself in one of three slightly differing shapes.

(1) It is a fine line situated in a raised area and provided with two oval lips, one right, the other left. This is the form which is seen in *Pieris* and is shown in Pl. XV. fig. 1.

(2) It is a more strongly marked line inclosed in a nearly circular cup-shaped area with edges strongly raised. The sternal region of the ninth somite is a smoother continuation of the lateral portions of the somite. This form is the one seen in the genus *Vanessa* (*V. urticae*, *Io*, *Atalanta*, *polychloros*) and is shown in Pl. XV. figs. 4 and 5. In some specimens the edges of the inclosing area are more strongly pronounced on the right and left, forming a couple of lips, and then the area has a more or less oblong aspect.

(3) It is a very well defined linear depression, guarded by two lips, one on the right, the other on the left. These lips are tumid, broad at their centres, and pointed at either extremity; or, in other words, they are either oval or somewhat triangular, the bases of the triangles being the linear depression itself. The whole structure lies either in the centre of the sternal region or at its posterior limit. Examples are *Papilio Machaon* (Pl. XV. fig. 8) and *Sphinx ligustri* (Pl. XV. fig. 11). The latter figure is taken from a spirit-specimen of an individual killed immediately on pupation; in older living specimens the dark colour and the thickening of the pupal cuticle rather obscure the structure. All the Heterocera which I have examined possess this third shape.

The female sex is to be recognized by the aspect of the sternal regions of the eighth and ninth somites. There are typically and primitively two linear depressions, one in each of the sternal regions named, but they may be hidden or become confluent. These depressions coincide respectively with two pairs of vesicles invaginated from the hypodermis; see *infra*, pp. 159–160. There are several types of structure to be distinguished.

(1) The eighth and ninth sterna are each marked by a short fine longitudinal line, surrounded by an oval and slightly raised area. This type is seen in *Pieris* and is shown in Pl. XV. fig. 2.

(2) The eighth and ninth sterna are marked by a longitudinal line which is apparently continuous. The sternal region of the ninth somite is, as in the male, a smoother continuation of the lateral portions of the somite. This type is seen in the various species of the genus *Vanessa* and is exemplified in Pl. XV. figs. 6 and 7, taken from *V. Io*. The essential difference between it and the preceding type depends on the formation of a median furrow corresponding to the course of the azygos oviduct by

which the two typical linear depressions seen in *Pieris* are effectually obscured. Pl. XV. fig. 15 is a view of the inner aspect of the empty pupal cuticle of *V. Io*, and shows the remnants of the chitinous linings of the duct of the bursa copulatrix (*b*) and of the oviduct (*o*) respectively, at a late stage, however, of growth, and therefore of greater extent than in the newly formed pupa. Still they indicate the existence of the structures evidenced outwardly in *Pieris*, and described in *V. Io* in the second section of this paper (pp. 159-160, 162, 164)\*.

(3) In all specimens of *Papilio Machaon* that I have seen the ninth somite is very narrow ventrally and is crossed by a line as in *Tanessa*. The ventral portion of the eighth somite is broader, and a line extends forwards from its hind margin for about one third of its breadth. This type is figured Pl. XV. fig. 9.

(4) All the Heterocera which I have examined are characterized by a peculiarity of the ninth sternal region. It is prolonged forwards to a greater or less extent as a triangular plate invading the eighth sternal region, and it is at the same time not clearly limited from the tenth somite behind; or in other words the intersegmental line between the ninth and tenth somites is not quite continuous from side to side across the ventral line. These features are shown in two of the Sphingidæ, *Protoparce mauritii* (Butler), Pl. XV. fig. 10, and *Sphinx ligustri*, fig. 12, on the same Plate. The figures also illustrate a further peculiarity of the Heterocera. In *Protoparce mauritii* it will be noticed that there are two fine longitudinal lines or depressions, one in the eighth sternum and a second, the shorter of the two, at the apex of the triangular forward extension of the ninth sternum, whereas in *Sphinx ligustri* there is but a single linear depression situated in the sternal region of the eighth somite, inclosed, however, by triangular lines passing backwards. The single depression represents the two depressions seen in *Protoparce*. Of the correctness of this conclusion I have no doubt, for the following reasons:—*First*, dissection of a one day's old pupa of *Sphinx ligustri* has shown me the existence of exactly the same parts that are seen in Pl. XVII. fig. 34, taken from *V. Io*. There is an anterior vesicle with rudiments of a bursa copulatrix and receptaculum seminis, and a posterior double vesicle. The main difference in these organs, as compared with the organs of *V. Io*, is that the anterior and posterior vesicles are closely apposed to one another. The *second* reason is that in the cast pupal cuticle of the same moth, as well as of a *Smerinthus ocellatus*, I have found two bands united at their bases, which are evidently the cast chitinous linings of the ducts of the bursa copulatrix (*b*) and of the oviductal tube (*o*). They are identical with the structures figured in *V. Io* on Pl. XV. fig. 15, and they are shown in figs. 16 and 17 on the same Plate. There is yet a *third* reason, and that is the occurrence of a single or of a double depression in different chrysalids of the same or allied species. Such a variation I have seen only once, and that quite recently, among the very many examples, probably 200 or more, of *Sphinx ligustri* that have passed under my notice. It is figured Pl. XV. fig. 13. A specimen of *Smerinthus oculatus* belonging to my friend Mr. Poulton is a second instance to the point; as a rule, however, this species has but a single depression.

\* See p. 155, on pupæ of *V. Io* of undetermined sex.

The same statement is true of *Sm. populi*, but a specimen in the Zeller collection in the British Museum and two specimens in my own possession are exceptions. In the Stephens collection of "Metamorphoses" in the British Museum is a specimen of *Cossus ligniperda* with two depressions distinctly separated. Other specimens that I have seen possess but one. Two specimens of *Zeuzera æsculi* in the same collection differ in a similar way; one has a single depression, the other a double. All examples of *Cucullia verbasci* bred by myself, and they are many, have had but one depression; the sole example of *C. scrophulariæ* seen by me, and it is in the Stephens collection, has two. In the same collection is a specimen of *Thyalira tridens* and another of *Th. psi*\*; the former has a single depression, the latter a double.

The external anatomical characters distinctive of sex in a chrysalis and above described are very constant, so far as I have seen after many years of observation; and whenever it has been in my power to verify my own conclusions on the subject, no error of determination has ever been detected. There is, of course, a certain amount of variability in minute details, but it is never of such a kind as to prevent the recognition of the sex. For some time past I have been collecting instances of this variability in *Pieris brassicæ*, and on a future occasion I may hope to figure them.

The following table gives a list of the species examined. It relates only to the female. From time to time single examples of individual species have come under observation of which unfortunately no record has been kept. They all belonged, however, to the Heterocera and to the type 4 b, *infra*. The numbers prefixed to the names indicate the number of specimens seen by me, and where no such number is given it is to be understood that it has been very great indeed. The letters "B.M." stand for British Museum, *i. e.* the Natural History Museum, as it is now called, and figures following these letters indicate the Museum number. "Z" stands for Zeller collection; "St" for the Stephens collection of Metamorphoses, both in the National collection. I may here express my thanks to my friend Mr. Heron, of the Zoological Department of the Natural History Museum, for his kind assistance, and to Mr. Doneaster, of the Strand, who courteously permitted me to inspect his stock of pupæ.

1. *Pieris brassicæ*; *P. rapæ*; 3 *P. napi*; 1 *Minetra cyaneus* (Moore), from Ceylon, B.M. 83, 52.
2. 137 *Vanessa Io*; *V. urticæ*; 26 *V. polychloros*; 2 *Papilio Alexandor*, Z.; 1 *P. polytes*, from N.W. India, B.M. 84, 38; 1 *Ornithoptera aeacus*, B.M.; 1 *O. (Papilio) minos*, B.M.
3. 28 *Papilio Muchaon*; 35 *P. podalirius*; 1 *P. merope*, from S. Africa, B.M. 78, 10; 20 *Thais cerisyi*; 3 *Th. hypermæstra*, B.M.

† a. With double apertures.

- 5 *Acherontia Atropos*; 1 *Sphinx convolvuli*, St.; 1 *S. ligustri*; 2 *Deilephila euphorbiæ*, St.; 2 *Chærocampa porcellus*, St.; 52 *Ch. elpenor*; 1 *Ch. alecto*, from N.W. India, B.M. 84, 38; 2 *Ch. nerii*, B.M., Z.; 1 *Smerinthus ocellatus*; 3 *Sm. populi*; 1 *Protoparce mauritii*, from Natal, B.M.; 1 *Daphnis Horsfeldii*, Java, from the Horsfield collection, B.M.; 1 *Cossus ligniperda*, St.; 1 *Zeuzera æsculi*, St.; 1 *Cucullia scrophulariæ*, St.; 1 *Thyalira (= Acronycta) psi*, Z.; 4 *Nyssia zonaria*.

\* These are the names given by Stephens; the species are now assigned to the genus *Acronycta*.

4 b. With a single aperture.

2 *Acherontia Atropos*; *Sphinx ligustri*; 2 *Chærocampa elpenor*; *Smerinthus ocellatus*; *Sm. populi*; 29 *Sm. tiliæ*; 11 *Euchelia jacobææ*; 23 *Arctia caja*; 2 *Cossus ligniperda*; 1 *Zeuzera æsculi*, St.; 1 *Stauropus fugi*, St.; 2 *Notodonta dictæoides*; 1 *N. dromedarius*, St.; 1 *Leucania straminea*, St.; *Phalera bucephala*; 1 *Thyatira* (= *Acronycta*) *tridens*, St.; 2 *Gortyna flavago*, St.; *Mamestra brassicæ*; 15 *M. persicariæ*; 1 *Achatia* (= *Panolis*) *piniperda*, St.; 5 *Dianthæcia irregularis*; 1 *Misellia oxyacanthæ*, St.; 1 *Hadena* (= *Agriopsis*) *aprilina*, St.; 3 *Hadena glauca*; 13 *H. chenopodii*; *Cucullia verbasci*; 1 *Bucephala* (= *Cucullia*) *umbratica*, St.; 3 *Gonoptera libatrix*; 2 *Selenia illustraria*; 18 *Nyssia zonaria*; 13 *Biston hirtaria*.

The structures to which are due the marks distinctive of sex in chrysalids develop towards the close of the caterpillar's life, and the cuticle that lines them is in continuity with the cuticle of the future pupa. It is conceivable that the cuticle of the caterpillar might in a given instance be sufficiently transparent to permit of their being seen; it is conceivable also, but not probable, that they might happen to develop at an earlier stage of larval existence. Under no other conditions is it possible for them to afford aid in deciding the question to what sex a living caterpillar belongs. It is easy enough to find the answer to the question by dissection, as will appear later on (pp. 158-159 and note), or by inspection in those few instances where the integument is of sufficient transparency to permit the testes and ovaries to be seen, and where at the same time there is a difference of colour in those organs. I have examined, and in vain, for distinctive external anatomical indications of sex, numbers of caterpillars of *Pieris brassicæ*, *Vanessa Io*, *Sphinx ligustri*, and *Phalera bucephala*, and have found none. It seems to me, however, that the larger and longer caterpillars of *Vanessa Io* and the smaller caterpillars of *Sphinx ligustri* belong, as a rule, to the female sex. But I should not like to be too positive without tables of measurements and weights. It is not only possible but likely, however, that instances where size differentiates the sex of the caterpillar may be found. Peculiarities of colouring are said to do so in some cases. For example Weniger has stated, in the 'Entomologist' (xx. 1887, pp. 87-89), that after the second or third moult of the caterpillar of *Attacus yama-mai*, *A. Pernyi*, *A. selene*, and *A. cecropia*, a coloured mark on the sternal region of the eighth abdominal somite affords a certain test of sex. The mark in the female is a "black blotch" in the middle of a yellowish tint, which in natural size is not larger than a large pin's head. The male differs from the female in the fact that the black blotch has in its centre "a dark green spot." In both sexes the distinctive mark disappears when they are killed and "emptied." It is therefore probably due to a peculiarity in the larval cuticle. At least there is no structure belonging to the reproductive organs in both sexes alike which has the position assigned by Weniger. Professor Westwood points out, on p. 193 of his 'Entomologist's Text-book,' 1838, that, according to de Geer, brown caterpillars of the yellow underwing, *Triphæna pronuba*, produce males, green caterpillars, females; and I gather from § 15, p. 20 of Herold's 'Entwicklungsgeschichte der Schmetterlinge' (Cassel & Marburg, 1815), that other instances are given in Rösel von Rosenhof's work 'Der monatlich-herausgegebenen Insecten-Belustigungen,' published at Nüremberg in 1746-61, and illustrated with a large number of plates. This work I have seen, but

want of time has prevented my searching its pages so as to point out the proper references\*.

ADDENDUM.—Since this paper was read I have found that the anatomical sexual distinctions of chrysalids were known in part to O. Wilde, and are briefly mentioned in his work ‘Systematische Beschreibung der Raupen unter Angabe ihrer Lebensweise und Entwicklungszeiten,’ Berlin, 1861. There is a copy of this book in the Insect Room at the Natural History Museum, where it was shown me by my friend Mr. Heron. In many of the plates to the *second part* sexual signs are affixed to some of the figures of the chrysalids. The cremaster appears to differ in some cases in the two sexes, just as do the antennæ. On p. 4 of the Introduction, Wilde states that the male pupa possesses “in der Mitte der Bauchfläche *des letzten Ringes* zwei kleinere, durch eine Längsfurche getrennte Höckerchen, während diese Stelle bei der weiblichen Puppe geglättet, dagegen aber hinter dem Einschnitte zwischen dem 7ten und 8ten Ringe, über der Mitte des letzteren, eine seichte, mehr oder weniger deutliche, kürze Längsfurche wahrnehmbar ist. Die Unterscheide entspreche der verschiedenen Lage der Fortpflanzungsorgane bei den beiden Geschlechtern.” Wilde appears to have been acquainted with only one type of the Heterocera, at least in the female, viz., the one with confluent apertures. A comparison with the foregoing account will show that there is a greater variety in the sexual marks than he supposes, and that he has not placed them with complete accuracy, owing probably to his not knowing the true number of segments in the abdomen.

A second authority has noticed the sexual apertures of chrysalids. Dr. Haase of Königsberg has been good enough to draw my attention to J. T. Ch. Ratzeburg’s work ‘Die Forst-Insecten,’ Th. ii. (Berlin, 1840), and to give me a reference to its pages. On p. 6, Ratzeburg compares the segments of the pupa with the segments of the caterpillar, to which he assigns, by the way, 9 abdominal segments (p. 4). Speaking of the last *three* larval segments, he says, “Letztere scheinen in der Puppe zwar 4 zu sein (also der ganze Hinterleib 10-ringlig), allein das kommt nur daher das der After sich besonders abschnürte. Dicht vor der Afterspalte liegt die Geschlechtspalte. Bei der männlichen Puppe setz sie sich aber bis in den vorletzten Ring fort, während sie bei den weiblichen auf der letzten beschränkt ist (z. B. T. xii. F. 3, 4, p.). So kann also, meine Beobachtung zufolge, männliche und weibliche überall in der Puppe unterscheiden (s. d. zahlreichen Abbildungen).” With reference to this passage I may remark that, as stated later on in the second part of my paper (pp 151–2), there are really *ten* abdominal segments both in the caterpillar and pupa alike, and that Ratzeburg (like his successor in time, Wilde) was not acquainted with the detailed variations of the sexual apertures of pupæ as described in the preceding pages. He figures in the female only *Vanessa polychloros* and the Heteroceran type *4b* with confluent apertures. In his

\* Mr. Doncaster tells me that in the Satyridæ the male caterpillar is brown, the female green, and that the male caterpillars of *Orgyia antiqua* and *O. gonostigma* have yellow dorsal brushes, the female brown. In all there are 13 or 14 species thus distinguished. Suckow (‘Anat. Physiol. Untersuchungen,’ Heidelberg, 1818, p. 23) states that the male *Dendrolimus pini* differs from the female (1) by its smaller size, (2) by its lighter, almost smoky grey colour, and (3) by a black-brown band, situated behind the second pair of prolegs, which begins laterally and takes an oblique dorsal course. This band is obscurely marked in the female.

account he also misplaces or misdescribes the positions of the apertures in the two sexes, though the particular figures to which he refers his readers appear to bear out his words. But others of his figures are more correct than his account; *e. g.* Taf. xiv. figs. 4 *p* ♀, 4 *p* ♂, and Taf. xvi. figs. 1 *p*, 2 *p*, 3 *p*, which show the male aperture in the segment in front of the anal segment, and the female (confluent) aperture as situated apparently in the centre of the eighth segment, *i. e.* the segment in front of the one in which the male aperture occurs.

Dr. Haase also remarks to me that the sexes of the Lepidopteran chrysalid have been "long known to all practical Lepidopterists." This may be the case in Germany, but it is certainly not so in England, so far as concerns the sexual apertures of the pupa. Before my paper was read I consulted Professor Westwood and several other practical Lepidopterists, who assured me to the contrary. Moreover, except on the assumption of ignorance, it is hard to account for the complete silence of text-books in general on the subject.

## § 2. *Development of the Azygos Oviduct and its accessory Organs in Vanessa Io.*

It is a well-known peculiarity of the Lepidoptera that the female ducts have two external apertures. The only exception known to me is *Nematois metallicus*, described by Cholodkowsky in the 'Zeitschrift für wiss. Zool.' xlii. 1885. From his account I gather that there is only one aperture in this Micro-Lepidopteran, and that one the posterior of the two usual apertures. All the Macro-Lepidoptera which have been examined possess an aperture which leads into the bursa copulatrix, and is placed on the ventral aspect of the eighth somite, and a second aperture which leads outwards from the oviduct and is placed ventrally to the anus, on the papilla that terminates the abdomen. The aperture of the bursa is the one by which copulation is effected; the oviducal aperture the one by which the ova are always laid. Fig. 19 on Pl. XV. shows the azygos oviduct and accessory organs of *Vanessa Io*, the type I have investigated. It is given more as a standard of reference for the developmental history than for any other purpose. The four ovarioles, cut short, are to be seen on each side (*ov.*, *ov.*); they are attached to the ends of the paired oviducts (*od.*, *od.*) which in their turn enter the azygos oviduct (*od'*)\*. This tube terminates by an aperture just below the rectum (*r*). The accessory organs appended to the azygos oviduct are, in order from before backward, a "seminal canal" (*s.c.*), leading to the bursa copulatrix (*b.c.*), a receptaculum seminis (*r.s.*), and a pair of sebaceous glands (*s.gl.*), with a common duct (*d.s.gl.*). Immediately below the termination of the azygos oviduct is a pair of glands supposed to be odoriferous by von Siebold. The left one alone is visible (*od.gl.*). The seminal canal (*s.c.*), it may be noted, opens on the dorsal aspect of the azygos oviduct. It is somewhat

\* Four ovarioles on each side is the number typical of Lepidoptera. The only known exceptions are mentioned by Cholodkowsky, in his paper cited in the text (*op. cit.* p. 560). They are the following:—*Psyche helix* with six on each side (A. Brandt), *Sesia scoliiformis* with fourteen (E. Brandt), and *Nematois metallicus* with twelve (one specimen), sixteen (one specimen), eighteen (two specimens), and twenty (six specimens).

dilated at its origin, as in *Euclidia glyphica* and *Plusia chrysitis* (von Siebold, Archiv für Anat. u. Physiol. 1837, p. 420); it is also tortuous in its course. It opens laterally into the duct (*d. b. c.*) of the bursa copulatrix (*b. c.*). In *Danais Archippus* (= *Anosia plexippus*) as described by Burgess (Anniv. Memoirs, Boston Soc. Nat. Hist. 1880) it has "near the middle a pear-shaped chamber, the spermatheca or sperm reservoir" (p. 12); and according to von Siebold (*loc. cit.*) it has in Tortrices an appended pyriform vesicle. The bursa is shown as collapsed, and its walls thrown into folds in this figure taken from an unimpregnated female. Its duct is slightly dilated near the aperture, which is shown on Pl. XVI. fig. 25, *a. b. c.* It will be seen from the same figure that the seventh and eighth sterna are fused, and that the eighth sternum is much thickened and, moreover, grooved ventrally. At the anterior end of the groove is an elliptical body, which is glass-like and transparent. It is formed by a hyaline chitinous thickening shown in section on Pl. XV. fig. 20, *c, b,* and guards the bursal aperture from below. Owing to its extreme thickness it must, I imagine, act like a clip on the intromittent organ of the male. The receptaculum seminis commences with a narrow portion, the ductus seminalis (*d. s.*), followed by two irregular dilatations, the equivalent of the capsula seminis (*c. s.*). To the dilatations succeed in turn a slender tube or gland (*gl., r. s.*), which is much longer than the imago itself, and consequently is shown only at its commencement. Von Siebold (*op. cit.* p. 420) states that the capsula is a dilatation of the duct in *Papilio Machaon* and *Hipparchia* (= *Cænonympha*) *pamphilus*. In *Pieris brassicæ* it is, as is usually the case, a pyriform vesicle. It is absent in *Danais Archippus* (*Anosia plexippus*) according to Burgess (*op. cit. supra*). The whole receptaculum is called the "eihörniges Absonderungsorgan" by Herold, who regarded it as a gland. Von Siebold, however, has found the capsule filled with sperm after coition (*op. cit.* p. 419)\*. The gland attached to the capsule is never absent, and in some instances terminates in a fork (von Siebold, *op. cit.* p. 420), *e. g.* in *Sphinx ligustri*. The paired posterior gland (*s. gl.*) is said by von Siebold (*op. cit.* p. 393) to secrete the substance that coats the ova and glues them to some foreign body. He calls it a sebaceous gland. The two tubular portions, or glands proper, are of immense length and tenuity, and their origins only are drawn in the figure. The two vesicles in which they end are here confluent, but in *Pieris*, as is usual, are completely separate; they have always a common duct leading to the azygos oviduct. The odoriferous glands are not universally present in Lepidoptera. Von Siebold records their existence in *Argymnis melitea*, *Zygæna*, &c. (*op. cit.* p. 417, or 'Anatomy of Invertebrated Animals,' translated by Burnet, London and Boston, 1854, p. 453, note 22). They are not figured by Herold in *Pieris brassicæ*, and may not exist in that species.

No explanation has yet been given as to how it comes about that there should be two separate apertures to the female ducts of the Lepidoptera, though the existence of the two apertures has been known from the days of Malpighi. De Lacaze-Duthiers has

\* The complete absence of the capsula in *Danais* (= *Anosia*), as described by Burgess, might seem to militate against Von Siebold's statement. It is no doubt replaced functionally in this butterfly by the dilatation present on the seminal canal, and termed by Burgess spermatheca. He does not, however, mention whether or not he ever found it full of sperm.

devoted a paper to the order in his researches on the female genital armature of the Insecta. Herold has treated of the development of the organs in both the male and female of *Pieris brassicæ*, and Suekow has investigated in a similar way *Dendrolimus pini*. Bessels's paper in the 'Zeitschrift für wiss. Zool.' xvii. 1867, deals solely with the testes and ovaries, their development, and the larval ducts in connection with them\*.

The conclusions come to by de Lacaze-Duthiers (Annales des Sci. Nat. (3), xix. 1853) may be shortly summarized to the following effect:—First, the aperture of the bursa copulatrix is in connection with the seventh abdominal sternum, and is a peculiarity of the Lepidoptera not met with elsewhere among Insecta. Secondly, the oviducal aperture is in the eighth somite, the normal position among Insecta; and its proximity to the anus is to be explained by the loss of the somites (ninth, tenth, and eleventh) which very commonly intervene between them. Thirdly, the abdomen is composed of eight somites; in the imago it appears, however, to consist in some instances of nine, even where another species of the same genus has but eight. The explanation is that a delicate lamella may be intercalated between the thorax and the first abdominal somite. The latter, in this case, is connected to the thorax by two processes, one on either side the lamella in question.

All these conclusions appear to be, I regret to say, incorrect. Their incorrectness may be deduced by reference to Pl. XVI. figs. 21, 22, 23, and 24, which represent the abdomen of the caterpillar, of the newly formed pupa, of the chrysalid more than one day old, and of the imago, of *Vanessa Io*. And the figures given not only display the somites of the abdomen, but, as they are drawn to the same scale, they show another point, the change of shape and size undergone by this part of the body in the passage from the larval to the imaginal state. It is a change often overlooked, and the only writer who has lately drawn attention to it is Graber, in his work 'Die Insekten' (Naturkräfte Series, xxii, 1877, pp. 513, 514); but his figures are small and diagrammatic †.

The older authorities on Entomology assign nine somites to the abdomen of the caterpillar. Packard has drawn attention to the fact that ten is the usual number (American Naturalist, xix. 1885, pp. 307, 308). This was the number found by Kowalewsky in the embryo of *Smerinthus populi*, all ten somites bearing feet (Mém. Acad. Imp. St. Pétersbourg (7), xvi. 1871, p. 53, Taf. xii. figs. 8 and 10); but I note in an abstract of Tichomiroff's Russian paper on the development of *Bombyx mori* that he found eleven abdominal somites in the embryo of this moth, all provided with feet save the first (Naples Jahresberichte, 1882, Hexapoda, p. 142) ‡. The first eight abdominal

\* Cholodkowsky has figured the genitalia in a young stage of *Abaxias (Zerene) grossulariata* (Zeitschrift f. wiss. Zool. xlii. T. xix. fig. 2); and Emerton has published some notes on the changes in the internal organs of the pupa of the Milk-weed Butterfly (*Anosia pleurippus*) in the 'Proceedings of the Boston Soc. Nat. Hist.' xxiii. pt. 4, 1888. But neither of them advances our knowledge of the subject in the least, beyond what was stated by Herold.

† For the remarkable diminution of weight which occurs in the pupa, see Poulton, 'Trans. Entom. Soc.' 1886, pp. 170–179, and Urech, 'Zool. Anzeiger,' xi. 1888, p. 205 *et seqq.*

‡ In the embryo of *Gasteropacha quercifolia*, Graber found the abdominal segments at first devoid of appendages. When the latter appear they develop only on those segments in which they persist in the adult. He therefore considers them as *secondary* appendages (Morph. Jahrbuch, xiii. 1888, pp. 609, 610).

somites of the larval *V. Io* have each, as is usual, a pair of spiracles, the ninth has none, the tenth bears the anal valve and anal prolegs. The distinctness of the ninth somite from the tenth was hinted at by Lyonet. The posterior ring, he says, appears "à la vérité souvent, comme ici, composé de deux; mais pour conserver l'uniformité, il convient de ne le considérer alors comme un seul anneau subdivisé" ('*Traité Anat. de la Chenille qui ronge le bois de saule*,' 1762, p. 21 of the "description anatomique"). Later on, in treating of the musculature, he speaks of the last ring, his ninth, as consisting of an anterior and posterior part. His figures demonstrate the separateness of the two portions. Sir John Lubbock assigns nine somites to the abdomen of *Pygæra (Phalera) bucephala*, as is clear from pp. 183, 184 of his memoir relating to the muscles of the caterpillar of that moth (*Trans. Linn. Soc. xxii. part iii. 1858*), but it does not appear that he regarded the tenth as a separately existing somite. A glance at Pl. XVI. fig. 29 proves at once that the ninth somite in *Vanessa Io* is completely separated from the tenth, and that it has bundles of muscles, fewer in number than the eighth, but strictly conformed to the same type. The latter statement would not be exactly true of the tenth somite. Attention may also be drawn to the existence on the ninth segment of this caterpillar of a latero-dorsal spine, and a tubercle with a small hair-like spine, representing the second row of spines of preceding segments; see Pl. XVI. fig. 21 and its description. W. Müller has drawn attention to a similar fact in the caterpillar of *Aeræa pellenea* as showing the double character of the so-called twelfth (*i. e.* ninth abdominal) segment (*Spengel's Zool. Jahrbücher, i. 1886, pp. 529, 530*).

In the pupal condition (Pl. XVI. figs. 22, 23) the same number of somites may be traced as in the caterpillar, and it is a curious fact that Kirby and Spence (*Introduction, iii. 1826, p. 251*) assign ten somites to the pupa, though not to the caterpillar. The two figures of pupæ here given are contrasted in certain respects. Fig. 22 is that of a pupa killed at the moment the suspended larva had begun to cast its cuticle, the operation being completed afterwards by dissection. It is slender, and its somites very distinctly separated from one another. Fig. 23 is that of a chrysalid more than one day old; it shows a stouter abdomen. The intersegmental membranes, which are of considerable extent in this species, are completely folded inwards and hidden; the rings of the somites are thus brought into close contact. This contraction in length and the greater stoutness of body are caused by the excessive shortening of the muscles soon after the assumption of the pupa state. The points to be noted in both figures alike are (1) the presence of eight pairs of spiracles, the first pair hidden by the wings in fig. 23, as is generally the case, whilst the last or eighth pair are, as usual, abortive, a fact evident on comparing Pl. XVI. figs. 27 and 26 with fig. 28 and the description given\*; (2) the perfect distinctness of the ninth somite; (3) the replacement of the anal valve by the cremaster (*cr.*); and (4) the formation of the sustentor ridges (*s.r.*) and sustentors of Riley. The distinctness of the ninth somite in the pupa is also shown in the side

\* Herold states that the male pupa of *Pieris brassica* has eight abdominal somites, the female seven or doubtfully eight; that both sexes have alike six stigmata, the first somite always being devoid of one. He is in error in all these statements. See his '*Entwicklungsgeschichte der Schmetterlinge*,' pp. 34, 60, 69 and note, 84, and p. xxiii of description of plates.

views of *Pieris* and *Sphinx* on Pl. XV. figs. 3 and 14. The homology of the anal valve and cremaster was discovered by myself in 1876, but was not published till 1888 ('Forms of Animal Life,' edit. 2, p. 153). Mr. Poulton has confirmed the homology by the presence of a peculiar streak of colour in *Agria tau* (Trans. Entom. Soc. 1888, p. 566). But I have found lately that Riley gave the same homology in his paper "On the Philosophy of Pupation" ('American Entomologist,' iii. 1880, p. 162). Künckel, however, in a brief account published in the 'Comptes Rendus,' xci. 1880, pp. 395-397, just after the appearance of Riley's paper, stated that the cremaster was made by the fusion of the anal prolegs. The truth of Riley's view is proved by Pl. XV. fig. 18, where the cremaster is drawn as displayed by dissection within the anal valve of the larva. The terms sustentor ridges and sustentors are proposed by Riley in the paper just quoted. He homologizes the sustentors with the soles or "plantæ" of the anal prolegs, the sustentor ridges with their limbs. In this homology I believe him to be wrong. The sustentor ridges and sustentors are probably peculiar developments of the *body* of the tenth somite, found only in some Lepidoptera. The eminences on either side the anal furrow (Pl. XV. figs. 1, 4, 8, 11, *r.p.*), or rectal prominences, as they are termed by Riley, represent the prolegs. To this point I hope to return in my next contribution, and will only add here that the anus of the chrysalis lies just below the base of the cremaster, at the dorsal end of a long anal furrow which represents the furrow or depression between the two anal prolegs of the caterpillar.

The abdomen of the imago (Pl. XVI. fig. 24), as compared with the abdomen of both caterpillar and pupa, is not only less in size and bulk, but it appears also to consist of only nine somites, the number usually assigned to it. The first somite is short, its sternum fused to that of the second somite; its tergum is composed of a middle lobe, de Lacaze-Duthiers' lamella (p. 151, *ante*), and of two lateral lobes; its spiracle (*sp.*) is hidden at the bottom of a deep recess\*.

The following six somites (2-7) with their spiracles are quite distinct, but the seventh sternum is fused to the eighth, as is more clearly figured in Pl. XVI. fig. 25. The eighth somite (8) has a distinct tergum and sternum, the latter containing the orifice of the bursa copulatrix (Pl. XVI. fig. 25, *a.b.c.*). Its spiracles are lost; indeed the atrophy of the tracheæ which originates from the abortive eighth spiracles of the pupa is nearly complete by the 4th or 5th day of pupal life in *Vanessa Io*. In a male imago of *Sphinx ligustri* I have seen slight scars indicating their position.

There remains the anal cone or papilla (*t.a.p.*, Pl. XVI. fig. 25), which contains the oviducal aperture as well as the anus, and is usually denominated the ninth somite. I shall show further on (pp. 166-7, Pl. XIX. figs. 73, 75, 77, 78) that when the oviducal aperture shifts backward till it is close beneath the anus, an ingrowth or fold of hypodermis takes place surrounding the anus, oviducal aperture, and odoriferous glands. This fold corresponds to a small portion only of the tenth somite, *i.e.* to the anal area. Consequently I believe that it is more correct to maintain, at least with reference to

\* The peculiar conformation of the tergum of the first somite is, I believe, due to the presence of strong bundles of muscles which arise from its middle lobe and pass into the thorax. The existence of the spiracles of this somite in the spot indicated was verified by dissection.

*Vanessa Io*, that the part of the abdomen from the posterior edge of the eighth sternum, and the spot where there is a slight fold in the pleural membrane of either side (Pl. XVI. fig. 25,  $\times$ ) backwards, represents the ninth and tenth somites of the larva and pupa, now indistinguishable, whilst the terminal cone is a new formation within the area of the tenth somite. The cremaster of the female pupa, it may be added, undergoes complete atrophy, and is not represented in the imago.

It remains to give a summary of what is described by Herold in his 'Entwickelungsgeschichte der Schmetterlinge' (Cassel and Marburg, 1815), and by Suckow in his 'Anatomisch-Physiologische Untersuchungen der Insecten und Krustenthierc,' Th. 1 (Heidelberg, 1818), so far as their accounts relate to our purpose.

In the full-grown female larva of *Pieris brassicæ*, the species investigated by Herold, the larval oviducts which are continuous with the larval ovaries run backwards near the dorsal middle line; they pass between the tracheæ given off from the seventh pair of stigmata, and are attached to a main trachea of the bundle by a filament; they each turn towards the ventral middle line in the seventh somite behind the seventh stigmata, pass beneath the main longitudinal and oblique muscles of the somite, and are attached close together to the hypodermis (=Schleimnetz) in the middle ventral line at the posterior margin of the seventh somite\*. From the attached ends of the larval oviducts start fine longitudinal striæ which traverse the eighth sternal region and connect the larval oviduct to a white mass composed of two oval pieces attached to the hypodermis (=Schleimnetz) beneath the rectum upon the intersegmental membrane immediately following the eighth somite (=auf der hintersten oder letzten ringförmigen Einkerbung der Raupenhaut, *op. cit.* p. 10). During the quiescent state preceding pupation the two oval pieces become approximated to the ends of the larval oviducts, owing to a shortening or contraction of the hypodermis (Schleimnetz). As soon as pupation has taken place, they fuse with the oviducts and acquire a soft loose consistence (eine weiche und aufgelockerte Consistenz, *op. cit.* p. 49). During the pupal state the two larval oviducts fuse together at their point of union with the oval pieces to constitute the common (*i. e.* azygos) oviduct, whilst the oval pieces give rise to three processes, a left larger, the rudiment of the bursa copulatrix (Herold's "Samenbehälter"), a right smaller, the rudiment of the receptaculum seminis (Herold's "ein-hörniges Absonderungsorgan"), and a bifid posterior, the paired sebaceous gland (Herold's "zwei-hörniges Absonderungsorgan"). The mass which gives rise to these processes disappears, whilst they increase in size and acquire the form they possess in the imago. Herold nowhere explains how the two separate apertures to the genital duct are acquired; nor can any information be gained from his text or later plates (Taf. xxvii., xxix., xxx., xxxi., and xxxiii.). But he was quite aware of their existence and describes them in his account of the genital organs of the imago with good figures (Taf. iv. figs. 1, 2).

Suckow's investigations were carried out on *Dendrolimus (Odonestis) pini*, or, as he terms it, following Linnæus, *Bombyx pini*. His results agree with Herold's, but certain slight differences may be noted. The two filamentous oviducts are prolonged beyond

\* Herold describes the course of the ducts correctly, but the way in which he figures them in his plates (Taf. vii., ix., xi.) is most misleading.

their point of attachment between the seventh and eighth somites as two separate broader and longitudinally striated bands, which end in contact with two small white knobs. They shorten gradually in the quiescent caterpillar, and are thickened at the commencement of pupal life. By their union they form the vagina. The two knobs just mentioned are, at the outset, separated from one another by a slight space, and are fixed to the hypodermis (Schleimnetz). A nerve derived from the terminal ganglion of the chain passes to each of them. Whilst the formation of the vagina is taking place, the knobs approach one another and unite; moreover they are brought by the contraction of the muscles and skin in pupation into opposition with the attached ends of the two oviducts, a statement which seems somewhat at variance with what is said as to the origin of the vagina. They are destined to give rise to four swellings, the rudiments of the bursa, the receptaculum, and the two sebaceous glands. The latter, with a want of consistency, are said to be derived from "the knobs themselves." Suckow, like Herold, does not explain how there come to be two oviducal apertures, though he knew them to be present, nor do his two plates (Taf. v., vi.) afford any clue to a solution of the difficulty.

My own investigations now to be detailed have been carried out entirely on *Vanessa Io*. It was my intention to re-examine *Pieris brassicæ*, but unfortunately there was a great scarcity of this butterfly at the beginning of the year 1889, and neither my own exertions nor the exertion of friends could procure a sufficient supply. I hope, however, to supplement next year the material now in my possession, and to give the results in my next contribution. Of *Vanessa Io* a large supply of specimens was obtained on July 10th and 14th from one and the same locality on the banks of the Isis. The history of these specimens may be shortly stated in the form of a table:—

Killed as larvæ by <i>Tachinæ</i> . . . . .	14
Dissected and preserved as larvæ . . . . .	44
Killed by accidents in pupation . . . . .	5
Pupæ of undetermined sex . . . . .	17
Male pupæ . . . . .	123
Female pupæ . . . . .	137
	340

In addition to the fourteen larvæ killed by *Tachinæ*, two pupæ subsequently perished by the same means. As to the pupæ of undetermined sex, it may be explained that if a pupa fails to catch hold of its pad of silk and consequently falls to the ground, owing to the strong contraction of the muscles which sets in soon after pupation, the abdomen becomes curved towards the ventral aspect, and the eighth and ninth sterna are drawn beneath the seventh sternum, so that the sexual apertures are completely hidden.

There are two points of biological interest connected with the pupæ to which I should like to draw attention briefly.

The first is the large proportion of females as compared with males, which contrasts greatly with what was found by Bessels in other species. Even supposing that the

seventeen pupæ of undetermined sex were all male, an unlikely occurrence, and it is to be regretted much that pressure of work prevented my examining closely the butterflies to which they gave origin, there would be 140 males to 137 females, *i. e.* about equal proportions of the two sexes\*. Another more curious circumstance was noted. The friends who kindly accompanied me and helped me to collect the specimens took their supply from different colonies of caterpillars from those from which I took my own supply. Our several finds were kept in different boxes, and it was found subsequently that the individuals in the several boxes were principally, but not entirely, of one or of the other sex. How far the colonies in which the caterpillars of *V. Io* feed may be derived from different batches of ova I do not know.

The second point relates to the coloration of the pupæ. It is a well-known fact that the pupæ of the Peacock butterfly may be very dusky in colour or green and golden. Every pupa that I saw actually at the moment of casting the larval skin possessed a light green hue; the only noticeable difference between individuals lay in the colour of the cœlomic fluid contained in the wings. The darker the tint the pupa was destined to assume, the darker the green of that fluid. My pupæ fell naturally into three classes.

(1) A large number of caterpillars suspended themselves singly on the food-plants, the common nettle. The part of the nettle, stalk, or leaf to which they were suspended was for convenience removed and pinned to the underside of a box-lid which was then placed over the box. They consequently hung in the dark. The pupæ to which they gave origin were yellow-green, their spines reddish, tipped with black. They had bright golden specks at the bases of the abortive spines of the anterior somites and a few pigmented streaks on the wings. Three caterpillars found by myself and my friend Mr. Latter, suspended to the nettles in the nettle-bed whence we obtained our supplies of specimens, pupated within a few hours of their capture and belonged to this class.

(2) Many caterpillars suspended themselves in larger or smaller groups to the nettles, to the sides of the boxes in which they were kept, or to the muslin covering the open tops of the boxes. The pupæ to which they gave origin differed *inter se*. Those at the

\* Bessels gives the following table of the numerical relations of males to females as he observed them (*Zeitschrift für wiss. Zoologie*, xvi. p. 560):—

Species.	No. of males.	No. of females.
<i>Pontia brassicæ</i> . . . . .	70	19
<i>Sphinx euphorbiæ</i> . . . . .	100	35
<i>Gastropacha rubi</i> . . . . .	40	10
„ <i>potatoria</i> . . . . .	48	13
<i>Mamestra brassicæ</i> . . . . .	80	30

The names are as he gives them. I have a number of pupæ of *Pieris brassicæ* (winter brood) at the present time. There are 26 males to 37 females.

Mr. Doncaster, of the Strand, has lately permitted me to go over a number of pupæ. The following notes as to the relative proportions of males and females were taken:—*Papilio Machaon*, ♂ 21, ♀ 28; *P. podalirius*, ♂ 37, ♀ 35; *Thais carysi*, ♂ 24, ♀ 20; *Sphinx ligustri*, ♂ 19, ♀ 17; *Smicrinthus populi*, ♂ 15, ♀ 20; *Sm. tiliæ*, ♂ 35, ♀ 29; *Charocampa alpenor*, ♂ 49, ♀ 50; *Diantharia irregularis*, ♂ 12, ♀ 5; *Hadena glauca*, ♂ 8, ♀ 3; *H. chenopodii*, ♂ 17, ♀ 13; *Nyssia zonaria*, ♂ 21, ♀ 22.

outer margins of the groups resembled very closely the pupæ in class (1), whereas those in the centre were more and more dusky according as the group contained more or fewer members. There was in fact a regular gradation in the amount of black pigment present.

(3) A large number of caterpillars which had just ceased to feed were placed at the bottom of an empty wooden box; the box was covered with muslin, and over the muslin was placed the lid of a linendraper's box covered with purple-black paper. The dark side was turned to the caterpillars; the lid overlapped the box by six inches at least on every side, and it was pressed down by a weight. The prisoners were thus in absolute darkness. Without exception they suspended themselves to the muslin, and the pupæ to which they gave rise had extremely dark bodies and peculiar sooty-looking wings. The golden spots at the base of the abortive spines were scarcely visible\*.

These experiments on colour-variation, which were quite by the way, seem to me to bear out Mr. Poulton's conclusions, formulated in his paper on "The cause and extent of a Special Colour-relation between certain exposed Lepidopterous Pupæ and the surfaces which immediately surround them," in the 'Philosophical Transactions,' vol. 178, 1888, p. 311 *et seqq.*

Turning now to the development of the azygos oviduct with its accessory organs, I shall divide their history into the following five stages:—(1) the full-grown caterpillar; (2) the formation of the azygos oviduct, which occurs during the quiescent period preceding pupation; (3) the stage during the time in which the bursa copulatrix is still in direct union with the oviduct; (4) the stage in which it acquires its adult indirect union; (5) the formation of the terminal papilla of the abdomen. This mode of division seems to me better than taking stages of so many days old. As a matter of fact different

\* My friend Mr. Mitchell was rearing caterpillars of *V. urticae* at the same time that I was rearing those of *V. Io*. He fed them in a dark brown box with a few holes punched in the lid for the sake of ventilation. The holes were small and could have admitted but little stray light. The caterpillars turned to pupæ which were uniformly of a very dark hue with a slightly reddish ground-tint. Among the nettles brought to me I found two pupæ of *V. urticae* of the most brilliant golden and green hue, so golden and green, in fact, that my friend Mr. Poulton declared them both to be ichneumonid. He was right as to one, and wrong as to the other, which produced a perfect butterfly.

The difference noted in the text in the tone of the green colour of the œolomic fluid, in accordance with which the pupæ became light or dark, was very striking. Another point worth recording was the presence, at least here and there, of a red pigment in the hypodermis (as I suppose) of the caterpillar preparing to pupate, but not visible, however, in the newly formed pupæ, and the brilliant ruddy hue of the residue of food in the digestive tract. It has struck me that an examination of the following points might yield interesting results in connection with the variability of the colour of pupæ of *V. Io*:—the spectroscopic quality of the light passing through the larval cuticle; the origin, distribution, and fate of the red pigment of the hypodermis; the effect produced by the evolution of the yellow fat-body which increases so enormously in bulk after the suspension of the caterpillar; the spectroscopic value, if any, of the yellow colour of the fat-body, and of the green-coloured œolomic fluid of caterpillars reared in light and darkness. It is probable that an answer to these points, into which I hope to enquire in the course of next summer, may lead to a comprehension of the physical basis underlying the colour-changes of pupæ. As all the newly formed pupæ of *V. Io* have much the same tint, and the pigmentation is produced rapidly after the assumption of the pupal state, it seems to me that much must depend on the nature of the nutritive material supplied to the pigment-producing cells by the œolomic fluid.

individuals do not develop quite at the same rate. My caterpillars taken on July 10, pupated between July 13 and 17; the butterflies emerged between August 1 and 4, *i. e.* they were 20 to 23 days in the pupal condition, or as a possible maximum 23 days, and as a possible minimum 16 days. The second batch taken July 14 pupated between July 18 and 22, and emerged between August 3 and 7, *i. e.* they were in the pupal state 17 to 21 days, or as a possible maximum 21 days, and as a possible minimum 13 days. It may be added that in both sets of instances emergence was quite irregular, or, in other words, those which pupated first did not necessarily emerge first. It is stated by implication in Buckler's 'Larvæ of the British Butterflies and Moths,' edited by Stainton, Ray Soc. 1886, i. p. 179, that the pupal state of this butterfly lasts 13 to 15 days. The great prolongation of time in some, at least, of my own specimens was due beyond a doubt to the cold weather that set in just after they became pupæ, and the fact that emergence of the whole batch took place within the limits of one week was caused by the sudden heat that began on July 29 and lasted through the first week of August.

#### (1) THE FULL-GROWN CATERPILLAR.

The larval ovaries are situated in the fifth abdominal somite, and close to the dorsal middle line, as in caterpillars of other species. Their proximal or attached extremities are approximated and they diverge from one another posteriorly. In colour they are whitish, with a yellow tint over their proximal halves, a tint which deepens in intensity during the quiescent period preceding pupation, and during the first few days of pupal existence. They are cylindrical in shape, but when the neighbouring parts of the fat-body are drawn away their outline becomes somewhat irregular owing to traction on the delicate filaments which connect their edges to the adjacent lobules of fatty tissue. Four opaque white lines, the future ovarioles, traverse the larval ovaries lengthwise and converge to their hinder extremities, from which spring the larval oviducts. The latter are very delicate filaments, extremely hard to see. If the caterpillar is still feeding they are generally free for their whole course or involved in the fat-body only here and there, but the nearer the quiescent period approaches, the more involved in it do they become. They run backwards more or less parallel to one another in the latero-dorsal region; they approach and pass between the tracheæ arising from the seventh pair of stigmata, and are tied, each by a delicate filament, to one of the main tracheal stems. They then turn abruptly towards the ventral aspect of the body and are attached to the hinder edge of a trachea. This trachea arises from the seventh stigma on each side, runs inwards beneath the musculature of the seventh somite, and unites with its fellow in the ventral median line. Each oviduct accompanies the transverse trachea of its own size as far as the ventral edge of the ventro-lateral longitudinal muscle-bundles. It then takes a curved course beneath the ventral longitudinal muscle-bundles to the spot where it is attached. This attachment is close to the posterior edge of the seventh somite, internal to, *i. e.* nearer the middle line than the attachments of the ventral muscles. A small space separates the attachments of the two oviducts. These facts are illustrated Pl. XVI. figs. 29, 30, 31, and are explained in the description of the figures. The

attached extremity of a right larval oviduct is figured Pl. XVI. fig. 32. The left oviduct of the same specimen had an exactly similar appearance, and both end in a single root. A delicate and short filament passes from the oviduct near its root to the hypodermis. It seems to consist simply of nucleated connective tissue, and in that case would point to the existence of a superficial coat of cells such as was found by Spichardt to invest the pupal vas deferens of *Liparis dispar*. He states that the coat was absent, however, in the pupæ of *Smerinthus ocellatus* and of other species examined by him, though it appears to be always present in the adult. See Verhandl. des naturh. Vereins der preuss. Rheinlande, 1886, pp. 7, 8, 28, 29. A small trachea also approaches the root of the oviduct, but I do not know its destination. Bessels, in the Zeitschrift für wiss. Zool. xvii. 1867, describes (p. 561) the oviduct as terminating in the hypodermis (Schleimnetz) by four unequal branches each of which "opens" separately; and he makes this mode of termination distinctive of the oviduct as contrasted with the vas deferens, which "opens" by a single slightly broadened out termination. He figures (Taf. xxxiv. fig. 30) the ventral end of the oviduct of *Gastropacha rubi*. The oviducts are at this period, as at a later, solid structures (Pl. XIX. fig. 59)\*.

The ventral muscle-bundles leave a small space in the median ventral line uncovered throughout the whole length of the abdomen. The chain of nerve-ganglia overlies this space. The terminal and compound ganglion of the chain is situated about its centre in the seventh somite and forms a very convenient landmark. In the vacant space of the eighth somite, and in its posterior half, is a rounded body divided by a median furrow into two oval halves, one right, the other left, rarely completely symmetrical and alike. A second body is placed in the vacant space of the ninth somite, but in its anterior half;

\* The male caterpillar may be at once identified by the following points of structure:—The testes are placed close together dorsally in the same somite as are the ovaries, but each of them is a deep orange-coloured semilunar body divided by three furrows into four segments one behind the other. The convex aspects of the testes are turned towards one another. The rudiments of the four future testicular tubes are placed transversely. The vas deferens originates from the concave aspect of the testis and from its third segment. It passes behind the eighth abdominal spiracle, and then turns round the bundle of tracheæ originating from that spiracle towards the ventral line, but above, not under, the musculature. The two vasa deferentia are attached to the anterior edge of a small disc-like body, which in its turn is attached by filaments to the ventral surface of the rectum, and not to the hypodermis as Herold states of *Pieris brassicae*. The invagination of hypodermis destined to form the ductus ejaculatorius and accessory glands takes place in the ninth somite, and in the position occupied by the paired posterior vesicles of the female (Pl. XVII. fig. 33).

The testes and ovaries are often dissimilar in colour. Bessels gives the following table (Zeitschrift für wiss. Zool. xvii. p. 553):—

Species.	Ovary.	Testis.	Fat-body.
<i>Liparis dispar</i> . . . . .	Yellow.	Flesh-red.	White.
<i>Gastropacha potatoria</i> . . . . .	„	Yellow.	„
<i>Sphinx euphorbiæ</i> . . . . .	„	Reddish.	Yellow.
<i>Pontia brassicæ</i> . . . . .	„	Violet.	White.
<i>Cossus ligniperda</i> . . . . .	White.	White.	„

*Sphinx ligustri* and *Phalera bucephala* agree, I find, with *Cossus*. In *Pontia* (= *Pieris*) *brassicæ* the fresh fat-body posteriorly to the 6th segment is greenish or olive-yellow, anteriorly to it opaque yellow or green on the dorsal aspect, but on the ventral aspect white. The fat-body of *Vantessa Io* is yellow and becomes orange in the pupa.

it is divided by a furrow into two almost pear-shaped halves, the broader ends of the pears being apposed, their stalks represented by filaments, usually double, rarely single or incompletely double. The two bodies, the anterior in the eighth somite, the posterior in the ninth, are completely independent one of the other; the ninth intersegmental furrow crosses between them. The furrows which divide them into two halves, a right and a left, indicate their bilateral character. In *Pieris brassicæ*, which possesses paired bodies of exactly similar character, the furrows are deeper, and in *Phalera bucephala* the two halves are at first independent and separated by a space. They may be originally independent in *Vanessa* and *Pieris*, but if so it is at a stage earlier than any I have seen. Transverse sections of the bodies show that they are formed by wide-mouthed and shallow invaginations of the hypodermis. The filaments attached to each half of the posterior vesicle are also attached at their opposite extremities to the rectum. The anterior filament consists of connective tissue, inclosing a trachea. The posterior consists similarly of connective tissue, but it contains a well-defined band which looks like degenerating muscular tissue. In my specimens no cross striæ are visible in it, and consequently its nature must remain for the present undetermined. Both filaments spread in a radiating fashion over the roof of the vesicle. They atrophy away and disappear entirely by the time the larva becomes a pupa.

The paired bodies of this stage are seen on Pl. XVI. fig. 29, and on an enlarged scale Pl. XVII. fig. 33. The series of sections Pl. XVII. figs. 50 *a*, *b*, *c*, *d*, belong to the earliest stage in my possession, Pl. XVIII. figs. 52 *a*, *b*, *c*, to a later stage. They are taken from the first pair of vesicles and show very clearly their paired character. In certain of the sections (figs. 50 *c*, 50 *d*) a small lateral fold ( $\times$ ) may be noticed. Comparing them with the corresponding sections of an older stage, Pl. XVIII. figs. 52 *a*, 52 *b*, it will be noted first that the lateral folds ( $\times$ ) have increased in depth, and that the vesicle itself is perched upon them, is deeper and somewhat less evidently paired. The lateral folds in question are the first indications of the median portion of the azygos oviduct; at present they extend no further than the base of the vesicle. Figs. 51 *a*, *b*, Pl. XVII., represent sections of the posterior pair of vesicles of the early stage, and they differ but little from the corresponding sections (figs. 53 *a*, *b*, *c*, *d*, Pl. XVIII.) taken from the later stage.

It is generally said that no cell-outlines are distinguishable in the hypodermis of Insecta, and that it consists of a layer of protoplasm with scattered nuclei overlying a homogeneous basement-membrane (see A. Schneider, Zool. Beiträge, ii. pt. 1, pp. 82, 83), but if a reference is made to Pl. XVI. fig. 32, it will be seen that cell-outlines are very distinctly indicated in the hypodermis of the caterpillar of *V. Io*. And it seems to me in consequence that the lines crossing the sections of the vesicles at this stage do really indicate cell-outlines. Further particulars as to this point are given in the account of the next or second stage of the development.

## (2) FORMATION OF AZYGOS OVIDUCT.

The formation of the azygos oviduct, and the changes which accompany it, take place during the quiescent period preceding pupation. The characteristics of this stage may be summarized thus. They comprise:—

- (1) Changes in the two pairs of hypodermic vesicles of the larva;
- (2) The formation of the azygos oviduct and the establishment of the apertures of the bursa copulatrix as well as of the oviduct; and
- (3) The connection of the paired larval oviducts to the azygos oviduct.

It will be seen therefore that the second stage is one of prime importance in the history of the organs with which this investigation deals.

The first pair of vesicles loses completely all trace of its original paired character. There is a gradual increase in size and at the same time an elongation in the antero-posterior direction. The two ends of the vesicle increase in length and become pointed, especially the posterior end (Pl. XVII. figs. 34, 37, *bc.*, *rs.*). And as the time of pupation approaches, the anterior end becomes more swollen and even slightly bilobed, though this, I am inclined to think, may be an abnormality, whilst the posterior end increases still more in length, and is bent down upon itself to the left side (Pl. XVII. fig. 36, *bc.*, *rs.*). It is readily seen from a comparison with later stages that the swollen anterior end of the vesicle is the future bursa copulatrix, and the pointed posterior end the future receptaculum seminis.

The posterior pair of vesicles also increases in size and in length, and towards the end of this stage gives origin to two posterior tubular processes (Pl. XVIII. fig. 54 *k*, *gl.*). The two processes increase in length and become curved ventrally upon themselves so that they are cut twice over in sections taken from specimens about to pupate (Pl. XVIII. fig. 55 *i*, *gl.*, *gl.*). In fact the external appearance at this stage is very similar to what is seen in Pl. XVII. figs. 38, 39, *gl.*, *gl.* The dorsal median part of each vesicle is converted partly into one of the tubular processes in question and partly into a common or single short anterior portion, which subsequently connects the two tubes with what is now the widely open basal portion of the vesicles from which the extreme posterior portion of the azygos oviduct is developed, see figs. 54 *g*–54 *k*, Pl. XVIII. The basal or oviducal portion closes ventrally, just before the larva becomes a pupa but remains in continuity with the hypodermis. It leaves, when it closes, a small aperture, the future oviducal aperture, at its anterior end (Pl. XVIII. figs. 55 *f*, 55 *g*).

The azygos oviduct is formed in three portions: first, the part underlying the anterior pair of vesicles, which is partly developed in the preceding stage; secondly, the part which connects the anterior vesicle to the larval oviducts, which is established next; and thirdly, the part connecting the anterior vesicle to the posterior vesicles. The two latter parts differ in their mode of origin.

The median portion is completed early in this stage. The two folds noted in the previous stage, one on each side of the anterior vesicles (Pl. XVII. fig. 50, Pl. XVIII. fig. 52,  $\times$ ,  $\times$ ), increase in vertical height, and their lower margins approach and fuse. The closure appears to take place first in front of the future bursal aperture and then behind it.

The development of the second portion is very rapid indeed. The hollow base (Pl. XVII. fig. 50, Pl. XVIII. fig. 52,  $\times$ ,  $\times$ ) upon which the first vesicle is raised extends forwards, but it does so apparently only for a certain distance. At present exact details as to the mode of growth at the apex of this portion are not clear to me. This much is certain that while near the base of the vesicle there is a tube with walls formed of a single layer of cells, the tube as it nears the larval oviducts becomes solid, and is more or less confounded with the hypodermis. My own impression is that there is an ingrowth from the hypodermis of cells which subsequently arrange themselves in the form of a tube; in other words the invagination of cells is at first solid. This impression is borne out by the section shown in fig. 56, Pl. XIX., which comes from a quiescent caterpillar. The cells of the hypodermis are at this time considerably elongated, at least in the posterior portion of the body of the animal. Moreover, they lie sloping forwards obliquely in the region of the oviduct and are consequently always cut at an angle in a transverse section.

The posterior portion of the azygos oviduct develops as a widely open furrow extending backwards from the anterior vesicle to the posterior vesicles, with the basal portion of the cavity of which it is continuous; in fact it is seemingly formed by a continuation of the two folds which elevate the anterior vesicle (Pl. XVII. fig. 50, Pl. XVIII. fig. 52,  $\times$ ,  $\times$ ). By the time the caterpillar is ready to pupate, the furrow is converted into a tube by the fusion of its edges.

The tubular azygos oviduct thus constituted opens to the exterior in two places, by a small aperture beneath the anterior vesicle, which coincides usually more nearly to the base of the receptaculum seminis than to the base of the bursa copulatrix, and by a second aperture just in front of the anterior end of the sebaceous region of the posterior vesicles. A well-marked external or superficial furrow corresponds to nearly the whole extent of the azygos oviduct, even after its complete establishment. The chitinous cuticle dips into this furrow, which is thus the cause of the longitudinal line crossing the sternal regions of the eighth and ninth somites of the chrysalis.

The facts stated above are illustrated in the series of figures given in Pl. XVIII. figs. 54, 55.

The larval oviducts are taken up by the anterior extremity of the first section of the azygos oviduct. Their ventral ends are at the close of this period perfectly separate from the hypodermis at the spot where the hypodermic ingrowth of cells to form the azygos oviduct becomes connected to them. It seems to me that they grow slightly at their ventral extremities towards one another; for the distance between the two ventral ends in the active caterpillar is certainly diminished in the quiescent caterpillar about to pupate. They are still solid in cross section at this time, and possess a single layer of superficial nuclei (Pl. XIX. fig. 59). A surface view of the ventral ends of the two ducts (Pl. XIX. fig. 58), taken from a caterpillar which had just entered on the quiescent stage, lends support to the idea that the oviducts grow ventrally.

If a section of the hypodermis at this stage, made more or less parallel to the surface, is carefully stained, it will be seen that it consists of distinctly darker areas surrounded by lighter lines. The darker areas, I believe, represent the bodies of the hypodermic cells connected by a small amount of intercellular substance (Pl. XVII.

fig. 47). In cross sections the hypodermis is marked by vertical lines indicating elongate cells; the nuclei are small and stain very darkly (Pl. XVII. figs. 48, 49). A detailed figure of a section through the walls of the azygos oviduct beneath the anterior vesicle is given (Pl. XIX. fig. 64), from which it will be seen that the walls of the oviduct, like the walls of the vesicle, have the same histological appearance as the cells of the hypodermis from the body-wall. In this figure there is also shown a coating or envelope of tissue (*m*) exterior to the layer of hypodermic cells. Similar tissue is found investing more or less the bursa copulatrix, receptaculum seminis, median and posterior portions of the azygos oviduct. It has, under a low power of the microscope, a finely granular look, quite different from that of the fat-body. Under a high power it appears to consist of minute irregularly shaped cells. It is present in later stages, and is found to assume, when a specimen is stained with borax carmine, a pink colour, quite distinct from the more yellow colour of the fat-body. It seems to me, in fact, composed of mesoblast cells derived from the ecdemic fluid (?), which give origin finally to the muscular and connective tissue coats of the genital apparatus, the invaginated hypodermis forming only the epithelium.

### (3) GROWTH AND CHANGES WITH THE BURSA COPULATRIX IN DIRECT UNION WITH THE AZYGOS OVIDUCT.

The period covered by this stage lasted in my specimens for about four days. The changes in shape and size which take place in the parts already formed will be readily understood from a study of Pl. XVII. figs. 38-45 and the following brief description.

The bursa copulatrix is at first a pyriform vesicle, with no stalk at all worth mentioning. It lies in the middle line and is placed very nearly vertically, a position which is exchanged for one slightly tilted backwards, then for one turning forwards and inclined more or less to the animal's right side, and last of all for one pointing straight forwards on the left side of the animal. The stalk or duct of the vesicle grows considerably in length, and becomes well marked off from the vesicle itself. The latter commences to grow somewhat later, and the sharp distinction between it and its stalk at the place where the two parts unite, may, as in the specimen figured Pl. XVII. fig. 44, be lost to a certain degree. This, however, is not invariably the case.

The receptaculum seminis is at the beginning of this period short and sharply bent down upon itself to the left; but it increases very rapidly in length, and the portion bent down becomes straightened. The whole structure is, in the early part of this stage, strongly inclined backwards, and to the animal's left side, but becomes by degrees more and more vertical. Its base or point of origin is at first placed a little to the left, and slightly behind the base of the stalk of the bursa copulatrix. The two gradually separate, and towards the end of this stage, the point of origin of the receptaculum is very decidedly behind the origin of the stalk of the bursa and on the median dorsal aspect of the azygos oviduct.

The changes undergone by the region of the posterior vesicles which gives origin to the paired sebaceous glands of the imago are considerable. At the beginning of the

stage the oviducal aperture is placed well in front of the anterior tubular end of the sebaceous portion (*cf.* p. 185 on fig. 65), which is separated throughout its whole extent on the ventral aspect from the hypodermis, the space between the two being occupied by intrusive fatty tissue. The two tubular portions, the future glands, lie parallel to one another, are sharply arched and curved upon themselves, and the portion common to them at their point of origin is flattened dorso-ventrally, of fair lateral extent, but of no great length (Pl. XIX. figs. 65, 66). As development proceeds the tubes show a general increase in size, become a little tortuous, but continue to be curved upon themselves. The common basal portion is a little shorter, slightly dilated on each side; the oviducal aperture is more directly beneath it, and consequently the tubular anterior portion of the gland apparatus is nearly vertical and somewhat confused with the azygos oviduct, as is seen from the sections Pl. XIX. figs. 67, 68. All the changes just detailed are more and more accentuated by degrees. The gland-tubes diverge from one another laterally and are directed backwards, but as they lengthen, curve forwards at their apices. The common basal portion is distinctly separated into a right and left dilatation, connected as sections show (*cf.* figs. 67, 68) to the azygos oviduct by a short and distinct tubular duct hidden in the vertical view beneath the common basal portion. The oviducal aperture is now placed immediately below or slightly behind the common basal portion of the gland tubes. Finally, as may be seen from Pl. XVII. fig. 44, the duct (*d.v.gl.*) connecting the two dilatations or vesicles of the sebaceous glands to the azygos oviduct lengthens out, and the azygos oviduct itself extends backwards (*p.odl.*), carrying its aperture, *i. e.* the oviducal or posterior aperture, with it.

As to the azygos oviduct. At first, that is to say at the time corresponding to fig. 38, Pl. XVII., no change of any noticeable degree is obvious from what obtained at the close of the preceding stage. Its anterior or bursal aperture lies just below the bases of the bursal and receptacular outgrowths (Pl. XVIII. fig. 55 *d*), its posterior or oviducal aperture is just at the anterior end of the sebaceous apparatus (Pl. XVIII. fig. 55 *f*). Both apertures are very minute and very close together. At the time corresponding to fig. 40, Pl. XVII., its anterior extremity is still solid, but the portion in front of the bursal aperture is rounder in cross section than it was, and separated by a greater distance from the hypodermis, fatty tissue intervening. The portion of the azygos oviduct behind the bursal aperture and in front of the oviducal aperture is now clearly separated from the hypodermis by a space filled with intrusive fatty tissue (Pl. XVII. fig. 41). The oviducal aperture itself is nearly directly below the base of the sebaceous vesicles. At the close of this stage the bursal aperture is connected by a tubular duct (Pl. XVII. fig. 45) to the azygos oviduct, and the oviducal aperture is still further back, situated well behind the base of the sebaceous vesicles (Pl. XVII. fig. 44, *p.odl.*).

The paired oviducts increase in size, and at the period to which fig. 40, Pl. XVII. belongs have acquired a distinct lumen (Pl. XIX. fig. 60). The lumen is a fine channel which appears to extend ventrally, or in other words it develops in a direction proceeding from the ovary towards the azygos oviduct. It never communicates with the latter until the parts have assumed the size and proportion shown in figs. 61, 62,

Pl. XIX., which in the case of my specimens indicates a lapse of about three days or rather more from the close of the previous stage. The communication is figured Pl. XIX. fig. 62. I am inclined to think that it is not established sometimes till a yet later period.

There is nothing much to be noted in the histology of the organs during this stage. Their walls are composed of a single layer of cells. The chitinous cuticle lining the azygos oviduct and its apertures to the exterior is very much more distinct than it was; and a delicate cuticle may be traced in the stem of the receptaculum seminis and the vesicles of the sebaceous glands. The minute cells mentioned before (p. 163) as coating the azygos oviduct, especially the portion between the two external apertures, may be traced in a thin coat over the paired oviducts, anterior section of the azygos oviduct, duct of the bursa, stem of the receptaculum seminis, duct and vesicles of the sebaceous glands. There does not seem to be any change in the histological appearance of these cells.

(4) THE INDIRECT UNION OF THE BURSA COPULATRIX WITH THE AZYGOS OVIDUCT,  
AND THE DEVELOPMENT OF THE ODORIFEROUS GLANDS.

The bursa copulatrix has up to this time been in direct union with the azygos oviduct. At the close of the preceding stage it assumes, as figs. 44, 45, Pl. XVII. show, a position decidedly to the left of the middle line of the azygos oviduct, a change of position which is shared by the tube connecting the azygos oviduct to the anterior or bursal aperture. The connection between the bursal duct and the oviduct is converted in this stage into a short tube which opens into the azygos oviduct on its dorsal aspect, and into the bursal duct itself laterally. This tube is the future seminal canal. It is shown in fig. 46, Pl. XVII., and in section in fig. 69, Pl. XIX. As may be seen from the latter figure, the course taken by it is not horizontal, but obliquely upwards from the oviduct to the bursal duct. Of the two ends of the tube the oviducal is larger than the bursal. In later stages it assumes an S-shaped curvature, and its oviducal end is frequently markedly dilated. It may be noted that the bursal duct proper is now in the same straight line or in direct continuity with the duct which previously led from the azygos oviduct to the anterior or bursal aperture. The duct last mentioned is derived, in the first instance, not from the anterior paired vesicle of the caterpillar, like the dorsal portion of the bursal duct of the imago, but from the azygos oviduct itself.

Another important feature at this period is the appearance of the two odoriferous glands. The posterior or oviducal aperture of the azygos oviduct continues to shift backwards; it is behind the vesicles of the sebaceous glands and near the anus. Eighteen to twenty sections intervene between it and the bursal or anterior aperture, as compared to four, five, or eight sections, at the assumption of the pupal condition. It is separated from the anus by only six to eight sections. In other words the distance it has gained in one direction it has lost approximately in the other. The odoriferous glands develop as two tubular ingrowths of the hypodermis, one on the right, the other on the left, of the middle line, perfectly distinct one from the other; that is to say, each of

them has its own separate aperture to the exterior. The ingrowths are in front of or anterior to the oviducal aperture, between it and the bursal aperture. They are near the oviducal aperture and underlie the anterior margin of the vesicles of the sebaceous glands. One of them is shown in fig. 74, *od.gl.*, Pl. XIX.

Two points of minor interest may be noted. The stem of the receptaculum seminis constantly bears near its entrance into the azygos oviduct a minute pyriform vesicle (Pl. XIX. fig. 70). This vesicle is evident to the naked eye in dissections belonging to later stages. It is not present in the imago, and it represents transitorily the pyriform capsula seminis of *Pieris* and many other Lepidoptera, which is replaced, functionally at least, by irregular dilatations of the receptaculum in *Vanessa*.

The second point is the almost complete disappearance of the furrow in the ventral hypodermis corresponding to the ventral furrow in the chitinous cuticle crossing the eighth and ninth sternal regions. The hypodermic cells themselves are of much diminished vertical length, and very readily separate from the pupal cuticle. On their outer surface is a darkly staining layer looking like a new cuticle. It is, I believe, a coagulable fluid, for in the next stage it is increased in amount, and in some of the sections the growing scales may be seen imbedded in it. There is also a curious median ridge of elongate hypodermic cells (Pl. XIX. fig. 71) running forwards for a short distance from the bursal aperture, which is now a deep funnel-shaped cavity. The cells of this ridge appear eventually to secrete the thickened glass-like chitin of the globular body covering the entrance to the bursal aperture; see p. 150, *ante*.

#### (5) THE FORMATION OF THE TERMINAL ABDOMINAL PAPILLA.

At the commencement of this stage, in specimens, that is to say, 24 to 36 hours older than the last described in the previous stage, the two odoriferous glands have increased in length, their apertures have approached one another medianly, or to put it in other words, and perhaps more correctly, the hypodermis forms a prominent ridge to the outer side of both apertures, so that they open into a common depression or pit. To the right and left of this depression there is a slight infolding of the hypodermis ( $\times$ ), the first indication of the formation of the terminal abdominal papilla. These facts are shown in the section drawn Pl. XIX. fig. 75. The infolding becomes a little deeper in sections following the one figured and taken from the same specimen (Pl. XIX. fig. 77,  $\times$ ).

In specimens about 24 hours older still, the changes thus described are much more conspicuous. The apertures of the two odoriferous glands are more deeply placed, and there appears to be a very short common vestibule, as may be gathered from the section figured (Pl. XIX. fig. 76). The condition of the parts closely approaches that which obtains in the imago. The lateral infoldings of hypodermis to form the terminal abdominal papilla are deeper, much more so indeed further back, as may be seen from a section through the anus (Pl. XIX. fig. 78,  $\times$ ). The oviducal and anal apertures are now so close together that the latter is cut through two sections behind the former. It may be added here, to point the contrast, that the anal aperture at the commencement

of pupal life was distant 2 millim. from the bursal aperture, and 1·7 millim. from the oviducal as measured approximately. At this stage it is about 1·75 millim. distant from the former, whilst, as just stated, it is now immediately behind the latter.

A dissection from a specimen slightly older than the one from which the sections were prepared is figured Pl. XIX. fig. 73. It shows the rectum (*r*) above, the oviducal aperture (*o.ap.*) in the middle, and the odoriferous glands (*od.gl.*) below, and the infoldings of hypodermis (*f.f*) surrounding them. The distance from side to side measured from the apex or ridge of one to the other fold is ·75 millim. approximately, and in a vertical direction from just above the rectum to the common base of the odoriferous glands about the same amount. The terminal papilla, which is represented by the area inclosed by the folds, consequently occupies but a small portion of the whole area of the tenth somite of the pupa. In this somite the vertical distance from the base of the cremaster to the spot where the ninth sternum ends between the sustentor ridges is 2·45 millim., and from the ridge of one sustentor to the ridge of the other at the spot where they are widest apart, 2·1 millim. These facts speak for themselves.

The only other points to be mentioned are the following:—(1) The paired oviducts are now very short, have increased in diameter, and their lumina are of considerable size (Pl. XIX. fig. 63). (2) The tubular duct connecting the sebaceous vesicles to the azygos oviduct takes now, as it does in the imago, a decidedly backward course. (3) There is a very well developed and thick coat of minute cells surrounding the median and posterior portions of the azygos oviduct, and the coagulable fluid (?) mentioned before (p. 166) is much increased in amount, and may be seen here and there imbedding the growing scales, and drawn out into irregular bands and filaments by the separation of the pupal cuticle from the hypodermis (Pl. XIX. figs. 72, 77, *cu.l.*).

The formation of the terminal papilla of the abdomen is the last feature requisite to complete the developmental history dealt with in the present paper. The generative organs have by this time almost assumed the proportions they possess in the imago. There is a slight further growth in size, but the final histological differentiation of the organs has scarcely commenced. It is not my purpose, however, to enter here into a detailed investigation of changes of the latter kind.

#### SUMMARY OF RESULTS.

##### § 1. *The External Anatomical Characters distinctive of Sex in the Chrysalis.*

1. The male chrysalis is characterized by a linear depression in the ninth sternal region.

2. The female chrysalis is characterized in one of the following ways:—

(i.) By two linear depressions, one in the eighth sternal region, the other in the ninth.

(ii.) By a longitudinal furrow crossing the posterior third of the eighth sternal region, and a similar complete furrow crossing the ninth.

- (iii.) By a continuous longitudinal furrow crossing the eighth and ninth sternal regions.
- (iv.) By a triangular forward extension of the sternal region of the ninth somite invading the sternal region of the eighth, together with *either* (a) a linear depression in the eighth sternal region, and another at the apex of the triangular extension, or (b) a single depression close to or in the apex of the triangular extension and produced by a confluence of the two depressions before mentioned.

§ 2. *Development of the Azygos Oviduct and its accessory Organs in Vanessa Io.*

(1) The paired oviducts of the imago are developed from the larval oviducts. The latter are, as stated by Herold, Suckow, and Bessels, attached at their ventral ends to the hypodermis near the posterior margin of the seventh somite, close together and in the median ventral line. They are at first solid, but acquire lumina early in pupal life. A little later their lumina open into the lumen of the azygos oviduct.

(2) The azygos oviduct is derived from the hypodermis; it may be divided into *three* sections, a median, an anterior, and a posterior.

The median section develops as two folds, one on either side of the anterior hypodermic vesicle (5 *infra*). The folds meet ventrally and fuse, leaving, however, an aperture, the future bursal aperture.

The anterior section, the first completed in order of time, appears to develop, so far as its posterior portion is concerned, by the ventral union of two folds extending forwards from the median section; but so far as its anterior portion is concerned as a solid ingrowth of hypodermic cells which becomes subsequently tubular. The anterior end of this section unites with the ventral ends of the larval oviducts while they are still solid.

The posterior section, the last to be completed in order of time, develops as a deep furrow formed by two lateral folds, an extension backwards apparently of the lateral folds, which give origin to the median section. They unite with the base of the posterior hypodermic vesicles (6 *infra*). The future oviducal aperture is left when the base of the posterior vesicle closes.

(3) The anterior aperture of the azygos oviduct or bursal aperture retains a constant position; it opens in the sternal region of the eighth somite. At first it leads directly into the azygos oviduct, but during growth the connection between the two becomes tubular, the tube being formed from the oviduct, and forming eventually the ventral portion of the bursal duct of the imago.

(4) The posterior or oviducal aperture is at first close behind the anterior aperture, but during pupal life shifts backwards and comes to be placed immediately below or in front of the anus.

(5) The bursa copulatrix and receptaculum seminis are both derived from a paired anterior vesicle, invaginated from the hypodermis of the eighth somite in its middle sternal region. The vesicle loses its paired character and overlies the median section

of the azygos oviduct. It grows in length antero-posteriorly. Its anterior end becomes swollen and develops into the bursa copulatrix; its posterior end becomes elongated and pointed, and develops into the receptaculum seminis.

The rudiment of the bursa copulatrix gives origin to the terminal vesicular portion of the organ and to that portion of the bursal duct which is dorsal to the point of entrance of the seminal canal. The bursa and its duct at first open into the dorsal aspect of the azygos oviduct; they then shift to its left side and are continuous with the tubular portion of the oviduct leading to the bursal aperture, which becomes the portion of the bursal duct ventral to the point of entrance of the seminal canal. Finally, the lateral connection between the bursal duct and the azygos oviduct becomes tubular and forms the seminal canal.

The rudiment of the receptaculum seminis is at first bent down upon itself to the left side; it increases rapidly in length and straightens out. It has a transitory pyriform vesicle appended to it. Later on it is differentiated into the three sections recognizable in the imago.

(6) The two sebaceous glands of the imago, their vesicles and common duct leading to the azygos oviduct, are derived from the median dorsal portion of the paired posterior vesicles invaginated from the hypodermis of the ninth sternal region, whilst the common or basal ventral portion of the same vesicles becomes the extreme posterior end of the azygos oviduct.

The anterior end of the dorsal portion retains an aperture into the azygos oviduct and becomes subsequently the tubular duct and the vesicular dilatations of the glands.

The posterior end of the dorsal portion grows out into two tubes, a right and left, the sebaceous glands proper. They are at first curved upon themselves and parallel to one another. As they lengthen they diverge and turn forward.

(7) The odoriferous glands of *Tanessa* originate as separate tubular ingrowths, a right and a left, from the hypodermis just in front of the oviducal aperture. Later on they acquire a common vestibule.

(8) It has been shown incidentally that the caterpillar and the pupa possess ten abdominal somites, corroborating Packard's statement as to the caterpillar.

(9) The terminal papilla of the abdomen of the imago is formed by the ingrowth of two folds of hypodermis, a right and left, inclosing a small portion only of the area of the tenth somite. Accordingly it does not represent a ninth somite, as is generally held; the whole ninth somite and the rest of the tenth somite of the pupa are not clearly marked off from the eighth somite of the imago. The cremaster disappears completely in the course of pupal life. The apparent eighth tergum of the imago probably represents the eighth and ninth pupal terga, and the tenth, if any portion of it is persistent. The pleural region of the ninth pupal somite and of the tenth, so far as it exists, is represented by the soft membrane lying behind the ridge extending dorsally from the eighth sternum of the imago (Pl. XVI. fig. 25 ×). As the bursal aperture lies near the centre of the eighth sternum, this region may possibly include in the imago a portion of the ninth sternal region as well. The softer integument behind connecting it to the base of the terminal papilla would in that case coincide with a portion of the

ninth sternum, and the ventral portion of the tenth somite of the pupa anterior to the place of origin of the terminal papilla.

(10) The eighth pair of abdominal spiracles is abortive in the pupa and is lost in the imago. The other seven pairs of abdominal spiracles persist.

(11) There is a cuticular secretion, apparently fluid, formed by the hypodermis just before the appearance of the scales.

There are a few points as to which further investigation or confirmation is necessary. They are the following:—the nature of the band contained in the posterior filaments attached on the one hand to the rectum, on the other to the posterior paired vesicles of the caterpillar; the exact mode in which the anterior section of the azygos oviduct originates; the way in which it becomes connected to the paired oviducts whether by its growing up to them, or by their growth uniting them to it; the details of the histological process by which the posterior oviducal aperture shifts backwards; the character of the secretion found in the later stages (4 and 5) between the hypodermis and the pupal cuticle. These various points I hope to determine in the course of next summer.

#### GENERAL CONCLUSION.

The uniformity which prevails in the structure of the genitalia of the Lepidoptera at large, so far as concerns essential features, is so great in the species that have been examined, that it warrants the assumption that a similar uniformity will be found to obtain in the mode in which they develop. It is true that Herold has given a very different account of the development as observed by him in *Pieris brassicæ* to what is stated in the foregoing pages. He has stated that the paired and azygos oviducts in that Butterfly are alike derived from the paired larval oviducts, and that the bursa copulatrix, receptaculum seminis, and sebaceous glands are all outgrowths of a common rudiment placed at the anterior margin of the ventral region of the ninth somite. Suckow's account of the development of the organs in *Dendrolimus pini* is identical in all essentials. But an examination of several full-grown female caterpillars of *Pieris brassicæ* has shown me that the very same rudiments are present in them as have been described in *Vanessa Io* in the present paper. So, too, the full-grown female caterpillar of *Phalera bucephala* and a one-day old female pupa of *Sphinx ligustri* have parts exactly similar to what are shown in Pl. XVII. fig. 33 in *Vanessa Io*. There can be little doubt that Herold's and Suckow's descriptions are erroneous, and that a fair uniformity prevails, at least in the Macro-Lepidoptera, in the mode in which the accessory female sexual apparatus develops.

It is a remarkable fact that very little has been done to elucidate the mode of origin of the secondary genital ducts and their appended accessory organs, either in the male or female, in different orders of Insecta\*. Balbiani asserted in 1872, but in general terms

\* ADDENDUM.—The statement in the text refers solely to developmental data. The presence of a chitinous cuticular lining appears to constitute a safe anatomical criterion for the purpose of differentiating the portions of the sexual apparatus derived from epiblast or hypodermis from those which are not so derived. See on the subject, as treated from a comparative-anatomy point of view, Palmén's work 'Ueber paarige Ausführungsgänge der Geschlechtsorgane bei Insecten:' Leipzig, 1884.

only, the independent origin of the ovarioles and the efferent ducts of oviparous Aphides (Ann. des Sc. Nat. 5, xv. no. 4, p. 43). But he regarded the vagina as a modified or enlarged portion of the common oviduct (*op. cit.* (5), xiv. 1870, no. 9, pp. 7, 8); he stated, however, at the same time, in the last-quoted memoir (pp. 8-11), that the accessory female organs were outgrowths of the vagina itself, an origin surmised by Weismann in his account of the post-embryonal development of the Muscidae (Zeitschrift für wiss. Zool. xiv. 1864, pp. 296, 297). Witlaczil has described in his 'Entwicklungsgeschichte der Aphiden' the formation of the vagina from an ectodermic invagination, and the derivation of the oviducts from the ovarioles, and in the oviparous female the outgrowths from the vagina which give rise to the accessory organs (Zeitschrift für wiss. Zool. xl. 1884, pp. 599, 605, 606). The same facts have been observed by Anton Schneider in several insects (*Coccus*, *Lepisma*, *Acanthia*, *Chironomus*, *Tenebrio*). His results are stated very briefly and without illustrative figures (Zool. Beiträge, i. 1885, pp. 263, 264). To the ectodermic invagination in both sexes he gives the name of "Herold's duct," and says that it was discovered by Herold in the male and female caterpillars of *Pieris brassicae*. This statement is, however, erroneous; no such discovery was made by Herold, as the text of his memoir or of the abstract of it given p. 154 of this paper will show. The most precise investigations on the subject have been made by Joseph Nussbaum in both sexes of two species of Pediculidae, *Lipeurus bacilus* and *Goniocotes hologaster*, parasites of the Dove, and in *Blatta orientalis*; but in the last named his observations on the female were only carried out to a certain extent, whereas they were complete in the case of the male. The account *in extenso* of his work was published with figures in the Polish language, to which was added a German summary in 'Kosmos,' Lemberg, 9th yearly issue. From the Naples 'Zoologischer Jahresberichte' for the year 1884, p. 148. Arthropoda, I gather that he describes also in this paper the development of the parts in *Culex*. I have not been able to see it, but in the record mentioned it is stated to be essentially the same as the preliminary paper published in the 'Zoologischer Anzeiger,' v. 1882, pp. 637-643. As to *Blatta* there is a brief account of the development, signed by Nussbaum in Miall and Denny's work on the Cockroach (Studies in Comp. Anat. iii. 1886). The formation of the reproductive organs is treated of on pp. 193-195, and figures given of the developing parts in the male.

Nussbaum's conclusions, as summed up by himself on p. 642 of the 'Zool. Anzeiger,' v. are to the following effect:—

(1) The current impression that the larval ducts unite with one another and give origin to the whole system of sexual ducts is incorrect; they form only the vasa deferentia or the oviducts.

(2) All other parts of the efferent apparatus (uterus, vagina\*, receptaculum seminis, ductus ejaculatorius, penis, and appended glands) develop from the hypodermis.

(3) The connective tissue and the musculature of the efferent apparatus are derived from mesoblast cells present in the body-cavity.

(4) The efferent ducts originate as paired rudiments. All azygos parts (uterus, penis,

\* The term "uterus" here is applied to what is usually called vagina, and the term "vagina" means, according to Miall and Denny, what is usually called genital pouch, so far, at any rate, as concerns the Cockroach.

receptaculum seminis, azygos glands, &c.) are at first paired. The azygos efferent apparatus of Insects must therefore be deemed as morphologically a secondary and more complicated form.

(5) The male and female efferent ducts are strictly homologous.

(6) The cavities of the oviducts, uterus, vagina in the female, of the vasa deferentia, appended organs and ductus ejaculatorius of the male arise independently and come into connection secondarily.

My own observations on *Vanessa Io*, which are, however, limited to the female, support Nussbaum's conclusions in most particulars. The larval oviducts which seem to come from the same embryonic rudiments, as do the ovaries themselves, are converted into the paired oviducts of the imago, whereas the rest of the efferent apparatus with its appended organs is derived from the hypodermis. The hypodermis, however, only gives origin to the epithelium of the organs; their connective and muscular tissues spring from other cells which appear to be contained in the cœlomic fluid or blood. The rudiment from which the bursa copulatrix and receptaculum seminis are derived is distinctly paired in *Vanessa*, more so in *Pieris brassicæ*, and most of all in *Phalera bucephala*, where the two parts are at first entirely separate. The paired character of the rudiment is lost, and then the bursa and receptaculum grow out, not from opposite sides, so that one of them might be considered as an organ belonging to the left side of the body, the other to the right, but from opposite ends, a very remarkable feature; consequently neither of them belong to one or other side of the body, but both equally to both sides, if regard be had to the primitive condition of the rudiment. Similarly the sebaceous glands, which are paired, are derived from the dorsal portion of a paired rudiment, the two parts of which are widely separated in *Phalera bucephala*. In these organs, however, the paired character of the rudiment is persistent, and the only fusion that takes place is in the portion which forms the vesicles of the sebaceous glands and the single duct that leads from them to the azygos oviduct.

The azygos oviduct itself, however, is not paired either primitively or at a later period, unless the posterior extremity derived from the basal portion of the posterior vesicles may be considered as paired in the first instance. In this respect the development of the organ in *Vanessa* contrasts with the conclusion formulated by Nussbaum. At the same time it agrees with the simple character of the vaginal rudiment in *Aphis* and some other Insecta; only it must be borne in mind that in the Butterfly it is, as will be pointed out presently, a portion only of the anterior section of the azygos oviduct that is really homologous with the vagina of other Insecta, and this portion, as it happens, differs, in part at least, in its mode of development from the rest of the azygos oviduct. Moreover, and this is a second point of difference, the cavity of the azygos oviduct of *Vanessa* is from the first in connection with the cavities of the rudiments of both bursa and receptaculum and of the sebaceous glands. This is not true, however, with respect to the paired oviducts. They are at first solid; their cavities when formed are independent and only come into connection at a later period with the cavity of the azygos oviduct, facts entirely in accordance with Nussbaum's statement on the same point.

But the most curious feature in the developmental history of the Lepidopteran azygos oviduct is the distinct evidence it affords of the fact that it is divisible into sections which must have been successively acquired in the phylogeny of the order. Up to the last stage of active existence the female caterpillar may be said to exist, so far as its genitalia are concerned, in an embryonic condition, one which is persistent only in female *Ephemeridæ* among living insects, as has been shown by Palmén, 'Ueber paarige Ausführungsgänge der Geschlechtsorgane bei Insecten,' Leipzig, 1884. The ovaries and the paired oviducts are alone present, and the latter end ventrally near the posterior edge of the seventh abdominal somite. Were they sexually mature, this is the exact state of things found by Palmén in the female imago of the Mayflies. The prolonged embryonic condition of the parts as they exist in the caterpillar, clearly shows, among other things, that the larva of the Lepidoptera is a specialized form. The next step is the appearance of the rudiments of the accessory organs, and then of a fold on either side of the common rudiment of the bursa and receptaculum. The two folds approach one another ventrally; their edges do not fuse, however, and *before they do so* the first section of the azygos oviduct is established and in connection, solid connection it is true, with the paired oviducts. The first section may therefore be considered as the homologue of the vagina in other Insecta. The condition now established is very similar to what is found in sexually mature Orthoptera, using that term in the signification to which it is limited by F. Brauer, in his "Systematisch-Zoologischen Studien" (Sitzb. Akad. Wien, xci. Abth. 1, 1885, p. 358), to include only the Orthoptera vera of other authors, minus the *Forficulidæ*. In *Blatta* a short vagina, the uterus, so-called by Nussbaum, connects the paired oviducts to the exterior; it opens on the eighth sternum. The spermatheca opens behind the vaginal aperture on the ninth sternum and the colleterial or the sebaceous glands still further behind. The same arrangement obtains in the *Acrididæ* and *Truxalidæ* according to Berlese (Atti Accad. dei Lincei (3), Memorie, xi. 1881, p. 273), but in the *Mantidæ*, *Locustidæ*, and *Gryllidæ* the spermatheca opens into the dorsal wall of the vagina—in other words, the latter is of greater length (Berlese, *op. cit.* pp. 271-273). The middle section of the azygos oviduct of *Vanessa* persists for some time as an open furrow, and the third section, the last formed, is a furrow in direct continuity with it, extending backwards as far as the base of the sebaceous apparatus. The conversion of the whole furrow into a tube does not take place until pupation is at hand; and when its closure occurs it leaves two openings, an anterior and a posterior, a peculiarity of the Lepidoptera, and one that clearly stamps, from the phylogenetic point of view, the middle and especially the third section of the oviduct as later acquired structures\*.

Of the two apertures in question the anterior or *bursal* must be considered as the

\* Doyère stated, in the *Annales des Sc. Nat.* (2), vii. 1837, pp. 203-205, that in the Cicada there is a vestibule into which opens anteriorly the azygos oviduct, and dorsally the spermatheca; it opens itself posteriorly into the base of the ovipositor, and ventrally behind the ovipositor. I have no means of verifying the fact myself, and de Lacaze-Duthiers throws no light on it in his paper on the composition of the ovipositor in the *Cicadule* (*Annales des Sc. Nat.* (3), xviii. 1852, p. 339 *et seqq.*). No later authority seems to have written on the subject.

partial homologue of the vaginal orifice in other orders of Insecta. It opens in the sternum of the eighth somite, the typical position of the vaginal aperture, as disclosed by the researches of de Lacaze-Duthiers. It is only a partial homologue for the following reason. A little consideration shows that the true vaginal aperture is the opening of the first into the second section of the azygos oviduct. The bursal aperture is, strictly speaking, the ventral opening of the second section, and it leads into a tube which has been secondarily developed by the ventral closure of a furrow. Its persistence may be explained on the supposition that it is necessary for copulatory purposes, and points rather to the conclusion that the bursa copulatrix and receptaculum seminis were differentiated structures at a time when the second and third sections of the azygos oviduct were still a continuous open furrow. The lateral position of the bursa and its separation from the azygos oviduct are probably late features in the phylogenetic history of the Lepidoptera, subsequent even to the closure of the furrow.

The existence of a second or posterior aperture is probably to be attributed to the advantage gained by a terminal position for the aperture through which the ova are laid. The remarkable way in which this aperture shifts backwards seems to point very distinctly to this explanation, especially as the Lepidoptera are entirely devoid of the outgrowths which form the ovipositor in some orders, *e. g.* most Orthoptera.

It may therefore be said that there are three stages traceable in the evolution of the genital ducts in the Lepidoptera: an Ephemeral stage, which ends towards the close of larval life; an Orthopteran stage, indicated during the quiescent period preceding pupation; and a Lepidopteran stage, which begins with the commencement of pupal life. As was mentioned before (p. 149) the female genital ducts of *Nematois metallicus* possess but a single external aperture, and the bursa opens into the dorsal wall of the azygos oviduct. It is possible that a better acquaintance with the anatomy of the Micro-Lepidoptera may disclose transitional or primitive states of the organs in question, just as Walter's researches (*Jenaische Zeitschrift*, xviii. 1884) have clearly shown that a primitive biting condition of the mouth-parts exists at the present day in some Micro-Lepidoptera, and more particularly in the genus *Micropteryx*.

There is one other point to which it is worth while drawing attention. What is the significance of the cuticular secretion formed by the hypodermic cells at a certain period of pupal life? Is it analogous to what occurs in the higher Amphibia, lizards and snakes, where certain cells break down completely and provide a liquid which facilitates the process of casting the old cuticular epidermis? If this be the explanation it would naturally be a process occurring at every moult. Whether such is the case with the moults of the caterpillar I do not know, but the surface of a newly-formed pupa is moist with a liquid, and it is the hardening of this liquid when exposed to air that glues the wings and legs to the surface of the body. Or is the secretion to be regarded as a modified cuticle thrown off within the first formed pupal cuticle? It is well known that an Ephemeron casts a thin pellicle after it has escaped from the sub-imago state, and there is some evidence to show that the same process occurs in the Lepidoptera. Professor Westwood drew my attention some time ago to a passage in Curtis's 'British Entomology,' in the description of plate 147, where that most accurate authority records

the fact that he saw an imago of *Acherontia Atropos* moult a complete and thin pellicle after its emergence from the pupal cuticle. I have also noted a passage in Packard's 'Guide to the Study of Insects' (9th edit., 1889). It runs thus:—"In the last stage of *Bombus*, just before the imago leaves its cell, the body and limbs are surrounded by a thin pellicle. This pellicle also envelops the moth just before it leaves the pupal state, and is cast off when it moults the pupa skin. This is probably identical with the skin cast by the active sub-imago of *Ephemera* soon after it takes its flight" (p. 68).

The subject is one which I hope to pursue further on another occasion, and will only add here that cast pupal cuticles of *Sphinx ligustri* may occasionally be met with in which a thin pellicle can be raised from the inner surface. An inquiry into this and other structural changes taking place during pupal life in a series of metabolic Insects would probably throw light on the still obscure question of the origin and significance of the quiescent pupal stage.

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## DESCRIPTION OF THE PLATES.

### PLATE XV.

- Fig. 1. *Pieris brassicae*, male. Ventral view of the four terminal segments (7, 8, 9, 10) of the abdomen. ♂ indicates the aperture of the ductus ejaculatorius. The tenth segment bears the sustentor ridges, *s.r.* of Riley. The centre of the segment is marked by a line, the anal furrow, which corresponds to the furrow between the two anal prolegs of the caterpillar, and leads to the anus at its posterior end. *cr.*, the cremaster; *r.p.*, the eminences representing the anal prolegs. The natural size is indicated in this and nine of the following figures by a line at the side.
- Fig. 2. *P. brassicae*, female. This figure is a corresponding view to the preceding, and the same explanation applies to the letters. ♀ indicates the two female apertures.
- Fig. 3. *P. brassicae*, female. A lateral view of the four terminal segments of the abdomen. The perfect spiracle of the seventh segment, and the abortive spiracle of the eighth segment, are shown. The letters as before.
- Fig. 4. *Vanessa Io*, male. ♂ indicates the aperture of the ductus ejaculatorius. A similar view to fig. 1.
- Fig. 5. *V. Io*, male. Enlarged view of aperture of ductus ejaculatorius. Obj. *aa*, oc. 2, Zeiss, draw-tube full out.
- Fig. 6. *V. Io*, female. ♀ indicates the ventral furrow crossing the eighth and ninth segments in which are situated the two sexual apertures. The latter are minute and not visible. A similar view to fig. 1.
- Fig. 7. *V. Io*, female. Enlarged view of the ventral furrow of the preceding figure. Obj. *aa*, oc. 2, Zeiss, draw-tube full out.
- Fig. 8. *Papilio Machaon*, male. A similar view to fig. 1. ♂ indicates the aperture of the ductus ejaculatorius. *s*=sustentors.

- Fig. 9. *P. Machaon*, female. A similar view. ♀, indicates the female apertures. A fine line sometimes runs forwards to the posterior edge of the seventh segment from the sexual apertures as in fig. 10. *s*=sustentors.
- Fig. 10. *Protoparce mauritii*, Butler, a Sphingid from Natal. Ventral view of the last three abdominal segments. The ninth is seen to be prolonged forwards medianly as a short triangle, at the apex of which is one of the female apertures. It is also not completely marked off medianly from the tenth segment behind. The punctations of the chitinous cuticle are indicated on the right side of the figure. ♀ indicates the two female apertures. A fine dark line, which doubtless corresponded to the anterior section of the azygos oviduct, runs forward from the anterior female aperture to the hind border of the seventh segment. (Specimen in Natural History Museum collection.)
- Fig. 11. *Sphinx ligustri*, male. A similar view to fig. 1. The punctations of the chitinous cuticle are indicated in the eighth and ninth segments. ♂ indicates the aperture of the ductus ejaculatorius and its two triangular lips. *r.p.*, the prominences representing the anal prolegs.
- Fig. 12. *Sp. ligustri*, female. A similar view to fig. 11. ♀ indicates the confluent female apertures.
- Fig. 13. *Sp. ligustri*, female. Enlarged view of the two female apertures (♀) in an abnormal specimen. 8, 9, indicate the segments. It will be observed that the two apertures belong, as in *P. brassicae*, fig. 2, to consecutive segments.
- Fig. 14. *Sp. ligustri*. Lateral view, similar to fig. 3, of the four terminal segments of the abdomen. The seventh perfect and the eighth abortive spiracle are shown.
- Fig. 15. *Vanessa Io*, female. Internal view of the ventral region of the last four segments of the abdomen, taken from a cast pupal cuticle. 7, 8, 9, 10, the segments; *s.r.*, the left sustentor ridge, which is seen to be hollow; the hollow of the right ridge is seen just above. *b.o.*, the east chitinous linings respectively of the duct of the bursa copulatrix and of the oviducal tube.
- Fig. 16. *Sphinx ligustri*, female. A similar view to fig. 15. The lining of the bursal duct (*b*) is broken and bent down.
- Fig. 17. *Smerinthus ocellatus*. A similar view to fig. 15.
- Fig. 18. *Vanessa Io*. The larval cuticle dissected off and reflected in a specimen about to pupate. The numerals indicate the segments—on the left, of the larval cuticle; on the right, of the contained pupa. *an.*, the cuticular lining of the rectum partially pulled out. *er.*, the eremaster, which is seen to be contained within the cuticle of the anal valve of the caterpillar. Obj. *a*\*, oe. 2, Zeiss, draw-tube at 160.
- Fig. 19. *Vanessa Io*. The female organs of the unimpregnated female dissected out and drawn from a left latero-dorsal point of view. *ov., ov.*, the ventral ends of the four ovarioles of each side; *od.*, the two paired oviducts; *od'*, the azygos oviduct which ends immediately below the rectum; *b.c.*, the bursa copulatrix, here empty and therefore collapsed; *d.b.c.*, duct of the bursa; the portion dorsal to the seminal canal is derived from the anterior pair of larval vesicles, the portion ventral to it from the primitive azygos oviduct; *s.c.*, the seminal canal connecting the duct of the bursa to the dorsal aspect of the azygos oviduct; *r.s.*, the receptaculum seminis divisible into the following three regions:—*d.s.*, the ductus seminalis; *c.s.*, the capsula seminis, here two irregular dilatations instead of the more usual pyriform vesicle; and *gl.r.s.*, the appended gland. *s.gl.*, the two sebaceous glands terminating at their ventral ends, each in a thin-walled dilated vesicle; the two vesicles are here confluent; *d.s.gl.*, the common duct leading to the azygos oviduct from the sebaceous vesicles. *od.gl.*, the left odoriferous gland. *r.*, the rectum turned backwards. *t.a.p.*, the terminal papilla of the abdomen, derived from a portion only of the tenth segment of the abdomen. *ch.*, a fine pointed chitinous rod inserted basally into a chitinous ring-like thickening of the terminal papilla, and not shown in this figure; muscle-bundles, running forwards and backwards, are attached to the free apex of this

rod. Together with a similar apparatus on the opposite side of the body, it serves to protrude and retract the terminal papilla of the abdomen. Obj. *aa*, oc. 2, Zeiss, draw-tube in. The figure is reduced  $\frac{1}{2}$ .

- Fig. 20. Section of the elliptical chitinous body, *e.b.*, guarding the entrance to the aperture of the duct of the bursa copulatrix. It lies in a deep groove of the eighth sternum, and its centre is occupied by a darkly stained mass of hypodermic cells, the cells forming a ridge in the pupa and figured Pl. XIX. figs. 71, 72. The deeper or internal portion of the chitin forming this body, and of the thickened part of the sternum, stains slightly with hæmatoxylin. The soft tissues (hypodermis, &c.) have separated slightly from the chitinous cuticle of the sternum.  $\times$ , the line points to the spot where the bursal opening is situated in the next section to the one here drawn. Compare fig. 25 of next Plate. Obj. B, oc. 2, Zeiss, draw-tube in.

#### PLATE XVI.

All the figures in this and succeeding Plates are taken from *Vanessa Io*, ♀.

- Fig. 21. Lateral view of the abdomen of the caterpillar. 1-10, the segments of the abdomen. 3, 4, 5, 6, and 10 carry prolegs; 1-8 possess spiracles, indicated by the dark dots on each of them. It may be noted that the series of large latero-dorsal spines is present on all the segments of the abdomen, including the anal valve. The series of small spines immediately dorsal to the spiracles is represented in the first segment by a tubercle with a small central hair-like spine. A similar tubercle and spine are present on the ninth segment. The series of latero-ventral spines ceases with the eighth segment. The line at the side indicates the natural length of the specimen.
- Fig. 22. Lateral view of the abdomen taken from a specimen of a caterpillar which had just commenced to throw off the larval cuticle; the operation was completed by dissection. The metathoracic wing has been cut away at its base; the leg of the same segment has been left. 1-10, the segments of the abdomen. The tubercles representing the large dorso-lateral larval spines are confined to segments 2-7; in segments 6 and 7 they are deflexed by the stripping backwards way of the larval cuticle. Spiracles are shown on segments 1-8, but the eighth is very diminutive. *s.r.*, sustentor ridge; *cr.*, cremaster. The natural length is indicated by a line at the side.
- Fig. 23. Lateral view of the abdomen of a pupa 24 hours old, to show the remarkable contraction in length and expansion in width which it undergoes, owing to the shortening of the muscles and folding inwards of the intersegmental membranes. 1-10, the segments as before. The first spiracle is completely hidden by the wings, the second and third partially. The eighth is abortive. The line at the side indicates the natural length of the specimen.
- Fig. 24. Lateral view of the abdomen of an imago. 1-8, the terga of the corresponding segments; probably, however, the eighth tergum includes the ninth and what remains of the tenth. The sterna of the first and second, and of the seventh and eighth segments are continuous; but their separateness is indicated in both instances by ridges. Note a fold in the last pleural membrane extending dorsally from the eighth sternum, which probably indicates the posterior limit of the eighth pleural membrane. The pleural membranes are shaded by diagonal lines. The terminal papilla of the abdomen is retracted as it always is in the natural state of repose, but its hairs are visible. The line at the side indicates the natural length of the specimen.

The four preceding figures, 21-24, are all drawn to the same scale,—Obj. *a\**, oc. 2, Zeiss, draw-tube in. They consequently show the changes in size which take place in the passage from the full-grown larval to the imaginal condition.

- Fig. 25. Female. Enlarged ventral view of the termination of the abdomen. 7, 8, opposite the corresponding pleura; *sp.*, the seventh spiracles;  $\times$ , folds in the pleural membrane, probably indicating the posterior limit of the eighth pleura, the remaining and posterior portion of the membrane belonging to the ninth and tenth segments. *t.a.p.*, terminal papilla of the abdomen, which is covered with hairs and has a ventral furrow in which open the odoriferous glands anteriorly, the azygos oviduct in the middle, and the anus posteriorly. The major part of the eighth sternum is thickened and is confluent with the seventh. Its thickened portion has a ventral longitudinal groove lodging anteriorly a transparent elliptical body, which protects the entrance to the duct of the bursa copulatrix, indicated by the letters *a.b.c.* Compare fig. 20 on Pl. XV. Obj. *a\** at 5, oe. 2, Zeiss, draw-tube full out.
- Fig. 26. A small portion of the seventh pupal spiracle to show the spinose eminences guarding the aperture; spines and eminences are alike absent in the eighth spiracle. Obj. D, oe. 2, Zeiss, draw-tube full out.
- Fig. 27. Horizontal section through the pupal seventh spiracle and commencement of the trachea, to show the continuously open lumen. Obj. D, oe. 2, Zeiss, draw-tube in.
- Fig. 28. A similar section from the eighth pupal spiracle to show the smooth-walled entrance, collapsed lumen, and blind ending of the trachea. Obj. D, oe. 2, Zeiss, draw-tube in.

The three foregoing preparations were made from a cast pupal cuticle.

- Fig. 29. The ventral and ventro-lateral internal aspect of the seventh, eighth, and ninth segments, with part of the sixth and tenth segments, of a full-grown active and feeding caterpillar. The overlying portions of the fat-body have been completely removed in dissection. 6, 7, 8, 9, 10, the last five segments of the abdomen. The dotted lines indicate the intersegmental divisions. The figures 6, 7, 8 are placed opposite the bundles of tracheæ originating from the spiracles of the corresponding segments. A longitudinal trachea connects the spiracles together. *v.l.*, ventro-lateral longitudinal bundles of muscles present in all the segments, but very thin and somewhat spread out and scattered in the tenth. *v.*, ventral longitudinal muscle-band, similarly present. Various oblique and transverse muscles are seen at a lower level. *n.c.*, the ganglion of the sixth abdominal segment, from which longitudinal commissures pass backwards to the terminal compound ganglion situated in the seventh segment; nerves are given off by this ganglion, of which the median pair are cut short. *od.*, the line points to the larval paired oviduct of the right side, represented by a fine white line passing backwards between the tracheæ originating from the seventh spiracle, to one of which it is attached by a filament. It is seen to turn towards the mid-ventral line in the seventh segment, and is attached to the posterior border of a transverse trachea; it passes under the muscles and at the ventral border of the ventro-lateral muscle-bands quits the trachea and takes a curved course backwards beneath the ventral muscle-band. Its attachment to the hypodermis near the median line and close to the posterior border of the seventh segment is shown. The left oviduct is also partly displayed. The anterior paired oval vesicles are seen in the median line near the posterior border of the eighth segment, and close behind them, in the ninth segment, the posterior paired vesicles, to which are attached on each side a pair of laterally directed filaments. *an.*, placed opposite the anus. *r.m.*, the band of muscle filaments which retains the rectum; anteriorly it invades the ninth segment. Obj. *a\**, oe. 2, Zeiss, draw-tube in.
- Fig. 30. The central portion and right half of the seventh segment of the same caterpillar. The terminal nerve-ganglion, with the nerves to which it gives origin cut short, lies in the median ventral line. The longitudinal inner layer of muscles is dissected away, showing the longitudinal and oblique muscle-bands beneath them *in situ*. The transverse trachea and right oviduct are shown as before. Obj. *a\**, oe. 2, Zeiss, draw-tube in.

- Fig. 31. A similar preparation to the preceding, but the fat-body is removed and all the main muscles, leaving only some very fine transverse muscle-bands. The anastomosis of the transverse tracheæ of the right and left sides is shown, as well as the course of the larval oviduct. Obj. *a\**, oc. 2, Zeiss, draw-tube in.
- Fig. 32. Portion of hypodermis and attachment of right oviduct of an active feeding caterpillar. *od.*, the solid oviduct with faint longitudinal striations and numerous nuclei, elongated parallel to the axis of the oviduct. At its ventral end the oviduct passes into continuity with the hypodermis. A fine clear filament with a few nuclei passes off from the oviduct near its termination to the hypodermis. *tr.*, a minute trachea. The hypodermis is seen in this surface view to consist of a number of nucleated cells, with a small amount of transparent non-staining intercellular substance. The amount of this substance is perhaps slightly exaggerated in this drawing. The cell-outlines are irregular. Obj. D, oc. 2, Zeiss, draw-tube in.

## PLATE XVII.

The following figures, 33-46, are drawn under obj. *aa*, oc. 2, Zeiss, draw-tube in.

- Fig. 33. Enlarged view showing the median attachments of the two oviducts, the anterior pair of vesicles in the eighth segment, and the posterior pair in the ninth, of a full-grown active and feeding caterpillar. It is taken from the same specimen as fig. 29. *od.*, the line points to the right oviduct, which is attached close to its fellow. *v.*, the ventral muscle-band of the eighth segment; there is a similar band in the ninth. *r.m.*, the band of rectal muscles. To the posterior pair of vesicles is attached on either side a pair of filaments, of which the anterior contains a trachea.
- Fig. 34. A similar view taken from a quiescent caterpillar. 8, 9, the corresponding segments; *od.*, the paired oviducts; *od'*, the anterior part of the azygos oviduct. The anterior vesicle is no longer paired; its anterior end, *b.c.*, is elongated and rounded, and forms the rudiment of the bursa copulatrix; its posterior end is more pointed and forms the rudiment of the receptaculum seminis, *r.s.*; the anterior vesicle is connected to the posterior, *p.v.*, by the posterior section of the azygos oviduct. The posterior vesicle is elongated, and there is a very distinct median furrow. Its filaments are undergoing atrophy. *r.m.*, the rectal muscles. Note the shortening of the muscle-bands and segments. The azygos oviduct is for the most part a ventrally open furrow at this time.
- Fig. 35. Lateral view of the same specimen from right side. Letters as before.
- Fig. 36. View from above of a specimen similar to that from which fig. 34 is taken. The rudiments of the bursa, *b.c.*, and the receptaculum, *r.s.*, are more pronounced, but the posterior vesicles appear to be somewhat retarded in development. Letters as before.
- Fig. 37. An abnormally elongated and pointed anterior vesicle from another similar specimen.
- Fig. 38. View from above, taken from a pupa *one* day old. The terminal nerve-ganglion with the nerves it gives off is seen anteriorly and in the middle line. Immediately behind it is the rounded apex of the bursa, *b.c.*, and behind that again the elongated receptaculum seminis, *r.s.*, bent upon itself. *gl.*, the right sebaceous gland derived from the posterior vesicle; the corresponding gland on the left is not lettered; the two are parallel to one another. The azygos oviduct is seen behind the bursa extending back to the sebaceous glands.
- Fig. 39. A lateral view of the same specimen from the right side. Letters as before. The bursa, *b.c.*, is pyriform; the left sebaceous gland, *gl.*, is seen arched upon itself, and its anterior end is dilated. This dilatation is the rudiment of the future left sebaceous vesicle. *od'*, the azygos oviduct, which has a considerable vertical depth.
- Fig. 40. View from above, taken from a pupa *two* days old. Letters as before. The bursa copulatrix, *b.c.*, is bent backwards; the receptaculum, *r.s.*, has become nearly straightened, elongated, and

turned to the left side; whilst the sebaceous glands, *gl.*, are no longer parallel to one another, but are still directed backwards.

- Fig. 41. Lateral view of the same specimen from the right side. The duct of the bursa, *b.c.*, has become slightly apparent; there is still a slight hook at the free extremity of the receptaculum, *r.s.*; the sebaceous gland, *gl.*, is much longer, strongly bent upon itself, and the vesicle from which it springs is more pronounced. The azygos oviduct, *od'*, is well seen; it is vertically swollen beneath the base of the receptaculum, *r.s.*, and this is the region where the bursal duct will be specialized. Behind the swelling in question it is seen to be arched, *i. e.* it is completely detached from the hypodermis between its bursal and oviducal openings. It ends abruptly beneath the vesicle of the sebaceous gland.
- Fig. 42. View from above, taken from a pupa *three* days old. The bursa, *b.c.*, is now a stalked vesicle; the vesicle is the bursa itself, the stalk that section of its duct which is dorsal to the point of entrance of the seminal canal. The receptaculum, *r.s.*, is elongated and entirely straightened out; its base of attachment to the azygos oviduct is behind and to the left of the base of the bursal duct. *od.*, the paired oviducts, and *od'*, the azygos oviduct. *p.od'*, the section of the azygos oviduct which is extending backwards behind the sebaceous vesicles; it is only just visible in this view from above. *gl.*, the sebaceous glands, which now diverge from one another, but are directed backwards. Note the want of symmetry between the two glands, and the well-marked vesicles from which they spring.
- Fig. 43. Lateral view of the same specimen from the right side. The two paired oviducts, *od.*, come into sight for the first time in this aspect. The bursa, *b.c.*, and the dorsal section of its duct are well seen; the receptaculum, *r.s.*, is quite straight; the vesicle, *v.gl.*, of the sebaceous gland, *gl.*, is of large size. The ventral section of the future bursal duct, *d.b.c.*, is now a vertically elongate tube, but it is in direct continuity with the azygos oviduct. *p.od'*, the posterior section of the azygos oviduct behind the sebaceous vesicles; it leads to the oviducal opening, which is now distinctly shifting backwards. Compare it in fig. 41.
- Fig. 44. View from above, taken from a pupa *four* days old. The bursa, *b.c.*, is now distinctly on the left side of the azygos oviduct; it is dilated apically, but is not so sharply marked off from its stalk as in fig. 42. *ov.*, the four ovarioles of the right side; *od.*, the paired oviducts, which are much enlarged; *od'*, the azygos oviduct; *r.s.*, the receptaculum, now directed forwards; *gl.*, the sebaceous glands, which are more slender and also turned forwards; *v.gl.*, their vesicles, which are better marked off; and *d.v.gl.*, the common duct leading from the vesicles to the azygos oviduct. *p.od'*, the much elongated section of the azygos oviduct posterior to the entrance of the common duct of the sebaceous glands.
- Fig. 45. A front view or elevation from the same specimen, showing, *od.*, the paired oviducts, *od'*, the azygos oviduct, *d.b.c'*, the section of the bursal duct dorsal to the azygos oviduct, and *d.b.c.*, the section ventral to it. It will be observed how completely these structures are placed to the left side of the azygos oviduct, and how much elongated is the ventral section of the bursal duct. *s.*, the line points to the region which will differentiate into the seminal canal. The change is already indicated.
- Fig. 46. Vertical view, taken from a pupa between *five* and *six* days old. *od.*, the paired oviducts greatly increased in diameter; *od'*, the azygos oviduct, now a tube of the same diameter throughout. *d.b.c'*, the dorsal section of the bursal duct differentiated from the stalk of the bursa itself; *d.b.c.*, the ventral section of the same duct differentiated by growth from the azygos oviduct; *s.c.*, the seminal canal or tubular connection between the bursal duct and the azygos oviduct; *r.s.*, the basal portion of the receptaculum seminis, removed by a slight space from the point where the seminal canal enters the azygos oviduct.
- Fig. 47. Horizontal section of hypodermis from the seventh segment of a female caterpillar on the point of pupation. It shows the cells with their nuclei in transverse section and a small

amount of clear non-staining substance between the cells. Compared with fig. 32, which is magnified to the same degree, it is at once evident that the cells are smaller in diameter. Obj. D, oc. 2, Zeiss, draw-tube in.

Fig. 48. Vertical section of hypodermis from the seventh segment of the same specimen. The cells are elongated and close set; their nuclei are nearer their outer than their inner ends. The intercellular substance is visible. There is a thin basement-membrane, *b*, and a very delicate pupal cuticle, *cu*. The latter is partly seen from the surface. Obj. D, oc. 2, Zeiss, draw-tube in.

Fig. 49. A similar preparation, similarly magnified, from the cremaster of a *one* day old pupa. The nuclei are at the *inner* ends of the cells.

The six following figures are taken from an active full-grown caterpillar, still feeding, with paired vesicles, in the stage represented fig. 33, Pl. XVII., and are all drawn under obj. B, oc. 2, Zeiss, draw-tube in.

Figs. 50 *a* to 50 *d*. Transverse sections from the anterior paired vesicle.

50 *a*. From the anterior end, second section of the series; the median furrow is seen in the centre.

50 *b*. The next following section; the median furrow is deeper.

50 *c*. The sixth section of the series;  $\times$ , the lateral fold which is the first indication of the forming middle section of the azygos oviduct.

50 *d*. The next following or seventh section;  $\times$ , the same fold, which is rather deeper. The left side of this section is partly broken and bent, therefore dotted in. Three more sections, which closely resemble 50 *a*, end the series.

Figs. 51 *a* and 51 *b*. Transverse sections from the posterior paired vesicle of the same specimen.

51 *a*. The first section from the anterior end.

51 *b*. The sixth section of the series; *f*, one of the filaments. This section seems to me slightly oblique to the long axis. The five following sections are very similar, but diminish gradually in size.

#### PLATE XVIII.

All the sections in this Plate are drawn to the same scale as figs. 50 and 51 in the preceding Plate, *i. e.* under obj. B, oc. 2, Zeiss, draw-tube in.

Figs. 52 *a* to 52 *c*. Transverse sections of the anterior paired vesicle of a caterpillar ceasing to feed and about to suspend itself.

52 *a*. The fourth section from the anterior end;  $\times$ , the lateral fold to form the middle section of the azygos oviduct. The median furrow is still visible.

52 *b*. The seventh section;  $\times$ , the lateral fold is of large size, and the basal aperture is somewhat narrowed. The three following sections are similar but larger, and the series then diminishes in size.

52 *c*. The thirteenth section; there is no trace of a median furrow. One more section similar, but much smaller, ends the series.

Figs. 53 *a* to 53 *d*. Transverse sections from the posterior paired vesicle of the same specimen.

53 *a*. The first section of the series.

53 *b*. The third section of the series; the median furrow is very distinct. The next section is similar and larger.

53 *c*. The fifth section of the series; a portion of the roof of the vesicle on the left side is cut obliquely.

53 *d*. The eighth section of the series; *f*, one of the filaments; *m*, the portion of the roof of the vesicle coinciding with the dotted line is converted into the sebaceous apparatus of the adult. Compare figs. 54 *g* to 54 *k* following. The rest of the vesicle forms apparently the posterior end of the oviduct.

Figs. 54 *a* to 54 *k*. Transverse sections through the vesicles and azygos oviduct of a caterpillar about the middle of the quiescent suspended stage, corresponding to fig. 34, Pl. XVII.

- 54 *a*. Transverse section, the sixth of the series, through the azygos oviduct. A small amount of intrusive fatty tissue intervenes between it and the hypodermis, *h*.
- 54 *b*. The ninth section of the series, corresponding to the posterior limit of the anterior portion of the azygos oviduct. The folds are just in contact ventrally.
- 54 *c*. The eleventh section of the series; *b.c.*, the lumen of the bursa copulatrix; *od!*, the lumen of the middle section of the azygos oviduct, still open ventrally.
- 54 *d*. The eighteenth section of the series, taken between the bursa copulatrix and the receptaculum seminis, but nearer the latter. The lumina of the anterior vesicle and the middle region of the azygos oviduct, *od!*, are indistinguishable.
- 54 *e*. The apex only of the twenty-second section of the series, taken through the base of the receptaculum seminis, *r.s.* *od!*, the lumen of the azygos oviduct, which in shape resembles fig. 54 *d*. It becomes gradually diminished in height and increased in width in the following sections.
- 54 *f*. The twenty-ninth section of the series, towards the posterior limit of the hind region of the azygos oviduct, where its height is least.
- 54 *g*. The thirty-second section of the series, through the anterior edge of the posterior vesicle. The narrower upper part above the dotted line appears to correspond with *m*, fig. 53 *d*, and to form a portion of the sebaceous apparatus, *gl.* *od!*, the azygos oviduct open below.
- 54 *h*. The thirty-fourth section of the series. The dorsal or sebaceous portion, *gl.*, of the vesicle is more constricted basally. *od!*, the azygos oviduct open below.
- 54 *i*. The thirty-fifth section of the series. The sebaceous portion, *gl.*, of the vesicle is distinctly divisible into a right and left half, with a median furrow. *od!*, the azygos oviduct as before. *m*, mesoblast cells.
- 54 *k*. The thirty-sixth section of the series. The sebaceous portion of the vesicle is divided into two tubes, *gl.*, a right and a left. The tubes are traceable through the three following sections and the basal or oviducal region, *od!*, through one more in addition.

Figs. 55 *a* to 55 *i*. Transverse sections similar to the above from a caterpillar just about to pupate. The larval cuticle was split in the dorsal thoracic region. The parts evidently resemble very closely in anatomical character fig. 38, Pl. XVII., but are smaller.

- 55 *a*. The sixth section of the series. *b.c.*, lumen of the bursa copulatrix; *od!*, the azygos oviduct; *h*, the hypodermis of the body.
- 55 *b*. The eighth section of the series. The lumina of the bursa, *b.c.*, and of the azygos oviduct, *od!*, are continuous; *h*, the hypodermis of the body-wall.
- 55 *c*. The tenth section of the series. *r.s.*, the lumen at the base of the receptaculum seminis, just open to the lumen of the azygos oviduct, *od!* The hypodermis, *h*, and very delicate pupal cuticle, *cu.*, are shown.
- 55 *d*. The eleventh section of the series. *r.s.*, the base of the receptaculum just separated off from the azygos oviduct, *od!* Between it and the oviduct the obliquely cut ends of some cells of the vesicle. The azygos oviduct opens below by a small pore into which the cuticle, *cu.*, is prolonged. The pore is the bursal aperture.
- 55 *e*. The thirteenth section of the series. *r.s.*, the receptaculum cut across. *od!*, the posterior region of the azygos oviduct completely closed in below by union of the edges of the furrow seen in fig. 54 *f*. It is still in continuity with the hypodermis, *h*, of the body-wall. *cu.*, the pupal cuticle.
- 55 *f*. The sixteenth section of the series, just at the commencement of the sebaceous apparatus, *gl.* The azygos oviduct, *od!*, opens to the exterior by a second pore, the posterior or oviducal

aperture, into which the pupal cuticle, *cu.*, is prolonged. A small portion of the cuticle lies detached in the lumen of the oviduct.

- 55 *g.* The eighteenth section of the series. The sebaceous region, *gl.*, is more clearly marked. The azygos oviduct, *od.*, is closed below, but continuous with the hypodermis, *h.* *cu.*, the pupal cuticle.
- 55 *h.* The twentieth section of the series. The vesicle region of the sebaceous glands, *v.gl.*, is shown dorsally; below it are the cut ends of the two sebaceous glands, *gl.*, which are turned ventrally. *h.* and *cu.*, as before.
- 55 *i.* The twenty-second section of the series. The sebaceous glands, *gl.*, are so much curved upon themselves that they are cut through twice over. The next section passes through the apex of the curve. Compare fig. 38, Pl. XVII., which shows what the external appearance corresponding to the sections must be alike. *h.* and *cu.*, as before.

### PLATE XIX.

With the exception of figs. 59 and 64, all the figures on this Plate are drawn to the same scale as the figures on the preceding Plate, viz. under obj. B, oc. 2, Zeiss, draw-tube in.

- Fig. 56. Transverse section through the anterior end of the azygos oviduct. Three sections behind fig. 58. *od.*, the azygos oviduct. It is solid and composed of cells cut obliquely, with a small amount of transparent intercellular substance closely resembling fig. 47, Pl. XVII., which is, however, more highly magnified. It is seen to be continuous with the hypodermis, *h.* and probably represents a solid invagination of that layer of cells. *cu.*, the delicate pupal cuticle. *cu.*, the larval cuticle.
- Figs. 57 *a* to 57 *d.* Transverse sections of the azygos oviduct from a pupa one day old.
- 57 *a.* Section just behind the spot where the solid azygos oviduct, *od.*, is joined by the paired oviducts. Note the extreme thinness of the hypodermis, *h.* beneath it, a feature seen also in the next section, and showing probably that the hypodermis cells have undergone transverse fission.
- 57 *b.* The next succeeding section, still solid.
- 57 *c.* The next section with a lumen; its ventral wall is thin.
- 57 *d.* The next section. The lumen is larger; the hypodermis, *h.* is cut obliquely and therefore looks abnormally thick. *cu.*, the pupal cuticle. It is naturally V-shaped, as the portion cut through is the commencement of the median furrow in the eighth segment, shown fig. 7, Pl. XV.
- Fig. 58. Surface view of the junction between the paired oviducts, *od.*, and the azygos oviduct, *od.* The plane of the section is nearly parallel to the surface. The hypodermis cells are cut transversely. The section is taken from a quiescent caterpillar, the same specimen from which fig. 56 is taken.
- Fig. 59. Transverse section of the right paired oviduct taken from the same specimen as fig. 55 in the preceding Plate. It is solid and there is a single row of superficially placed nuclei. Obj. D, oc. 2, Zeiss, draw-tube in.
- Fig. 60. Longitudinal section of the right paired oviduct from a pupa *two* days old. The drawing is taken close to the ventral end, just where the lumen ends. The union with the azygos oviduct in this specimen is solid.
- Fig. 61. A similar section from a *three* days old pupa.
- Fig. 62. A transverse section from a pupa of the same age as the last, showing the junction between the lumina of one of the paired oviducts, *od.*, and the azygos oviduct, *od.*

- Fig. 63. A transverse section through one, the right, of the paired oviducts from a pupa between seven and eight days old.
- Fig. 64. A small portion from the wall of the azygos oviduct, the same section that is drawn fig. 55 c. Pl. XVIII. It is the left-hand portion just above the dotted line leading from the letters *od'*. The cells of the wall, *w.* of the oviduct with their nuclei are plainly seen, together with an aggregated mass of mesoblast cells, *m*, on the outer surface of the oviduct. Obj. D, oc. 2, Zeiss, draw-tube in.
- Fig. 65. Transverse section from a one day old pupa of the tube connecting the sebaceous apparatus to the hinder end of the azygos oviduct, the external opening of which was cut through five sections in front of the one here figured. *d.v.gl.*, the tube which becomes subsequently the common duct of the sebaceous vesicles. *m*, mesoblast cells. Compare fig. 38, Pl. XVII.
- Fig. 66. The next section posterior to the preceding, showing the central cavity, *d.v.gl.*, continuous with the duct, and the two lateral cavities, *v.gl.*, which become subsequently the vesicles of the sebaceous gland.
- Fig. 67. Transverse section from a two days old pupa showing, *v.gl.*, the sebaceous vesicles; *d.v.gl.*, their common duct, nearly vertical in position; *od'*, the lumen of the azygos oviduct opening by the oviducal or posterior aperture to the exterior. *m*, mesoblast cells; *h*, hypodermis of the body-walls; *cu.*, the pupal cuticle, V-shaped and indicating the median ventral furrow of the pupa seen in fig. 7, Pl. XV.
- Fig. 68. The following section. The common duct, *d.v.gl.*, of the sebaceous vesicles is seen opening medially between the vesicles, *v.gl.* *od'*, the posterior end of the lumen of the azygos oviduct. *m*, mesoblast cells intruding between *d.v.gl.* and *od'* *h*, the hypodermis of the body-wall.
- Fig. 69. A combined drawing of two consecutive sections from a pupa between six and seven days old, showing the lumen of the azygos oviduct, *od'*, communicating by a short seminal canal, *s.c.*, with the duct, *d.b.c.*, of the bursa copulatrix. *m*, mesoblast cells. There are traces of a delicate cuticle in the oviduct and seminal canal.
- Fig. 70. A combined drawing of two consecutive sections from a pupa between five and six days old, showing the minute and transitory pyriform vesicle, the homologue, probably, of the pyriform capsula seminis as it is usually seen in Lepidoptera, appended to the receptaculum seminis, *r.s.*, the receptaculum seminis.
- Fig. 71. Transverse section through the hypodermis, just anterior to the bursal aperture of a pupa between five and six days old, to show the ridge of elongated cells which subsequently form the transparent elliptical body, *e.b.*, fig. 20, Pl. XV., covering the bursal aperture of the imago.
- Fig. 72. A similar section close to the bursal aperture of a pupa seven to eight days old. The elongated cells are cut obliquely. *d.b.c.*, the wall of the bursal duct cut parallel to the duct. *cu.*, irregular lamella and filaments of the enticular liquid ? formed about this period.
- Fig. 73. View from the internal aspect, showing the rectum, *r.*, cut through; *o.ap.*, the terminal portion of the azygos oviduct; *od.gl.*, the two odoriferous glands meeting in a common vestibule; and *f, f*, the folds of hypodermis which constitute the terminal papilla of the abdomen. From a dissection of a pupa between nine and ten days old.
- Fig. 74. Transverse section to show the origin of the odoriferous glands in a pupa between five and six days old. *od'*, the azygos oviduct, showing the commencement of the common duct of the sebaceous vesicles. *m*, mesoblast cells. *od.gl.*, odoriferous gland of the right side, a simple tubular invagination of the hypodermis, *h*.
- Fig. 75. A similar section from a pupa six to seven days old. *od'*, the azygos oviduct, two sections in front of the one in which the common duct of the sebaceous vesicles appears. *m*, mesoblast cells. *od.gl.*, the left odoriferous gland. The aperture of the right gland is shown. The apertures of the two glands are now nearer to one another, and the vestibule, *v*, is forming.  $\times$ , indication of the lateral fold to form the terminal abdominal papilla.

- Fig. 76. A transverse section through the ventral apertures of the two odoriferous glands, *od.gl.*, showing the greater depth of the vestibule, *v*, in a pupa between *seven* and *eight* days old. The section passes through the apices of the cells forming the anterior wall of the vestibule; the contour of the latter is indicated by dotted lines.
- Fig. 77. A transverse section through the oviducal or posterior aperture of the azygos oviduct, *od.*, with the right lateral fold,  $\times$ , of the hypodermis, which is now much deeper as compared with fig. 75. *cu.l.*, filaments and bands of the cuticular liquid (?). From a pupa between *six* and *seven* days old.
- Fig. 78. Transverse section through the anus, *an.*, and the right lateral fold,  $\times$ , of the hypodermis, from a pupa between *seven* and *eight* days old. The terminal papilla is now, as may be concluded from this figure, of considerable size.

V. *The External Morphology of the Lepidopterous Pupa: its Relation to that of the other Stages and to the Origin and History of Metamorphosis.*—Parts I.—III. By EDWARD B. POULTON, M.A., F.R.S., F.L.S., of Keble and Jesus Colleges, Oxford.

(Plates XX. & XXI.)

Read 21st November, 1889.

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**INTRODUCTION.**—The observations recorded in this paper and those which will follow it were begun in the autumn of 1883, and have been continued intermittently up to the present date. The remarkably characteristic form of the external generative organs in both sexes of the pupæ of several British Sphingidæ first directed my attention to the subject. For a long time I hoped that it would be possible to bring out a monograph dealing with the whole question. The length of time which must have elapsed before anything like a complete treatise could have been produced, and the difficulties attending the only suitable form of publication, as a quarto volume, have induced me to take the advice long ago offered by Prof. E. Ray Lankester, and to bring out a series of papers dealing successively with the various morphological features which can be detected on the surface of the Lepidopterous pupa.

In the meantime my friend Mr. W. Hatchett Jackson, Deputy Linacre Professor of Human and Comparative Anatomy in the University of Oxford, has also been studying

one part of the same subject, viz. the external reproductive organs, although the principal part of his investigation has been concerned with the development of the internal organs. Under these circumstances we both agreed that it would be advisable to publish at the same time and through the same channel. The two papers will thus supplement each other—Mr. Jackson's supplying the details of internal anatomy at various stages of development, mine dealing with the external organs in a number of different species. For this reason the first paper of my series is chiefly concerned with the external reproductive organs. I may add that I had intended to work out the internal anatomy by means of sections and dissections, but, in the press of other work, such an investigation might have caused the indefinite postponement of publication; I am therefore especially pleased that Mr. Jackson should have been led to undertake this inquiry.

*The Names of the various Appendages &c. of the Pupa.*—It has been the custom hitherto to speak and think of the various parts of the pupa as if they were mere cases for the corresponding part of the imago. Thus the terms *ophthalmotheca*, *pterotheca*, *ceratotheca*, *podotheca*, &c. have been applied to the parts within which the imaginal eyes, wings, antennæ, legs, &c. are respectively contained. The investigations which will be described in this series of papers have convinced me that these terms and ideas are entirely erroneous. Such appendages or organs represent parts of the pupa, and I shall speak of them as pupal eyes, wings, antennæ, legs, &c. Although modified in shape, so that the imaginal organs can be contained within them, their form and structure are not identical with the latter, but are far more ancestral; they are remnants of a time when the last stage of metamorphosis in the ancestors of Lepidoptera was something very different from a butterfly or moth. The old terminology obscured the fact that the pupa has a morphological meaning of its own, and that traces of an extremely remote past can be deciphered by the study of its structure.

It is well known that the pupa can be dissected out of the skin of a mature larva many hours before the occurrence of normal pupation. Under these circumstances the pupal appendages are not soldered down by a thick coat of varnish, which hardens on exposure to the air, but stand out freely as evident legs, wings, &c. These appearances are nevertheless unaccountably described by many authors as the appendages of the *perfect insect*. Thus Swammerdam points out the method by which the pupa can be freed from the larval skin in *Pieris brassicæ*; he then says:—"This done, it is clearly and distinctly seen that within this skin of the caterpillar a perfect and real butterfly was hidden" ('Book of Nature,' ii. 26). This erroneous view is corrected by Sir John Lubbock\*.

Professor Weismann's great discovery that the contents of the pupa of Diptera break down (histolysis) into nutrient fluids and lowly differentiated units, from which the imago is subsequently built up by a process akin to embryological development, has an important bearing upon the subject. If we examine a section of a pupal antenna or leg (in Lepidoptera) we shall find that there is no trace of the corresponding imaginal organ until shortly before the emergence of the imago. In the numerous species with a long

\* 'Origin and Metamorphoses of Insects,' p. 67.

pupal period the formation of imaginal appendages within those of the pupa is deferred until very late, and then takes place rapidly in the lapse of a few weeks. This also strengthens the conclusion that such pupal appendages are not mere cases for the parts of the imago, inasmuch as these latter are only contained within them for a very small proportion of the whole pupal period.

*A Classification of the various Features constituting the External Morphology of the Pupa.*—Anticipating the results of investigations to be described in future papers, we shall find that the features which can be made out on the surface of a pupa may be grouped, according to their origin, under four chief heads:—

I. The first of these heads includes the essential and ancestral features derived from stages of a more ancient and continuous form of metamorphosis, and probably in some cases also transmitted from the ultimate, sexually mature, stage of a still earlier and simpler method of development. To this division belongs the general structure of the body: its segments, spiracles, limbs, wings, and probably antennæ; but not the details of these. Also, more specially, the pupal external generative organs and the crescent-shaped compound eye.

II. The second head includes those modifications of the general structure which are due to the development of a very different form within it. These modifications have determined the special form and, in some cases, sculpture of the wings, limbs, and antennæ, and have probably taken a much larger share in producing the present form of the pupal maxillæ. Inasmuch as a modification once wrought upon the pupa will often outlive the imaginal structure which caused it, we have some interesting proofs of former structural arrangements in the imago. These modifications due to the imago may be classified: ( $\alpha$ ) Those details which are common to a large number of pupæ, and in which the imaginal structures fit the corresponding parts of the pupa. This includes the vast majority of the details arranged under the second head. ( $\beta$ ) Those obviously recent and exceptional modifications of the pupal structure which have been formed to accommodate a rapidly increasing imaginal structure. This includes the development of special outgrowths to contain the elongating imaginal maxillæ. ( $\gamma$ ) Those details which, once impressed by an imaginal structure, have remained after the latter has shrunk and changed. This includes the large pectinated antennæ of female pupæ, giving rise to imagines with filiform antennæ. ( $\delta$ ) Those details which have followed the collapse of the contained imaginal structure, but have kept behind the latter, so that they form actual proofs of the shrinkage by showing to us that the imaginal structures were once a size larger. This includes the wings of female pupæ without the power of flight in the imago stage.

III. The third head includes those structures or marks which are due to the adult larva, and are of no morphological significance. These are either a mere concession to the mechanical condition of the process of pupation (sears of claspers and processes) or are due to the larval pigment still lingering unchanged in the pupal hypodermis cells.

IV. The fourth head includes those features which are due to the exigencies of pupal life as it now is. Such are the protective forms, markings, and colours of exposed pupæ; the colour of those that pupate in or upon the earth; and the rings of locomotive hooks

or spines possessed by those that pupate in tubular galleries cut in plant-stems or formed by rolled-up leaves.

*Conclusions as to the Nature of Lepidopterous Metamorphosis.*—Many writers have pointed out that the form of metamorphosis which consists of three sharply separated stages has been, in all probability, derived from a form in which many closely similar stages gradually led up to the final sexually mature form. The present metamorphosis of Lepidoptera &c. has been derived from the more ancestral form, still witnessed in the Orthoptera, by the omission of intervening stages, and also by the subsequent specialization of the final stage. In estimating the position of the lost stages it is most important to gauge the morphological relation of the pupa to larva and imago. Directly we attempt this comparison we find that, whatever morphological feature we adopt as a criterion, the position of the pupa is immensely nearer to the imago than to the larva. The great morphological break is between larva and pupa, an interval so wide as to dwarf the minor differences between pupa and imago.

At the change of skin which separates the two former stages we suddenly pass from a stage with simple eyes, without wings or external generative organs, into a stage with compound eyes, wings, and well-marked external generative organs. We may therefore safely conclude that many stages have been lost between larva and pupa.

At the time when these stages intervened the stage represented by the pupa was very near to the final form, if not the final form itself. This conclusion follows from the close morphological similarity of pupa to imago, and from the presence of distinct external generative organs.

The suppression of intervening stages has left the first or larval stage in an extremely ancestral condition, so that the larva in Lepidoptera is far more ancient than the first stage of those insects (Orthoptera), which still retain the more ancestral method of metamorphosis. These, therefore, have lost the early stages, while Lepidoptera &c. have lost all the stages intervening between the earliest and a very late stage.

It is probable that there are very few, if any, lost stages between pupa and imago, but the differences between them are due to subsequent specialization in the latter. Such specialization is frequently of quite recent date.

It is most interesting to inquire for the possible reasons which determined the loss of the intervening stages and the concentration of metamorphosis. It is quite clear that the loss is associated with, and in fact rendered possible by, the quiescence of the pupal stage, during which the tissues can be broken down (histolysis) and re-developed in the form of the imago. Thus the great morphological interval between larva and imago can be crossed without the need of intervening stages.

One interesting result of pupal quiescence and of histolytic change is the conclusion that there is no definite pupal stage, as far as the internal parts are concerned. The external parts will be shown to possess a clear and obvious morphological meaning, but a meaning which only becomes clear on the supposition that the internal parts possessed an equally definite significance at some time in the past. The sculpture on the surface of the pupa—its parts and their arrangement—point to a very definite stage; but beneath the surface we find either a gradual transition from larval to imaginal organs or the

larval tissues in a state of histolysis, from which the imago will be rapidly built up at a later period.

Sir John Lubbock \* has suggested that the explanation of the quiescent pupal stage is to be found in the difficulty with which a *gradual* transition could be effected from the biting mouth-parts of the larva to the sucking mouth-parts of the imago. The intermediate form of mouth would be unfitted for either biting or sucking successfully; hence the necessity for a quiescent stage in which no food is taken, and during which the change can be accomplished.

The principle which underlies Sir John Lubbock's suggestion has probably been of very great importance for other structures as well as the mouth-parts, viz. the fact that specialization to the conditions of life in the final sexual phase of existence is thus readily attained without interfering with the great specialization of other antecedent stages. It would be of the greatest importance for the imago to be able to modify the methods by which it is adapted to its environment, without the cumbersome necessity for such modifications to be gradually introduced through a number of previous stages. This is the explanation of the quiescent pupal period adopted by the late F. M. Balfour †. A general support to this argument is to be found in the fact that the differences between larva and imago are far less in the Orthoptera, with their gradually progressive metamorphosis. The difficulty of specialization to different conditions in different stages has here been met by uniformity in the stages, so that one form of specialization is, with slight differences, available throughout.

I will briefly recapitulate the history of metamorphosis, which is, I believe, supported by the facts to be described in this and succeeding papers. One of the terminal stages of a gradually progressive metamorphosis, sufficiently advanced to possess well-formed external reproductive organs, became quiescent; this stage is largely preserved in the external morphology of the pupa. Histolysis and re-development of the final form then occurred, gradually displacing the stages immediately antecedent to the quiescent phase, which previously had been necessary in order to lead up to the latter and the final form to which it gave rise. Becoming more and more complete, the changes beneath the surface of the pupa gradually displaced the earlier stages until only the first, the larval stage, remained. The morphological intervals between pupa and larva and between pupa and imago have been subsequently widened by specialization to the conditions peculiar to each stage. The comparatively slight differences between pupa and imago are entirely to be explained in this way; for very few, if any, stages have been omitted between them.

These conclusions apply to the Lepidoptera, and probably with slight modification to other orders with a similar form of metamorphosis.

#### PART I.—THE PERSISTENT TRACES OF LARVAL STRUCTURES UPON THE PUPA.

Before considering the number of abdominal segments and their relation to those of the larva, it is necessary to describe certain characters which will form very convenient

\* 'Origin and Metamorphoses of Insects.'

† 'Comparative Embryology.'

aids in this part of the investigation. Not only is there the test of the spiracles, but owing to the manner in which the pupa is formed beneath the larval skin, almost any outgrowth of the surface of the latter leaves its impress upon the former. The scars thus produced are merely incidental and of no morphological significance, but they are extremely valuable as proofs of segmental identity. Other larval characters also appear on the surface of the pupa; their morphological meaning varies in the different cases.

1. *The Claspers.*—The posterior or anal pair of claspers are generally distinct in the pupa as convex cushion-like structures on each side of the anus. In certain individuals they may even retain the relative size and appearance which are characteristic of the larva (see Plate XX. figs. 8, 9, 10, showing different aspects of these parts in an extreme variety of *Smerinthus populi*). While the posterior claspers are thus represented by pupal structures and not merely by scars, the four anterior pairs only leave functionless traces upon the pupal cuticle. The first and second pairs are hidden beneath the fore wings, but on raising the latter (in pupæ placed in spirit immediately after throwing off the larval skin) the scars can be seen, and they may even be detected in living pupæ with exceptionally transparent wings (e. g. *Miselia oxyacanthæ*). The third and fourth pairs of claspers nearly always leave conspicuous scars upon the fifth and sixth abdominal segments (see Plate XXI. fig. 17 &c.).

2. *The Caudal Horn of Sphingidæ &c.*—This structure always leaves a scar on the pupa, even in those species in which it is feebly developed at the close of larval life (e. g. *Charocampa elpenor* &c.). The scar is especially distinct in *Macroglossa stellatarum*. In most pupæ of Sphingidæ there is a well-marked depression on the eighth abdominal segment behind the scar left by the horn. This must be due to the bending downwards of the horn, which becomes quite horizontal before the larval skin is thrown off, so that the posterior edge of its base and the continuous adjacent larval cuticle are depressed and leave a permanent impress upon the yielding surface of the pupa. In *Smerinthus tiliæ* the general surface of the pupa is corrugated, but the scar of the horn is quite smooth. (See Plate XX. figs. 13 & 14 for the scar in this species, fig. 2 for an unusually prominent trace in *S. ocellatus*, fig. 4 for the normal scar, figs. 9 and 10 for the scar in *S. populi*.)

The blunt horn of *Endromis versicolor* also leaves a large scar, very different in appearance from the rest of the pupal surface (see Plate XXI. fig. 14 for an unusually conspicuous example).

Not only does a firm chitinous structure leave a distinct trace on the pupa, but soft elevations of the surface, like those seen upon the first and eighth abdominal segments of the larva of *Acronycta psi*, can be plainly detected upon the corresponding segments of the pupa (see woodcut 1,  $\times 2$ , in which the pupa is seen from its dorsal aspect).

3. *Other Larval Structures which can be detected on the Pupa.*—The peculiar rough plate upon the dorsal surface of the anal flap of the larva of *Smerinthus tiliæ* is represented by the extremely rough dorsal surface of the terminal spine of the pupa, and is thus a valuable aid to the identification of these two structures. In the larva of *Pygæra bucephala* there is a "glabrous corneous black plate occupying the (dorsal surface of the) anal flap" (Newman, 'British Moths,' 1869, p. 220). This is represented on the anterior

dorsal part of the tenth abdominal of the pupa, which forms a deep furrow with the ninth abdominal. The edge of the furrow is crenated (see Plate XXI. fig. 6).

4. *Larval tufts of Hairs indicated on the Pupa.*—In the larva of *Orygia pudibunda* there is a well-known tuft of hairs, the “tussock,” upon each of the first four abdominal segments, and these are distinctly marked on the first three abdominal segments of the pupa, and perhaps to a slight extent on the fourth. On the other hand, there is a long pencil of hairs on the eighth abdominal segment of the larva, of which I could detect no trace in the pupa.

The larva of *Orygia antiqua* also possesses four large tufts in the position described above, and the indication of these structures upon the first three abdominal segments is perhaps the most conspicuous feature of the pupa; but there is not the slightest trace of the fourth tuft. The three tufts in the pupa form squarish light-coloured patches, which are very distinct against the dark pupal cuticle, and are especially prominent and well defined in male pupæ, which are much blacker than females. The entire absence of any trace of the fourth tuft is very remarkable.

These appearances on the pupæ belong to a very different category from the merely mechanical scars, such as those produced by the caudal horn in Sphingidæ &c. and by



Fig. 1.

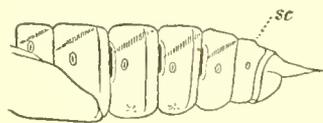


Fig. 2.

the four anterior claspers; for in the former case the pupa does not bear a scar of the larval tuft, but possesses a true hairy tuft itself. On the other hand, hairy prominences may be represented by mere scars, as in *Acronycta psi* (see woodcut 1).

Furthermore, in the pupa of *Saturnia carpini* distinct scars may be found which have been left by many of the brightly coloured hair-bearing warts of the larva. The scars are quite hairless and are much smoother than the rest of the pupa; they are rather depressed below the general surface.

5. *Larval Markings upon the Pupa.*—Sometimes the characteristic markings of the larva may be seen upon the pupa immediately after the skin of the former is thrown off, and these appearances may be fixed by placing the pupa in spirit and thus checking the darkening of the surface. The persistence of such colours depends upon the fact that the hypodermis cells of larva and pupa are the same; so that any pigment contained in them during larval life may remain unchanged after the pupal period has begun. Such colours are, of course, concealed in the living pupa by the opaque cuticle. I first noticed the persistence of larval colours in the freshly formed pupa of *Sphinx*

*ligustri*\* (see woodcut 2, natural size, showing the posterior part of an undarkened male pupa from the left side). The purple borders of the stripes are seen to bear a relation to the segments similar to that borne during the larval stage. This is especially well seen in the border of the last stripe. In the larva the last white stripe crosses the seventh abdominal and enters the base of the caudal horn on the eighth; its border is, of course, just in front of it during this course. The border in the pupa crosses the same segment, and its long axis points towards the anterior part of the scar of the caudal horn (see woodcut 2, *sc.*). So also the relation of the coloured borders to the spiracles is just the same as that of the larva. The borders in the figure are more distinct than in the spirit-specimen from which it was drawn, because the surface of the latter has darkened to some extent upon the back, and the borders appear to be merely lines of especial darkening as compared with the adjacent surface, which they resemble in colour (brown). In another spirit-specimen of *Sphinx ligustri* (preserved for nearly two years) the stripes remain very distinct and still retain a purplish tint. On removing a portion of the cuticle and examining its under surface, it was at once seen that the colour of the borders is due to pigment in the adherent hypodermis cells, which can be detached with loss of the colour. It is thus certain that the constitution of the coloured stripes in the pupa is similar to that in the larva, while the dark surface of the former is entirely different and due to a darkening of the cuticle.

Similar facts are true of the pupa of *Acherontia atropos*. When examined immediately after pupation the purple stripes and small circular patches (which probably spread from the bases of shagreen dots) of the larva are distinctly seen through the undarkened pupal cuticle. I have also observed the light oblique stripes, with their dark green borders, of *Smerinthus populi* and of *S. ocellatus*, conspicuously appearing upon the surface just after pupation.

The importance of these observations in homologizing the larval and pupal segments and structures is well shown by the following example:—"In the green freshly exposed pupa of *Aglia tau* all the markings of the larva are very distinct, and the subspiracular line which forms so prominent a feature of the larva, and which is continued along each side of the anal flap to its extreme apex, is equally conspicuous in the pupa, and occupies an identical position in relation to the terminal anal spine, which in this species is blunt and covered with an immense number of irregular hook-like cuticular processes" † (see Plate XXI. fig. 16 for the general form of this part of the pupa). Hence the position of the marking affords valuable confirmation of the identification of the anal flap of the larva with the terminal spine of the pupa, to be further discussed below.

There is little doubt that the careful examination of freshly formed pupæ will prove that such markings are of very general occurrence.

\* See Proc. Roy. Soc. vol. xxxviii. p. 278, in which this example is briefly described.

† Poulton, in Trans. Ent. Soc. Lond. 1888, p. 566.

PART II.—THE NUMBER OF ABDOMINAL SEGMENTS AND THEIR RELATION TO  
THOSE OF THE LARVA.

It is obviously necessary to determine these points before proceeding to the consideration of the external organs of reproduction, for the segmental relations of the latter are of the highest importance.

1. *The Number of Abdominal Segments in the Larva.*—There is no difficulty about the seven anterior abdominal segments, each of which bears a spiracle. Behind the seventh, however, there is a somewhat confused mass of segments, bearing a single spiracle on its anterior part; this spiracle is usually larger than those upon the other abdominal segments (see woodcut 4). This confused mass is sometimes described as a single segment and sometimes as two. Careful comparison with the pupa proves that it is certainly made up of three segments.

Woodcut 3,  $\times 2$ , represents the posterior part of the larva of *Gonoptera libatrix*, as seen from the left side. The separation of the anterior, spiracle-bearing part of the mass of segments behind the seventh abdominal (VII) is extremely distinct in this larva, clearly forming the eighth abdominal segment (VIII). Behind this there is a small ninth abdominal (IX), which is clearly separated off dorsally, although less distinct ventrally.

The pairs of dorsal bristles shown upon the eighth and ninth abdominal segments in woodcut 3 are obviously homologous with those on the anterior abdominal segments. In woodcut 4,  $\times 9$ , the same parts are seen from the right side in the larva of a Pyralæ, *Ephestia Kühmiella*; the ninth abdominal is seen to be even more distinct than in woodcut 3, and to be clearly defined ventrally. In the larva of *Agria tau* the independence of the ninth abdominal (and the tenth also) is strongly confirmed by the resemblance of the pair of dorsal tubercles to those upon the anterior dorsal segments\*. The accurate representation of these parts in many South-American larvæ should be studied in the plates of W. Müller's 'Südamerikanische Nymphalidenraupen' (Fischer, Jena, 1886).

In the pupa, this ninth abdominal segment, although small, is as distinct as any of the others; see, for instance, woodcut 5,  $\times 7$ , which represents the last three segments of a female pupa of *Pieris brassicae*, seen from the left side: the same parts of the same pupa are seen from the dorsal aspect in woodcut 6,  $\times 7$ . The distinct independence of the ninth abdominal is shown with equal clearness in most of the figures on Plates XX. & XXI.

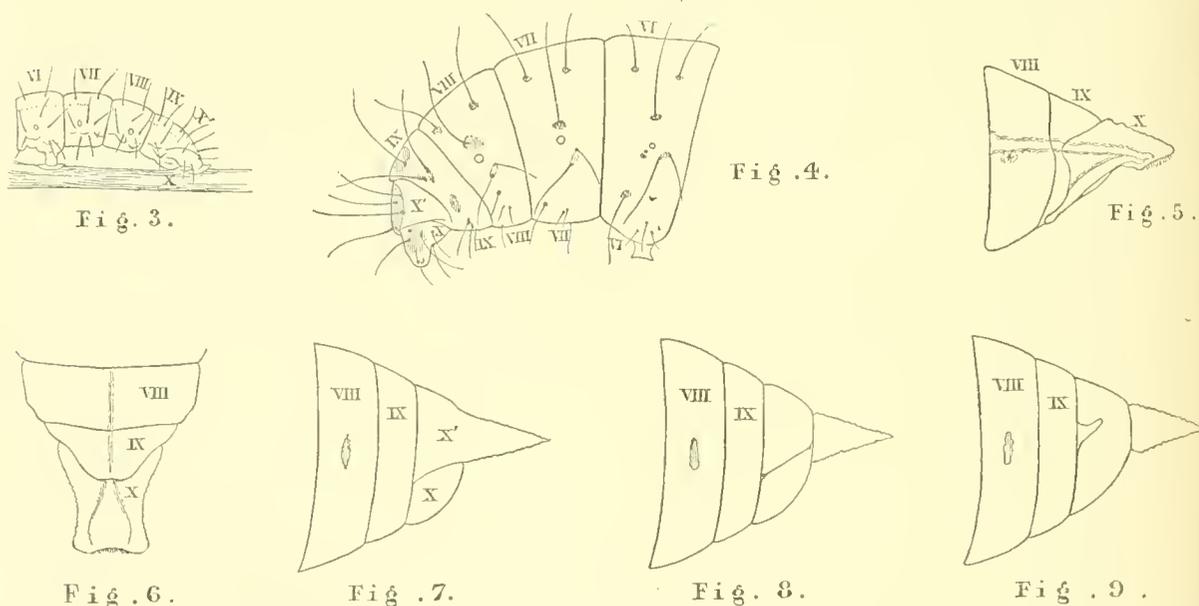
The part behind this segment in the larva forms a tenth abdominal. This segment is separated into a dorsal portion (x' in woodcuts 3 & 4), of which the posterior and lower part forms the anal flap, and a ventral portion (x), of which the anal claspers form the posterior and lower part; between the latter is the anus.

2. *The Relation of the Terminal Abdominal Segments of the Pupa to those of the Larva.*—The essential structure of the terminal parts of the vast majority of pupæ, as seen from the left side, is diagrammatically shown in woodcut 7. The identification of the various parts with those similarly numbered in the larva (woodcuts 3 & 4) is sufficiently obvious. The spiracle on the eighth abdominal is rudimentary in the pupa, although of exceptional

\* See Poulton in Trans. Ent. Soc. London, 1888, p. 561; woodcut 4 is copied from plate xvii. fig. 9 accompanying that paper.

size in the larva. The identification of the terminal spine (x') with the anal flap of the larva was published by Mr. W. H. Jackson in 'Forms of Animal Life' (1888, p. 153). I also find from my notes that I had independently arrived at the same conclusion. Important confirmation is afforded by the previously-described relation of certain larval structures and colours to those of the pupa. When a spine is absent, and the terminal part of the pupa is rounded, the part above the anus nevertheless corresponds to the larval anal flap (see Plate XX. fig. 27, Plate XXI. fig. 12, &c.). The rounded cushion-like structure (x) represents the left anal clasper of the larva, and bears a similar relation to the anus and dorsal part (x'). The proof of this identification is chiefly found in the previously described exceptional individuals in which this part retains the characters of the anal claspers (see Plate XX. figs. 8, 9, 10).

An examination of Plates XX. and XXI. will show that the condition represented in woodcut 7 is typical among pupæ. There are, however, certain species in which the



arrangement is somewhat different. Woodcut 8 represents diagrammatically one of these exceptions. An example is found in the pupa of *Agria tau* (Plate XXI. fig. 16). The base of the terminal spine is somewhat constricted off from the rest of the tenth abdominal; the latter is divided into an upper and lower part by an oblique furrow. In certain Geometræ the same conditions are still more strongly marked; they are diagrammatically represented in woodcut 9. *Melanippe fluctuata* is a good example of this condition of the tenth abdominal (see Plate XXI. figs. 21, 22, 23), while *Amphidasis betularia* is transitional from this to the normal condition shown in woodcut 7 (see Plate XXI. fig. 20).

For a long time I believed that the tenth abdominal is in reality composed of two segments arranged, as in woodcut 7, one over the other. The arrangement shown in woodcut 9 is then explained by the supposition that the two component segments have assumed a more normal mode of succession, the anal segment (x in woodcut 7) becoming

the tenth, and separating the rostral segment ( $x'$  in woodcut 7) as the eleventh from any contact with the ninth. Now, however, I think it is far more probable that the line of separation between the two parts of the tenth abdominal in woodcut 7 merely corresponds to the posterior part of the chink beneath the larval anal flap. The constriction which in certain pupæ encircles the base of the terminal spine would then cease to have any morphological significance; and this is also rendered probable by the fact that closely allied pupæ are altogether without it. The existence of a distinct line separating the supposed anal segment into a ventral and dorsal part in the condition represented in woodcut 8, and the indication of such a division in the more pronounced condition represented in woodcut 9, are also irreconcilable with the view that the terminal spine of these woodcuts represents the whole of the dorsal part of the tenth abdominal ( $x'$  in woodcut 7).

We may therefore conclude that both larva and pupa possess ten abdominal segments; and even if this conclusion may require subsequent modification, the segmental relations of the external reproductive organs will be unaffected; for these structures only come into relation with the eighth, ninth, and the ventral (anal) part of the tenth abdominal segments.

### PART III.—THE EXTERNAL GENERATIVE ORGANS.

1. *Introductory and Historical.*—It is very remarkable that these organs have not been universally recognized, considering that thousands of pupæ are examined every year by entomologists and dealers, while the organs are easily seen in large species by the naked eye. There are other well-known tests of the sex of pupæ, depending on the difference between male and female antennæ, and upon the greater size of the abdomen in the female. But the former only applies to certain species (in which such a difference exists), and in these the antennæ of the pupæ are far more alike in the two sexes than those of the imagines of the same species (as will be shown in a future paper). The latter test is even more precarious. I therefore think that a study of the sexual differences on Plates XX. & XXI. will be of practical assistance in many departments of the subject. I have myself found the knowledge invaluable for many years, in the management of some experiments with larvæ in which it was necessary to ascertain and allow for hereditary tendencies. The pupæ of moths can be arranged according to their sexes far more quickly than the imagines of the same species, except when there is some obvious secondary sexual character, such as a difference in the colouring of the wings, &c. The organs are especially easy to distinguish, because pupæ are either entirely hairless, and generally smooth in the region of these structures, or possess minute or scanty hairs which do not cause any obscurity.

In the first edition, now out of print, of 'Forms of Animal Life' (1870) by the late Professor Rolleston, these words occur on p. 76, in a description of the pupa of *Acherontia atropos*:—"The ninth abdominal ring is marked by a depression on either side of the middle ventral line, the lines limiting which extend into the interspace between it and

the eighth abdominal segment, and indicate thus the normal position of the outlet of the generative glands." It is very difficult to see how a morphologist could have come so near the discovery of the external organs of reproduction and yet have failed to find them. The only possible explanation can be that, in the examination from which the above description was written, only a single pupa was made use of, or perhaps a small number, all of which happened to be of the same sex. It is quite clear that Professor Rolleston was speaking of a female pupa, for the organs are so obvious as distinct structures in the males that they could not have been passed over. Besides, the description quoted above is under no circumstances applicable to the male sex, while it does form an imperfect account of the appearance in certain female pupæ.

On the other hand, almost all entomologists who have carefully figured large pupæ exhibit in their drawings traces of the sexual characters which are sometimes accurately rendered in the case of the males. Thus, Lyonet figures (plate 39. fig. 3) a pupa of *Cossus ligniperda* with distinct male organs; Moore ('Lepidoptera of Ceylon') represents some large pupæ with indications of the generative structures. Burmeister, in his beautiful illustrations of the Lepidoptera of the Argentine Republic, also represents these parts. Thus his plate 18. fig. 11 represents a distinct male pupa of *Attacus hesperus*; while his plate 20. fig. 5 B is an equally distinct female pupa of *Ceratocampa imperialis*. In the description of these figures the position of the generative aperture is pointed out, but the sexual differences are not observed. Mr. W. F. Kirby has pointed out to me that there is a brief description of the male characters in Berge's 'Schmetterlingsbuch' (5th ed. 1876, p. viii):—"Bei dem männlichen Geschlechte auf dem vorletzten Ringe zwei durch einen Eindruck getrennte Höckerchen."

The morphology of the sexual structures is never attempted in these descriptions, and the figures are not sufficiently accurate or detailed to be of any value. This is especially true of the female sex, and I believe that an accurate figure of the female characters has never been published until now.

I first noticed the male organs in a pupa of *Sphinx ligustri* in the autumn of 1883, and at once began to examine a number of pupæ in order to find the characters of the opposite sex. This led me to undertake a careful comparison of the external generative organs in a large number of species, and finally to investigate all the features which make up the external morphology of this stage in Lepidoptera. This investigation has been intermittently continued up to the present date. Many of the figures on Plates XX. and XXI. were drawn during the autumn and winter of 1883 and early in 1884, namely, Plate XX. figs. 3, 4, 5, 6, 7, 12, 13, 14, 16, 18, 19, 22, 30, 31, 32, Plate XXI. figs. 4, 5, 6, 7. When I showed these figures to Professor Moseley, who took a very great interest in the work, and helped me with many kind suggestions, and with the results of his own observations upon pupæ, he expressed the opinion that the figures should be made on a much larger scale. The size of the other figures on the two Plates was adopted as the result of this advice. The smaller figures are of the natural size, and are useful in showing how much can be made out with the naked eye.

I have also to thank my friends Professor Meldola and Mr. W. White for kindly providing me with much of the material which has been made the subject of investigation.

Mr. White spent a great deal of time and trouble in examining pupæ and putting aside the most favourable specimens for my use. I owe the specimens from which the following figures were made to his kind assistance:—Plate XX. fig. 26; Plate XXI. figs. 9, 12, 13, 24, 25, 30, 34. Plate XXI. figs. 1, 2, 28, and 29 were drawn from Professor Meldola's material. Figs. 1 and 2 represent two especially favourable individuals selected after the comparison of a very large number.

2. *The Male External Reproductive Organs.*—A casual examination of a large pupa with the naked eye, or of a small one with the assistance of a low magnifying-power, at once shows the existence of two convex or flattened, roundish, oval, or trianguloid tubercles, placed one on each side of the middle ventral line, in the ninth abdominal segment. Careful examination throws some doubt upon the certainty of this segmental relationship. There is no doubt, however, that the organs always occur *in the zone of the ninth abdominal*, viz. in an area which would be included in the segment if the boundaries of the latter were produced in the direction indicated by their course in the dorsal and lateral regions. Between the tubercles is a furrow which generally becomes a deep pit in its central part; this pit is the ancient opening of the pupal *vas deferens*, and it now corresponds externally to the termination of the ducts internally.

It is furthermore possible by carefully selecting the pupæ, to find individuals which approach the condition of a perforate orifice. I have found *Smerinthus populi* the best species for this purpose, and on examining the organs from the *inside* of the empty pupa-case of a favourable individual, the lips of the depression are seen completely introverted, their internal surface having the black appearance and peculiar roughened texture which is characteristic of the exterior of the pupa, and with which it is of course continuous. The surface of the introverted funnel-like opening is covered with the same lustrous white layer which invests the whole interior of the cuticle, and which therefore is contrasted very sharply with the internal surface or lumen of the funnel. In this case the funnel is not closed at its deepest point, the lumen being obstructed a little higher up by the fusion and hardening of the semifluid substance into a solid plug immediately after pupation. When looked at from within, the sides of the sharply truncated funnel are quite free, recalling most vividly the condition in which the lumen was perforate throughout. The whole appearance from within, in fact, singularly resembles that of one of the superficial functional spiracles looked at from the same point of view. These have similar introverted lips, also sharply truncated, and showing the characteristic black surface which lines the lumen. The rudimentary eighth abdominal spiracle, on the other hand, is completely closed below, and the white surface lining the pupal cuticle is unbroken over it. It is very remarkable that this most ancestral generative organ should in certain cases retain such strong indications of the time when it was functional.

On the other hand, there are proofs of the ancestral nature of the male organs, and of their rudimentary condition, as far as the pupa itself is concerned. Thus the individual differences are very great in position and form, and in the degree to which the structures are developed. Furthermore, these organs are often asymmetrical when all other parts of the pupa are entirely normal. The asymmetry may be slight, as in Plate XX. fig. 11,

or pronounced, as in Plate XXI. fig. 34, or accompanied by marked deformity, as in Plate XX. fig. 26.

I have already stated that these organs appear to the naked eye to belong to the ninth abdominal. They are represented in this position in all figures which are of the natural size. When moderate powers are employed, together with the best means of illumination, and when the most favourable individuals are selected for examination, the organs appear to be surrounded by a furrow or line which is continuous on either side with the boundary between the ninth and tenth abdominal segments. This interpretation is supported by Plate XX. figs. 17, 18, 19, 21, and 23, and Plate XXI. fig. 2; that is to say, it is supported by all the most carefully drawn and highly magnified figures. In some of these, and especially in Plate XXI. figs. 12, 13, the organs appear to belong to an anterior median extension of the tenth abdominal.

I have not described the differences between these organs in the various species examined, nor the sculpture of their surface as compared with that of the adjacent area, because all this can be sufficiently made out by studying Plates XX. and XXI., and by reading the description of the figures.

3. *The Female External Reproductive Organs.*—These organs will also be described briefly, and the reader is referred to Plates XX. and XXI. for the details of specific and individual differences.

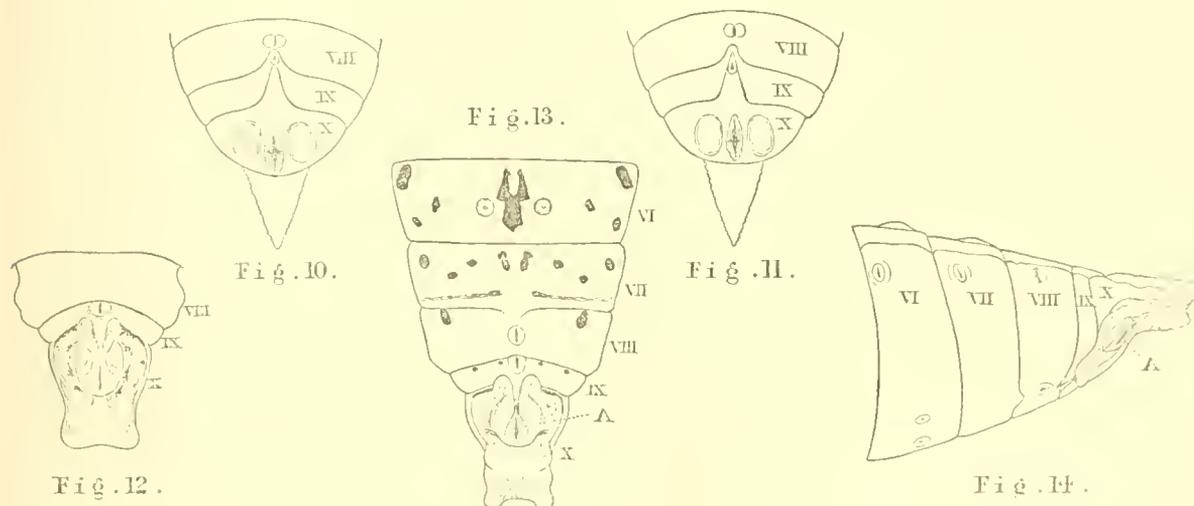
When the female pupa is examined with the naked eye, or with a low magnifying-power, the first character which arrests attention is an anterior median ventral wedge-shaped extension of the tenth into the ninth and sometimes into the eighth abdominal segment. In the majority of pupæ this feature is certainly more conspicuous than the generative apertures, and I observed and figured it long before I had detected the latter. It is interesting to note that Lyonet figured it in the pupa of *Bombyx rubi*, although without any other feature characteristic of the external reproductive organs. (See Lyonet, plate xxiv. fig. 12.) The median prolongation is especially conspicuous in the pupæ of Heterocera, but distinct traces of it can be often made out in Rhopalocera. The anterior median ventral margin of the ninth abdominal is also prolonged into the eighth for a variable distance, thus permitting the ventral prolongation of the tenth abdominal, or the generative aperture in connexion with its apex, to extend beyond the zone of the ninth abdominal (see page 199). The development of both these median processes varies extremely, not only in different species but in different individuals of the same species. Sometimes there is a median line which traverses the prolongation of the tenth abdominal, as in *Macroglossa stellatarum* (Plate XX. figs. 24 & 25). Sometimes the base of the prolongation appears to be separated from the rest of the tenth abdominal as in *Cossus* and *Zeuzera* (Plate XX. figs. 27 and 29; Plate XXI. fig. 1.) Any discussion as to the possible meaning of this feature is better deferred until after the consideration of the generative apertures.

There are two distinct generative openings in female pupæ—an anterior for the *bursa copulatrix*, and a posterior for the oviducts. The anterior is probably always associated with the eighth abdominal; it is more distinct than the other, and is usually provided with prominent lips. It is often slit-like, and extends from the posterior to the ante-

rior boundary of the segment, but is especially dilated at its posterior end (see Plate XX. figs. 15, 27, & 29). In a single individual of *Orgyia antiqua* (Plate XXI. fig. 10) it appears to be placed on a forward extension of the ninth abdominal into the eighth, but in another individual of the same species its position is normal (Plate XXI. fig. 9). We may safely conclude that the anterior generative opening is associated with the eighth abdominal segment.

The segmental relation of the posterior generative opening is far more difficult to determine. The two views as to its relationship appear to be about equally supported by the figures on Plates XX. and XXI. These are illustrated by woodcuts 10 and 11. In the former the posterior aperture is placed on the ninth abdominal, immediately in front of, but distinct from, the apex of the median prolongation of the tenth abdominal.

In woodcut 11 the aperture is placed on the apex of the prolongation itself, and therefore belongs to the tenth abdominal segment. In the majority of pupæ the opening occurs at the apex, and may or may not be considered to belong to it. This is the case, for example, with figs. 25 and 29 on Plate XX. Whether connected with the apex or not,



the aperture is always placed close to it. The posterior generative opening is often obscure and unrecognizable on the surface (*e. g.* Plate XX. fig. 1), and is often fused with the anterior aperture (*e. g.* Plate XX. fig. 8). Even when the two openings are fused and are prolonged into a common invagination, the double nature of the latter is shown by a furrow (Plate XXI. fig. 19). The posterior opening may be surrounded by prominent lips or by a swollen margin (*e. g.* Plate XX. fig. 15; Plate XXI. fig. 15), or it may be without these features (Plate XXI. fig. 3).

Although the female organs are not asymmetrical like those of the male, they are subject to even greater individual differences.

The pupæ of *Rhopalocera* possess essentially similar openings, but they are much more difficult to interpret because of the specialization in shape and the amount of surface sculpture. The ventral area of the ninth abdominal may even be entirely hidden (*e. g.* the male *Nemeobius lucina*, Plate XXI. figs. 32 & 33). Figs. 24-31 on Plate XXI,

selected from very favourable individuals, prove that both male and female external generative organs of Rhopalocera are essentially similar to those of the Heterocera.

A still more typical example is afforded by the pupa of *Pieris brassicae*, of which the male is shown in woodcut 12,  $\times 7$ , and the female, from two points of view, in woodcuts 13 and 14,  $\times 7$ .

The constancy and distinctness of the median prolongation of the tenth abdominal and the relation of its apex to one of the generative apertures indicates that it possesses some important morphological significance. Its shape suggests that it may represent an ancestral ovipositor formed as an anterior ventral extension of the tenth abdominal, and now fused to the pupa in its position of rest. Just as the male intromittent organ seems to be now only represented by the cuticle of that part of it which appeared on the surface when it was withdrawn, so the ancestral ovipositor is only represented by its external cuticular layer. The slight shifting of the generative opening, shown in woodcut 10, does not appear to disprove this hypothesis.

This hypothesis also explains the fact that there is a separate opening into the *bursa copulatrix*. Copulation would be almost impossible if the female aperture were placed on the apex of a conical process; hence the necessity for a more accessible aperture. This arrangement having been once set up, would be retained after the disappearance of the necessity under which it originally arose, because of the many co-adaptations which would have been entailed in both sexes.

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## DESCRIPTION OF PLATES XX. & XXI.

Representing the characters of the terminal abdominal segments and the external reproductive organs of Lepidopterous pupæ.

(The abdominal segments are indicated by Roman numerals, the anus by A, the terminal spine by Sp. Other structural features are described with reference to their segments, and will be identified easily.)

### PLATE XX.

All the figures on this Plate represent the pupæ of Heterocera.

Figs. 1-7. The terminal abdominal segments of the pupa of *Smerinthus ocellatus*, showing the form of the external reproductive organs.

Fig. 1.  $\times 7$ . The last three abdominal segments of a female pupa, seen from the ventral aspect. These segments, being the 8th, 9th, and 10th abdominal, are indicated by the numbers VIII., IX., X. The number VIII. is placed close to the last spiracle, rudimentary in the pupa, although functional in the larva. The rough terminal spine (Sp.) forms the extremity of the pupa; immediately in front of it (in the ventral line) is the anus (A), which is very distinctly indicated. The boundary between the 9th and 10th segments is prolonged forwards in the ventral line,

and the apex of the narrow triangular area which is thus formed represents the opening of the oviducts, invisible in this and most individuals of the species, although sometimes seen. Immediately in front of the apex of the above-mentioned area is the second or anterior generative aperture, that of the *bursa copulatrix*. This is very distinctly marked and is bounded laterally by prominent convex lips; it thus resembles the form of the male generative opening, but can be readily distinguished in that it is placed in the 8th abdominal segment, while the male aperture is situated in the 9th.

Fig. 2.  $\times 7$ . The same pupa as seen from the right side. The posterior part of the seventh abdominal segment is shown in addition to those represented in fig. 1. The number VIII. is placed close to the dorsal projection which corresponds to the caudal horn of the larva, and which is very exceptionally developed in this individual. Immediately below the terminal spine (Sp.) is seen a curved line dividing the tenth segment into an upper and a lower (or anal) part.

Fig. 3. Natural size. The terminal part of a female pupa, as seen from the ventral aspect in a good light. The narrow pointed prolongation of the boundary between the ninth and tenth abdominal segments is distinctly seen, although neither of the generative openings were visible in this individual without magnification. The anus is distinct, and the cushions on each side of it (representing the anal claspers of the larva) are somewhat more prominent than usual.

Fig. 4. Natural size. The same pupa as seen from the left side. Beneath the reference letter VIII. a normal trace of the larval caudal horn is seen, indicating the exceptional character of fig. 2 in this respect. The trace consists of an anterior slight elevation formed by the soft surface of the pupa rising in the hollow interior of the horn, and a posterior slight concavity caused by the hinder margin of the base being depressed into the soft surface when the horn is bent backwards, becoming nearly horizontal, before pupation.

Fig. 5. Natural size. The terminal part of another female pupa, seen from the ventral aspect; the opening into the *bursa copulatrix*, with its lateral lips, is peculiarly distinct.

Fig. 6. Natural size. The terminal part of a male pupa, seen from the ventral aspect. The opening of the male ducts is distinctly seen, placed between the prominent lips upon the ninth abdominal segment.

Fig. 7.  $\times 2$ . The ventral part of the ninth abdominal segment of the last pupa, showing the external reproductive organs more distinctly. The small pit in front of the organ is merely an accidental irregularity of the surface.

Figs. 8-11. The Terminal Abdominal Segments of the Pupa of *Smerinthus populi*.

Fig. 8.  $\times 5.25$ . The last three abdominal segments of a female pupa, seen from the ventral aspect. The anus is concealed in this position, owing to the altogether exceptional size of the anal cushions, which, in this individual, even retain the form of the larval claspers. An elongated opening, surrounded by a raised border, is situated in the normal position in front of the apex of the narrow median prolongation from the tenth abdominal segment. The opening is seen to be divided in two; it is probable that the posterior division represents the mouth of the oviducts; the anterior division, of course, corresponds to the *bursa copulatrix*. The remarkable sculpture of the surface is indicated in the figure.

Fig. 9.  $\times 5.25$ . The same pupa, as seen from the left side; the scar of the caudal horn is distinct, and the remarkable size and shape of the left anal cushion is better seen than in the previous figure.

Fig. 10.  $\times 7$ . The same pupa, as seen from the left side and behind. The object of the figure is to show the relative positions of terminal spine, anus, and anal cushions. These bear precisely the same relation to each other as the anal flap, anus, and anal claspers of the larva, thus

supporting other observations which prove that these parts are respectively homologous. The external reproductive organs are seen obliquely, and therefore indistinctly in this and the last figure.

Fig. 11.  $\times 4$ . The last three abdominal segments of a male pupa, seen from the ventral aspect. The male opening is distinct on the ninth abdominal segment; its direction is somewhat oblique, an irregularity which is not uncommon and probably follows from the extremely ancestral character of the organs. The lateral lips are flattened and marked with a sculpture which is different from that of the surface of the ninth abdominal segment. The anal cushions are of normal size, and serve as a gauge of the amount of abnormality of figs. 8, 9, and 10 in this respect.

Figs. 12-14. The Terminal Abdominal Segments of the Pupa of *Smerinthus tiliæ*.

Fig. 12. Natural size. The last four abdominal segments of a female pupa, seen from the ventral aspect. The median prolongation of the tenth abdominal is distinct, and the median slit in front of its apex represents one or both generative openings.

Fig. 13. Natural size. The last five abdominal segments of a male pupa, seen from the left side. The scar of the caudal horn is distinctly seen in profile. The generative organs cannot be seen, but the contour of the ventral part of the terminal segments is characteristic of the male sex.

Fig. 14. Natural size. The last three segments of a pupa (sex unnoted), seen from the dorsal aspect, in order to show the scar of the caudal horn from above.

Figs. 15-19. The Terminal Abdominal Segments of the Pupa of *Acherontia atropos*.

Fig. 15.  $\times 9$ . The median ventral part of the last three segments of a female pupa. Both generative openings are distinctly visible in this individual; the opening of the oviducts is large and surrounded by a thickened V-shaped lip. It is placed in front of the apex of the median prolongation from the tenth abdominal, and appears to be clearly situated in an anterior median extension of the ninth abdominal segment. The opening into the *bursa copulatrix* is immediately in front of the other aperture, but separated from it by the boundary between the eighth and ninth abdominal segments. The opening extends forward as a narrow median slit as far as the anterior boundary of the eighth abdominal. The anus (A) is distinct on the tenth abdominal. The sculpture on the surface of the pupa and the various wrinkles &c. are carefully copied in the figure. These details required for their elucidation the most careful examination of an especially favourable individual in a very strong light. The general resemblance of the generative apertures to those of a well-marked individual of *Cossus ligniperda* is very striking (compare figs. 27 and 29).

Fig. 16. Natural size. The last three segments of a female pupa, seen from the ventral aspect. The generative apertures could not be made out without magnification, but the median prolongation was very distinct, far more so than in the last figure. In front of the anus (A), at the base of the median prolongation, there is the deceptive appearance of an opening with lips, due to wrinkles in the pupal case. The true generative openings never assume so posterior a position. In fig. 15 the true nature of the marking is apparent.

Fig. 17.  $\times 9$ . The median ventral area of the ninth and the anterior part of the tenth abdominal segments of a male pupa. The figure hardly needs description as the male organs are quite typical. The lateral tubercles are roundish and somewhat flattened. The sculpture of the surface is represented. The exact relation of the male organ to the boundary between the ninth and tenth abdominal segments varies greatly in different species (compare figs. 11, 20, 21, 23).

Fig. 18. Natural size. The last three segments of a male pupa, seen from the ventral aspect, showing the appearance of the male organ when looked at without magnification.

Fig. 19.  $\times 2$ . The median ventral area of the ninth and the anterior part of the tenth abdominal segments of the pupa represented in the last figure, showing the form of the male organs with greater distinctness. The three minute pits in front of the reproductive organ are probably merely an accidental conformation of the cuticle, for they are not found in other individuals (compare fig. 17).

Figs. 20, 21. The Terminal Abdominal Segments of the Pupa of *Sphinx ligustri*.

Fig. 20.  $\times 4$ . The ninth and tenth abdominal segments of a male pupa, seen from the ventral aspect, showing the sculpture of the surface and the male reproductive organ. The latter is typical; its relation to the boundary between the ninth and tenth abdominal segments is better shown in the next figure, where it is seen to be nearly the same as in *Acherontia atropos* (fig. 17).

Fig. 21.  $\times 26$ . The median ventral area of the ninth and adjacent parts of the eighth and tenth abdominal segments, showing the male organ and the surface sculpture very distinctly; the lateral tubercles are more closely applied than in *Acherontia atropos*. The pit in front of the reproductive organ is merely an individual peculiarity.

Figs. 22, 23 The Terminal Abdominal Segments of the Pupa of *Deilephila euphorbie*.

Fig. 22. Natural size. The last three segments of a male pupa, seen from the right side. The rudimentary spiracle and the scar of the caudal horn are seen on the eighth abdominal. The horizontal furrow which divides the tenth abdominal into a dorsal (rostral) and ventral (anal) part is unusually distinct. The division is rendered especially apparent because the dorsal part extends further anteriorly than the ventral, so that the ninth abdominal is narrow in front of the former and becomes suddenly broader in front of the latter.

Fig. 23.  $\times 26$ . The median ventral area of the ninth and adjacent parts of the eighth and tenth abdominal segments, showing the male organ and the sculpture of the surface very distinctly. The male organ is somewhat asymmetrical. The two tubercles in front of it are probably an individual peculiarity.

Figs. 24, 25. The Terminal Abdominal Segments of the Pupa of *Macroglossa stellatarum*.

Fig. 24.  $\times 4$ . The last four segments of a female pupa, seen from the ventral aspect. The functional spiracles on the seventh abdominal and the rudimentary spiracles on the eighth are represented in profile. The posterior part of the pupa gradually tapers into the sharp black rostrum. The anus (A) is distinct. The chief peculiarity of the pupa is the remarkable distinctness of both the female reproductive apertures. Although clearly seen in this figure, their relation to the segments is better studied in the more highly magnified fig. 25.

Fig. 25.  $\times 40$ . The median ventral area of the last three segments of the pupa represented in the preceding figure. Of the very distinct reproductive openings, the anterior, leading into the *bursa copulatrix*, is seen to belong to the eighth abdominal, while the posterior, opening into the oviducts, apparently belongs to the ninth abdominal. The ventral prolongation of the boundary between the ninth and tenth abdominal is marked by a narrow pointed median band prolonged from the area round the anus (A). The latter is very distinct. The surface of the pupa is everywhere marked by circles with a dot in the centre of each, representing the (bristle-bearing) shagreen tubercles of the larva. The figure was drawn from a transparent object.

Fig. 26. The Terminal Abdominal Segments of the Pupa of *Sesia fuciformis*.

Fig. 26.  $\times 14.5$ . The last two segments of a male pupa, seen from the ventral aspect. The object of the figure is to show the remarkable distortion of the male organs in the individual represented. This is not accompanied by any want of symmetry in the adjacent parts. The anus (A), the large rostrum, the form of the segments, except in the parts directly affected by their close proximity to the male organs, are all undistorted.

Figs. 27-32. The Terminal Abdominal Segments of the Pupa of *Cossus ligniperda*.

Fig. 27.  $\times 7$ . The last three segments of a female pupa, seen from below, behind, and the left side. The reproductive organs were especially distinct in the individual figured. On the eighth abdominal the rudimentary spiracle and part of the dorsal semicircle of hooks are seen, together with the opening into the *bursa copulatrix*, which consists of a main aperture close to the posterior boundary of the segment and a narrow slit-like forward extension which reaches the anterior boundary. The semicircle of hooks on the ninth abdominal is also seen, together with the distinct opening into the oviducts, normally placed at the apex of the median prolongation of the tenth abdominal. On the tenth abdominal the anus is seen at A; the segment is divided, as in other pupae, into a ventral (x) and a dorsal (x') part. The semicircle of hooks on other adjacent abdominal segments is imperfectly represented on the tenth abdominal. In the median ventral line between the anus and the anterior prolongation there is a mark like that in a corresponding position on the female pupa of *Acherontia atropos* (fig. 16). In both pupae the mark is due to wrinkles in the pupa-case, and is probably of no morphological significance.

Fig. 28.  $\times 50$ . The median ventral area of the eighth, ninth, and part of the median prolongation from the tenth abdominal segments of the same pupa, as seen from within, from the right side and above. The main opening of the *bursa copulatrix* is seen to be prolonged into a laterally compressed funnel-shaped invagination of the cuticle, while the anterior extension is also distinctly marked by a long narrow ridge on the inner surface of the eighth abdominal. The opening of the oviducts is also marked by a very distinct invagination continuous posteriorly with the ridge-like boundaries of the median prolongation of the tenth abdominal. The small hemispherical elevation immediately in front of the last-named invagination is probably an individual variation.

Fig. 29.  $\times 9$ . The median ventral area of the eighth, ninth, and tenth segments of the same pupa, as seen from the ventral aspect. Many of the appearances described in fig. 27 can be followed more accurately and in greater detail. The surface sculpture is carefully figured. The above-described mark in front of the anus (A) is clearly shown, together with a pit in the posterior part of the seventh abdominal. The latter structure is probably also devoid of morphological significance.

Fig. 30.  $\times 4$ . The last two segments of a male pupa, seen from below and behind. The anus (A) is distinctly seen as a vertical slit in the ventral part of the small tenth abdominal. The spines which represent the semicircle of hooks on other adjacent abdominal segments are far less numerous than in the same part of the pupa shown in fig. 27, but, as in the latter, a single spine placed on each side of the anus is especially strong. The external reproductive organ is distinctly seen on the ninth abdominal; the lateral tubercles are flattened. Anterior to the organ there is a small flattened area with a different appearance from the rest of the surface. The semicircle of hooks on the ninth abdominal is seen, except in its dorsal part, which in this position is concealed by the tenth abdominal.

Fig. 31.  $\times 2$ . The last three segments of the same pupa, as seen from behind. The semicircles of hooks

are distinct on the eighth and ninth abdominal segments. The rudimentary spiracle on the former and the male organs on the latter are also seen. The division of the tenth abdominal into a ventral (anal) and dorsal part is distinctly shown. Four small spines are placed on the latter part, as in fig. 27.

Fig. 32. Natural size. The last five segments of the same pupa, as seen from the right side. The semi-circles of hooks on the sixth, seventh, eighth, and ninth abdominal segments are distinctly seen, together with the functional spiracles on the first two of these and the rudimentary spiracle upon the eighth abdominal. Some slight irregularities of the surface below the spiracle on the sixth abdominal represent the larval clasper. The two parts of the tenth abdominal and its imperfect semicircle of spines are also seen, together with the male organs on the ninth abdominal.

### PLATE XXI.

Figs. 1-23 represent Pupæ of Heterocera; the remaining figures represent the Pupæ of Rhopalocera.

Figs. 1, 2. The Terminal Abdominal Segments of the Pupa of *Zeuzera aesculi*.

Fig. 1.  $\times 26$ . The median ventral area of the eighth, ninth, and the anterior part of the tenth abdominal segment of a female pupa. The resemblance to the pupa of *Cossus* is very marked (compare Plate XX, fig. 29), although the two reproductive openings are almost fused together. The surface-sculpture is represented. The anterior prolongation of the tenth abdominal is very distinct, as in *Cossus*, although in both these species its base is separated from the rest of the segment by a well-marked line of demarcation and by a difference in the character of the surface.

Fig. 2.  $\times 26$ . The median ventral area of the ninth and the anterior part of the tenth abdominal segment of a male pupa. The male organ is beautifully regular; the lateral tubercles are somewhat flattened. The relation of the organ to the division between the ninth and tenth segments is carefully figured.

Figs. 3-6. The Terminal Abdominal Segments of the Pupa of *Pygæra bucephala*.

Fig. 3.  $\times 5.25$ . The last three segments of a female pupa seen from the ventral aspect. The median prolongation of the tenth abdominal is unusually long, so that its apex and the inconspicuous opening of the oviducts is carried forward beyond the middle of the eighth abdominal: the opening of the *bursa copulatrix* is distinct and has a thickened border. The anus ( $\Delta$ ) is small. The shape of the double terminal spine is remarkable. The rudimentary spiracles are seen at the sides of the eighth abdominal. The surface-sculpture is represented.

Fig. 4. Natural size. A representation of the same parts (except that the seventh abdominal is also included) in another female pupa. The object of the figure is to prove that sexual characters are easily distinguished by the naked eye. A characteristic feature is afforded by the median prolongation of the tenth abdominal. The female sexual openings are only distinctly seen in the majority of individuals by means of a lens.

Fig. 5. Natural size. The ninth, tenth, and the posterior part of the eighth abdominal segments of a male pupa, seen from the ventral aspect. The male organs are seen to be distinctly recognizable without magnification. They are characteristic in form and position.

Fig. 6. Natural size. The same segments, as seen from the dorsal aspect. The object of the figure is to show a structure which corresponds to the black plate upon the dorsal surface of the larval anal flap. It is placed on the anterior dorsal margin of the tenth abdominal, and is valuable in homologizing the larval and pupal segments.

Figs. 7, 8. The Terminal Abdominal Segments of the Pupa of *Cerura vinula*.

Fig. 7. Natural size. The last four segments of a female pupa seen from the ventral and posterior aspects. The median prolongation of the tenth abdominal is very distinct. A dorsal semi-circle of spines is seen on the ninth abdominal, together with the indications of a semicircle upon the dorsal division of the tenth abdominal.

Fig. 8.  $\times 4$ . The median ventral area of the ninth and adjacent part of the tenth abdominal segments of a male pupa. The male organs are characteristic in position and in form, except that the lateral tubercles are flattened as in *Cossus* (Plate XX. fig. 30).

Figs. 9, 10. The Terminal Abdominal Segments of the Pupa of *Orgyia antiqua*.

Fig. 9.  $\times 9$ . The median ventral area of the eighth, ninth, and the anterior part of the tenth abdominal segments of a female pupa. The two closely adjacent generative openings are enclosed between lateral lips which bear a striking resemblance to each other. The posterior opening is in a normal position at the apex of the median prolongation.

Fig. 10.  $\times 9$ . The same parts of another female pupa. A comparison between this and fig. 9 illustrates the very great amount of individual variation in the characters of the external reproductive organs. The differences, are, however, somewhat exaggerated by the fact that this figure was drawn from a transparent object, while fig. 9 was drawn from an opaque object. The two openings are seen to be fused. The posterior appears to belong to the tip of the median prolongation of the tenth abdominal, the anterior to a forward extension of the ninth; the latter is an exceptional appearance.

Figs. 11-13. The Terminal Abdominal Segments of the Pupa of *Odonestis potatoaria*.

Fig. 11.  $\times 5\cdot 25$ . The last three segments of a female pupa seen from a ventral and posterior aspect. The anterior generative opening is very distinct and surrounded by lips; it is placed on the posterior part of the eighth abdominal. The posterior opening is probably represented by the median line immediately behind the anterior opening, but there is another mark placed more posteriorly, which may indicate its presence. The posterior end of the pupa is seen to be rounded.

Fig. 12.  $\times 7\cdot 5$ . The last three segments of a male pupa, seen from a ventral and posterior aspect, but more posteriorly than in the last figure. Hence the division of the tenth abdominal into a ventral or anal (x) and dorsal (x') part is clearly indicated. The latter is entirely without a terminal spine, but is covered dorsally by minute hooks. The male organ is better studied in the next figure. The anus (A) is nearly terminal.

Fig. 13.  $\times 50$ . The median ventral area of the ninth and anterior part of the tenth abdominal segments of the same pupa, showing the male organ and its relation to the segments. The surface-sculpture is indicated. The male organ is seen to be somewhat asymmetrical; it is surrounded by a thickened margin rather than by the two lateral lips which are distinct in most male pupae (compare fig. 2). The relation to the limits of the ninth and tenth segments is carefully figured.

Fig. 14. The Terminal Abdominal Segments of the Pupa of *Endromis versicolor*.

Fig. 14.  $\times 7$ . The last three segments seen from the dorsal aspect. The surface of the pupa is extremely rough and richly beset with spines, which take a backward direction, and probably assist in emergence from the cocoon. The scar of the caudal horn is unusually distinct and large in this individual; it is placed, as in the pupa of *Sphingidae*, upon the eighth abdominal.

Figs. 15, 16. The Terminal Abdominal Segments of the Pupa of *Aglia tau*.

- Fig. 15.  $\times 7$ . The last three segments of a female pupa, seen from the ventral aspect. The surface-sculpture is represented. The generative openings are unusually distinct and separate from each other. The anterior (*bursa copulatrix*) occupies the entire breadth of the eighth abdominal; its margin is very prominent, and much resembles the appearance of the male organ. The posterior opening (oviducts) similarly occupies the entire breadth of the ninth abdominal; its margin is not so distinct as that of the anterior opening. The median prolongation of the tenth abdominal is short and broad. The anus (A) is placed on an oval convex area. Behind this area the base of the terminal spine is separated from the anal part of the tenth abdominal by a distinct furrow. The spine is rough and bristles with irregularly twisted thread-like processes. Its ventral surface, seen in the figure, is characterized by a large oval concavity marked by concentric lines.
- Fig. 16.  $\times 7$ . The last four segments of a female pupa, seen from the right side. The functional spiracle on the seventh abdominal differs from the rudimentary one upon the eighth in its oblique position. All the visible functional spiracles are oblique like that shown in the figure. The first thoracic is the only concealed spiracle in the pupa, for even the prothoracic is clearly exposed to view. The tenth abdominal is distinctly divided into a dorsal (x') and ventral part (x). The terminal spine (Sp.) is not, however, uninterruptedly continuous with the dorsal part, but is separated from the latter by a furrow which extends dorsally from that which was shown in the last figure, and surrounds the base of the spine. This tendency towards the separation of the terminal spine from the tenth abdominal is carried further in certain *Geometrae*.

Figs. 17-19. The Terminal Abdominal Segments of the Pupa of *Uropteryx sambucata*.

- Fig. 17.  $\times 2$ . The last five segments of a female pupa, seen from the ventral aspect. The traces of larval claspers are distinct upon the sixth abdominal. The morphology of the ventral area of the last three segments is confused by dark markings, and is better studied in the next figure.
- Fig. 18.  $\times 9$ . The last three segments of the same pupa, seen from the ventral aspect. The two generative openings are fused externally (compare the next figure), but the boundary between the eighth and ninth abdominal corresponds to the division between them. The base of the median prolongation from the tenth abdominal is marked by a triangular patch of dark pigment. The anus (A) is distinct; the terminal spines somewhat resemble those of *Melanippe fluctuata* (compare fig. 21).
- Fig. 19.  $\times 50$ . The ventral area of the ninth and adjacent parts of the eighth and tenth abdominal segments of the same pupa, as seen from within, from above, and the left side. The fused generative openings are seen to be invaginated to a considerable depth in the form of a long compressed ridge. The ridge is distinctly divided by a furrow continuous with the boundary between the eighth and ninth abdominal, indicating its essentially double nature. The relation of the posterior part of the ridge (the part which receives the oviducts) to the boundary between the ninth and tenth abdominal and to the median line along the latter seems to support the opinion that the posterior generative opening is associated with the median prolongation of the tenth abdominal.

Fig. 20. The Terminal Abdominal Segments of the Pupa of *Amphidasis betularia*.

- Fig. 20.  $\times 5.25$ . The last seven segments of a male pupa, seen from the right side. The dark bands on the posterior part of the fourth, fifth, and sixth abdominals indicate a peculiar texture

associated with the fact that motion is possible only at these intersegmental junctions. The rudimentary spiracle on the eighth abdominal forms a great contrast with those on the anterior segments. The junction of the terminal spine with the tenth abdominal is marked by a line. An oblique furrow extending posteriorly into the tenth abdominal probably represents an incomplete division into a dorsal and ventral part.

Figs. 21-23. The Terminal Abdominal Segments of the Pupa of *Melanippe fluctuata*.

- Fig. 21.  $\times 26$ . The last four segments of a female pupa seen from the ventral aspect. The boundaries of the median prolongation of the tenth abdominal are indistinctly visible and disappear towards the apex. This is a result of the polished surface of the pupa. Towards the posterior boundary of the eighth abdominal, the two generative openings are distinctly visible and are almost fused. It is impossible to feel any certainty as to the segments to which they belong, in this species. The anus (A) is very distinct and situated on a raised oval area. The terminal spine (Sp.) is distinctly segmented off from the tenth abdominal; it bears four bristles, the two central ones being stouter and larger than the others.
- Fig. 22.  $\times 14.5$ . The last four segments of another pupa (sex unnoted), seen from the dorsal aspect. The separation of the base of the spine from the tenth abdominal is very distinct. The median dorsal part of the anterior margin of the latter segment is extremely irregular.
- Fig. 23.  $\times 26$ . The last four segments of the female pupa represented in fig. 21, as seen from the right side. The furrow at the base of the terminal spine is very distinct. There is an oblique furrow extending posteriorly from the anterior margin of the tenth abdominal, as in the pupa of *Amphidasis betularia* (compare fig. 20).

The remaining Pupæ figured on Plate XXI. are those of Rhopalocera.

Figs. 24, 25. The Terminal Abdominal Segments of the Pupa of *Papilio podalirius*.

- Fig. 24.  $\times 7$ . The last three segments of a female pupa, seen from the ventral aspect. In this and the next pupa the surface-sculpture has been carefully figured. The opening of the *bursa copulatrix* is distinct on the eighth abdominal; there is a distinct median prolongation from the tenth abdominal, and the posterior generative opening is probably represented by the median line along its anterior part. The anus (A) is distinct, and there is a flattened area in front of it which terminates anteriorly in a raised rounded border overhanging the median prolongation of the tenth abdominal, and forming a very characteristic appearance.
- Fig. 25.  $\times 7$ . The same parts in a male pupa, seen from the same direction. The male organs are distinct and characteristic in form and position.

Figs. 26, 27. The Terminal Abdominal Segments of the Pupa of *Papilio machaon*.

- Fig. 26.  $\times 7$ . The last three segments of a female pupa, seen from the ventral aspect. The generative openings resemble those of *Papilio podalirius* (fig. 24). The position of the posterior opening on the median prolongation of the tenth abdominal is more distinct than in the latter pupa. The raised border in front of the anus (A) exhibits a tendency towards division into two parts. The part of the pupa represented in the figure is somewhat asymmetrical.
- Fig. 27.  $\times 9$ . The median ventral area of the ninth and adjacent parts of the eighth and tenth abdominal segments of a male pupa, seen from the ventral aspect. The male organs are distinct and characteristic. The raised border overhanging the male organs is not divided so deeply as that represented in the last figure.

Figs. 28, 29. The Terminal Abdominal Segments of the Pupa of *Ornithoptera minos*.

Fig. 28.  $\times 4.25$ . The last four segments of a female pupa, seen from the ventral aspect. The anterior generative opening is distinct upon the eighth, and the posterior upon the ninth abdominal segments. Markings which can be easily distinguished from the surface-sculpture form the distinct boundaries of lips, as in the anterior opening of *Papilio* (compare figs. 24 and 26). The raised border overhanging the ninth abdominal is very broad, but strongly resembles that of *Papilio*. The close affinity between *Ornithoptera* and *Papilio* is proved by such resemblances between the pupæ. The terminal attachment is seen to be far stronger in the former, being related to the greater size and weight of the pupa.

Fig. 29.  $\times 4.25$ . The same parts of the same pupa, as seen from the right side. The rudimentary spiracle upon the eighth abdominal is seen to be much smaller than the functional one upon the seventh. The tenth abdominal is clearly divided into a dorsal and ventral (anal) part. An immensely strong cable of black silk hangs from the hooks beneath the posterior extremity of the former, while the anterior extremity of the latter is formed by the raised border overhanging the ninth abdominal.

Fig. 30. The Terminal Abdominal Segments of the Pupa of *Gonepteryx chammii*.

Fig. 30.  $\times 9$ . The last three segments of a female pupa, seen from the ventral aspect. The anterior generative opening is large and distinct, occupying the whole breadth of the eighth abdominal. The outline of the large lateral lips is V-shaped. The posterior opening seems to be placed in the apex of the median prolongation of the tenth abdominal, while the ventral part of the ninth abdominal does not appear upon the surface of the pupa. In this respect the pupa resembles *Papilio* (compare figs. 24 and 26). The anus (A) is small but distinct; the area around and in front of it terminates anteriorly in a median and two lateral processes, the latter being spine-like. The hooks for attachment are placed upon a curved area below the posterior end of the pupa.

Figs. 31-33. The Terminal Abdominal Segments of the Pupa of *Nemeobius lucina*.

Fig. 31.  $\times 9$ . The ninth and tenth abdominal segments of a female pupa, together with the median ventral area of the sixth, seventh, and eighth abdominal segments, seen from the ventral and posterior directions. The hairs on the surface of the pupa are not represented in the figure. The anterior generative opening is distinct; it is in the form of a slit occupying the median ventral line of the eighth abdominal. The posterior opening could not be identified, and only a very small part of the ventral area of the ninth abdominal could be seen on the surface, owing to the extension forward of the raised border, forming the anterior part of the tenth abdominal. The anus (A) is distinct, and the tenth abdominal is clearly divided into a dorsal (x') and ventral (anal) part (x).

Fig. 32.  $\times 9$ . The last five segments of a male pupa, seen from the ventral aspect. The hairs are represented, but they should be of rather greater proportionate length. The scars of larval elaspers are seen on the sixth abdominal. The anterior border of the tenth abdominal completely conceals the ventral part of the ninth, so that the male organs cannot be seen upon the surface.

Fig. 33.  $\times 26$ . The last three segments of a male pupa seen from behind and the right side. The hairs are not represented. The manner in which the ventral part of the ninth abdominal segment is overlapped by the tenth is clearly shown. The dorsal (rostral) part of the tenth abdominal (x') is separated into three subdivisions by furrows. The rudimentary spiracle is distinct on

the eighth abdominal. The raised anterior border of the ventral (anal) part of the tenth abdominal (x) is very like that of *Papilio* and *Ornithoptera*, and exhibits traces of median division as in certain species of these genera (compare figs. 26 and 27).

The interpretation of the appearances in this species (*N. lucina*) presented great difficulty, but I believe that the solution suggested in figs. 31-33 is correct.

Fig. 34. The Terminal Abdominal Segments of some Rhopaloceros Pupa, probably that of *Arge galathea*.

Fig. 34.  $\times 14.5$ . The median ventral area of the last three segments of a male pupa. The anus (A) is distinct. The male organ is typical in form and position, except that it is twisted into an oblique direction. The object of the figure is to show the lack of symmetry in this structure in a pupa which was otherwise well formed. The uncertainty as to the species represented is therefore of comparatively small importance.

VI. *On the Morphology of the Gallinacea.* By W. KITCHEN PARKER, F.R.S., F.L.S., late Hunterian Professor of Comparative Anatomy and Physiology, Royal College of Surgeons.

(Plates XXII.-XXV.)

Read 3rd April, 1890.

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I.—Introduction.

ONE of my earlier papers on the Morphology of Birds deals with the skull of the Common Fowl (Phil. Trans. 1869, plates 81-87, pp. 755-807). In a later paper (*ibid.* 1888, plates 62-65, pp. 385-398) I have described the wing in the phasianine division of this family, and in my memoir on the "Shoulder-girdle and Sternum" I have described those parts (Ray Soc. 1868, plate 16, pp. 182-184). The present paper treats of the spine and the hind-quarters mainly of the Common Fowl, and partly, also, in some allied types, the most important of which is the "Button-Quail," or Hemipod, a type which is dying out, and is manifestly intermediate between the typical Fowls and the semi-struthious Tinamous. The Common Fowl will always be a convenient and most useful bird to the biologist, whatever part of the organization is the subject of research; and in this special field—Morphology—he who knows the Fowl

well is ready-prepared to interpret the structure of all kinds of birds. Although less modified than the fore limb, which has become a wing, the hind limb is profoundly modified in birds—that might have been expected. The most remarkable fact, however, with regard to the evolution of the amniotic Vertebrata, is that certain Reptilian types (the Iguanodons and their allies)—forms that no possible development of wings could ever have lifted a single inch from the Earth's surface—did, nevertheless, acquire a modification of the hind-quarters, quite similar to, and prophetic of, the hind-quarters of the Bird.

Remarkable as this coincidence certainly is, it helps us but little in our inquiry as to the ancestral form of the Bird. Certain birds (*e.g.* the Ostrich and its allies, recent and recently extinct), by such overgrowth of their bodies as made flight impossible on this planet, have been arrested as to the brain, and degraded as to the organs of flight. I value the results of Palæontology quite as highly as any of my fellow-workers; but a student of Development is the only worker who can let in any direct light upon this subject. Every form with which the Palæontologist amazes and delights us, had its own developmental history: that cannot be traced, it can only be tentatively supplied by the "scientific imagination" of one who is familiar with the development of living forms, which yield us all the stages of their transformation in their individual growth.

We are still in the dark as to the relations of the Bird to the more archaic cold-blooded Sauropsida; it has not closely imitated any one of those old inhabitants of the land, the marsh, and the water.

That composite "monster," my 1st stage (Plate XXII.), has not slavishly followed the pattern of any one of the lost tribes; its head is Ichthyosaurian, its spine Plesiosaurian, and its hind-quarters Dinosaurian. But what of its chest and fore-quarters? It certainly turns its small "thumb" inwards and upwards, as if to form a defensive spur, as in *Iguanodon bernissartensis* (Dollo, Bull. Mus. Roy. Hist. Nat. Belg. t. ii. plate 5).

Professor Huxley's "three-fold Law of Evolution" (Proc. Zool. Soc. 1880, pp. 649, 650) has mercilessly destroyed half the fore paw, and is beginning to melt together much of that which is allowed to remain. Nevertheless, the partial destruction of the paw will be the birth of the wing, such a wing as the cold-blooded Pterosauria lacked the power to produce. This type, however, was grown in Nature's "hot-house;" your newly-hatched chick is as ripe a creature after three weeks' growth as the newly-hatched Crocodile after three months and the Skate after six months! Moreover, the Fowl itself belongs to the slow-growing forms that have precocious young; it is one of the "Præcoeces:" the "Altrices" develop very much faster, and are almost as large and as active as their parents in four or five weeks after hatching, whilst in them the period of incubation is greatly lessened; they are, however, less mature at the time of hatching than those which are rightly called Præcoeces.

At the end of one week's incubation the skeleton generally is marvellously perfect; the disproportion between the skull and the rest reminds one of the Tadpole.

II.—Stage 1. *Skull and Visceral Arches of Chick after one week's incubation* \*.

The skull, at this stage, corresponds with the 2nd stage in my early paper. As it has already been described there, I will merely remark here that the prochordal tract is made up of three "trabeculae," the posterior paired bars and the anterior azygous rod or "intertrabecula," which ends in front as the prenasal rostrum, the part on which the large premaxillaries are modelled. The paired trabeculae end in front as small alæ, called in my former paper "super-vomerine alæ." The lower face, shown in this figure (Plate XXII.), has no true cartilage in the palatine region, although that tissue is developed, to some degree, in Passerine and some other Birds. There is, therefore, in the chondroeranium of the Chick no cartilaginous palato-quadrate, only a quadratum, whose pedicle is free above and the "otic process" of which, in the Chick, is not bifurcated above, but simply gains a small articular facet on its inner side, for articulation with the periotic capsule: this is true of the "Alectoropodes"—Phasianine and Tetraonine Fowls; but in the "Peristeropodes"—Curassows and Mound Makers (Cracidæ and Megapodidæ)—the head of the quadrate is double.

In Birds, as in Reptiles and many of the Ichthyopsida, the quadrate is formed, from the first, as a separate cartilage from the free mandible, or articulo-Meckelian rod. This is not always the case in the Salmon (Phil. Trans. 1873, plate 2, p. 123); and in Marsupials (e. g. *Macropus major*) the whole of this 1st visceral or intra-branchial arch is developed as a single rod of cartilage, which becomes segmented, afterwards, into an epi- and a cerato-branchial element. In the Marsupials and in all the Mammals the 1st visceral arch, as well as the 2nd, or hyoid, becomes arrested and largely devoted to auditory purposes; thus the quadrate becomes the incus, and the articular end of the primary mandible becomes the malleus †.

In my former paper I figured the columella (=stapes and hyomandibular) as the only part found (proximally) in the 2nd or hyoid arch. That is true of this stage; but

\* *The Stages of Growth in the Limbs of the Fowl*.—To be sure of my steps in this investigation, I have followed the growth of the limbs through a long series of stages: these are arbitrary: the 1st answers to the older chicks of my 2nd stage in the memoir on the Fowl's Skull (Phil. Trans. 1869, plate 81, pp. 761-768).

a. Stage 1. Embryo of 7 days' incubation.

b. „ 2. „ 8 „

c. „ 3. „ 10 „

d. „ 4. „ 12 „

e. „ 5. „ 14 or 15 „

f. „ 6. Chicken 2 or 3 days old.

g. „ 7. „ 33 „

h. „ 8. „  $\frac{3}{4}$  year old.

i. „ 9. Old Fowl.

† Some biologists, through want of embryological knowledge, are in doubt as to how the primordial mammal could make use of its mouth whilst a new hinge was being made to its jaws. My answer takes the form of a question. Namely, What does the Tadpole do when its terminal, suetorial mouth is being changed into that of the widely gaping aperture it possesses after metamorphosis?

a small epi-hyal soon appears, and soon loses its independence; for it unites with the descending ray of the columella, the infra-stapedial. In my figure of the columella of the old Fowl (*op. cit.* plate 87. fig. 3) the descending ray is a uniform narrow band; in Professor Huxley's figure (Proc. Zool. Soc. 1869, p. 399, fig. 5) it is dilated below; that dilated part was a separate epi-hyal; much of the cerato-hyal (*c.hy.*) is aborted, and the lower, or hypo-hyal part of it, is enclosed in the sagittate tongue.

### III.—*The Vertebral Chain of the Chick, Stage 1.* (1 week's incubation.)

For an account of the development of the vertebral chain up to this stage, the reader is referred to Foster and Balfour's 'Embryology' (1874).

The formation of hyaline cartilage is my "cue" in these researches; I enter into the labour of the Embryologist when the various tissues that form the creature are fairly differentiated; and then creep cautiously, along skeletal lines, leaving the other parts to other workers: if we are to conquer this territory, we must divide it.

The basal cartilage of the hind skull, parachordal, or "investing mass" (Plate XXIII. fig. 1, *iv.*), although not segmented, is homologous with the vertebral centra, and even in it the notochord (*n.c.*) shows a disposition to become moniliform ("Fowl's Skull," plate 82. fig. 3, *nc.*). The greatest amount of modification of the vertebral chain occurs directly behind the occipital arch, and in that part itself the paired parachordal cartilages unite round the notochord to form the single occipital condyle, which is bilobate in most of the *Præcoces*, but is a neat hemisphere in most of the *Altrices*.

There is, in the Urodeles, a remarkable foreshadowing, so to speak, of the pivot-joint, which is formed in addition to the proper occipito-atlantal articulation. In them (see Trans. Linn. Soc. ser. 2, vol. ii. plates 20, 21, *od.v.*) the so-called odontoid process of the axis vertebra is represented by an abortively-developed vertebra, which is formed between the occipital condyles and the *practical* "atlas," namely the vertebra which carries the skull. When we reach the Amniota, the first vertebra has its lower part and its arch divided from the epiosteal centrum, or that part which is formed round the notochord. That "core," set free, unites with the second vertebra—the axis or pivot-vertebra; and the so-called "centrum" of the atlas, or first vertebra, is a mere "inter-centrum." This part gets its own osseous centre, and behind it, in the fore part of the axis, another intercentrum is formed. After that the core of the atlas becomes ankylosed to that of the axis; and thus the pivot-joint is added to the very mobile proœlous articulation of the imperfect atlas with the occipital arch. In the Fowl these two highly modified vertebræ (Plate XXIII. fig. 1, *at., ax.*), the atlas and axis, are devoid of the small riblets (*c.r.*) which are developed from the 3rd onwards. In the Duck tribe (*Anatidæ*) and in most of the *Rallidæ* they are present even in the 1st and 2nd cervical vertebræ (see Proc. Roy. Soc. 1888, pp. 478, 479, and Proc. Zool. Soc. 1889, p. 173). At this stage (Plate XXIII. figs. 1–3) the neural arches (*n.a.*) are incomplete above; they are direct continuations of the cartilage that enrings the notochord, and do not, in the cartilaginous condition, show their primary independence. In the lower Vertebrata

(see "Skull of Marsipobranchs," Phil. Trans. 1883, plate 18) the rudiments of the arches may exist without the vertebral centra; they are the most archaic parts of a cartilaginous vertebra.

The notochord at this stage is in an ichthyic condition; it is constricted inside the centra, and is largest at the intercentral or segmental tracts (Plate XXIII. figs. 1-4, *n.c.*). The neural arches project outwards in their fore half; then diapophyses, or transverse processes, are modified at their inner edge, in front, so as to form an oblique articular facet; behind, the neural arch grows over that facet, forming another which glides upon it; the latter is the post-zygapophysis, the former the pre-zygapophysis. The ribs, which according to Baur ('American Naturalist,' Oct. 1887, p. 945) are developed from intercentra, and therefore are primarily between the centra, appear in the Chick from the 3rd cervical vertebra, backwards, as small curved styles of cartilage, with their pointed end looking backwards and outwards. These styles at first are about two-thirds the length of the centra, and they lie outside the burrowing vertebral artery. The last two or three of these in the cervical region are actually segmented from the diapophysis and the centrum: the rest are only partially separated from those parts; they are connected with them by means of newer tissue, a less perfect form of cartilage; the tissue is continuous, and the riblets, under a lower power, look more distinct than they are actually; they have, however, their own osseous centre, afterwards. In the 13th, and still better in the 14th, the riblet is segmented off from the diapophysis above, and from the centrum below. The little projection of the latter, to which the primary head (capitulum) is articulated, is called a parapophysis, or lower transverse process; it is near the fore margin of the centrum. In Mammals the articulation is *between* the centra, and is, therefore, more primitive, as in them also is the articulation of centrum with centrum. In many things, indeed, the Bird is a much more highly modified type than the Mammal.

The 15th cervical vertebra has its ribs developed considerably downwards; they tend to reach the sternum, and are two-thirds the length of the next rib, or the first dorsal. Five pairs of these dorsal ribs intervene between the 15th cervical and the first of the general sacral series, the first of which, also, has developed ribs, the sternal pieces of which are imperfect below (Plate XXII., *s.r.*). All the five dorsal vertebræ have ribs with sternal segments (*s.r.*); both the vertebral and sternal bars go on increasing in length from before backwards. The last cervical and the first dorsal ribs have an "appendage" (*u.p.*) above their middle, a distinct oval cartilage which looks backwards and upwards. The primary and secondary heads of the dorsal ribs (capitulum and tuberculum) are well developed in the dorsal region. In the sacrum (Plate XXIII. fig. 4) the 2nd, 3rd, and 4th vertebræ have riblets like those on the 14th cervical; one or two pairs of these may remain distinct in the adult. As a rule they become fused with the diapophyses which form strong buttresses to the pre-ilium. On the 9th and 10th of the general sacral series, these riblets reappear; behind them there is another, right and left; but the diapophyses and these die out towards the end of the chain, where the imperfect vertebræ ultimately unite to form the uropygial piece.

Fifteen of these vertebræ will be enclosed by the ilia, only ten are at present; the 9th and 10th are the first two of the uro-sacral series. In front, the dorso-sacral region is that which retains distinct ribs; the lumbo-sacral, those which have only "buttresses"—four altogether. The true sacrals are four in number, and the huge sacral ganglia abort their diapophyses, which are high up and flat. Behind the true sacrals, at this stage, the cartilage does not form a floor to the notochord, which is naked below. Thus the symmetrical cartilaginous nuclei that grow over the myelon above and enclose the notochord below are seen to be the homologues of the cartilaginous patches already referred to, that appear, right and left of the myelon, in the Lamprey, during its metamorphosis.

Thus at this stage there are fifteen cervical, five dorsal, fifteen general sacral, and, at present, ten caudal; the notochord projects considerably behind the last feeble pair of nuclei, which are not perfectly chondrified. There are forty-five in all; seventeen of these are behind the sacral nerves, and therefore correspond to those of the tail in a Reptile.

#### IV.—Stage 2. *Chick after 8½ days' incubation.*

In this stage I have only figured the hinder part of the vertebral chain—the sacral and caudal regions. The chondrification is rapidly becoming complete, but the arches are imperfect above, and the notochord still projects behind (Plate XXIII. fig. 5). In the dorso-lumbar end of this tract, the ribs on the 2nd, 3rd, and 4th, as well as that developed on the 1st, are still distinct; and those on the 1st and 2nd uro-sacrals are, as bars, separated from the diapophyses, although they are not segmented off; a distinct osseous centre afterwards appears in these lower bars. The notochord (*n.c.*) is still ichthyic, its partial segmentation tending to become hourglass-shaped, the constrictions being inside the centra. This stage gives us the best analysis of the sacral and caudal regions of the adult. The dorso-lumbar region of the general sacrum has one developed and three arrested ribs; then follow four more vertebræ that are the true sacrals; these have no ribs, and their diapophyses are seen to be high up; they are dilated to support the broad hip-plates, and scooped below, to make room for the large ganglia of the sacral nerves. Then as the nerves are suddenly diminished in size, the ribs break out again on the first two uro-sacrals, and the diapophyses growing outwards and a little backwards, gradually pass, as to form and size, into the caudal series. There is, however, a break between the uro-sacrals and the caudals, the segmentation being sharply defined behind the 7th uro-sacral or 15th general sacral vertebra. The next five are alike, but gradually lessen in size; they show no distinct intercentra such as exist in most birds. These are followed by six pairs of rudiments that do not cover the whole of the end of the notochord (*n.c.*); this series of fading vertebræ becomes the "ploughshare" or uropygial bone.

#### V.—Stage 3. *Embryo of Phasianus versicolor, two-fifths ripe; and of Common Fowl, 10 days' incubation.*

Among a large number of Gallinaceous embryos of various genera and species, one of *Phasianus versicolor* yielded me the clearest view of the cervical and dorsal vertebræ in

this stage—a very important stage, on account of the remarkable modification which is seen in it of the notochord (Plate XXIII. figs. 7 and 8, *n.c.*). The ichthyic condition of the notochord, that in which the constrictions correspond with the centra (figs. 1–4), has given place to an amphibian condition, in which the principal constrictions correspond with the intercentral segmental tracts. Nor is this all, for two more constrictions appear within the centrum; thus the whole chord is moniliform, and *suggests the arrest of two out of three of the ancestral vertebræ* (see Proc. Roy. Soc. 1888, p. 466).

Now, if this fine silken thread of suggestion holds, then we may follow it, as a clue, and fasten to it another, namely, that, long as is the vertebral chain of a modern bird, it has up to the sacral region only one-third the number of vertebræ in it that the old amphibio-dipnoan ancestor possessed. If this be a true suggestion, we must give up the notion (hypothesis) of the development of the bird gradually, and, as it were by chance, out of a full-blown amniotic Reptile, and figure to ourselves a swarthy, worm-like creature, long and unsightly, with no neat five-toed paws, but with simple paddles, supported from within by many rays, with many joints in them; in morphological language, they possessed not cheiropterygia, but ichthyopterygia. The tendency to further subdivision of the vertebral chain is not seen in the sacral and caudal regions, or only to a slight extent in the fore part of the sacrum (Plate XXIII. fig. 9). These regions are still unossified, although the hip-girdle is undergoing that change. There are twenty vertebræ in front of the sacrum; that region and the tail give us twenty-five more. The fore limbs being attached very loosely to the spine, the latter is but little modified in relation to these limbs; the intervertebral passages simply being larger to allow the exit of the large nerves that form the brachial plexus. But the necessity for fixity and strength in the hind-quarters has operated upon the third of the four regions of this chain; in all this region and in the hinder half of the fourth, or caudal, the vertebræ lose their freedom of motion. The Iguanodon, to a great degree, and the Bird to a greater, has the need for a long sacral series of vertebræ, which, if harmonized with the homologous vertebræ of a Lizard or a Crocodile, must have secondary regional names; but this human anatomy term, useful in spite of its etymological absurdity, is quite arbitrary, and can be applied to one or two, or to two dozen segments.

Here, in the Fowl, the first has developed ribs and helps to form the thorax; the next three, with their arrested ribs, are similar to our lumbar vertebræ; then come the four true sacrals. Now, after two or three days' further incubation, the sacrals show their greatest expansion, having to hold that swollen and ventricular part of the myelon which gives off the large sacral nerves: thus the axial extent of these segments is only one-fourth of their bilateral growth.

This bellying of the sacral vertebræ is not sudden; it begins in front of the sacrals proper, and is continued into the fore part of the uro-sacral region; the first and second vertebræ of that part are seen to have a rib-bar, right and left. The third caudal has the longest transverse processes; in the uropygial series they are lost; the spinal projections are low, they begin again on the uro-sacral series, and they have died out on the sacrals proper; the dorso-lumbar joints of the general sacrum have spines like those of the

dorsals. I find no intercentra in the caudal region, either in embryo, young, or adults, beyond a pair of thickenings under the 1st and 2nd of the imperfect uropygial segments.

VI.—*Sacral Vertebrae of a recently hatched Quail (Coturnix communis), answering to the 6th stage of the Chick.*

Leaving out two stages, I come to the 6th, and in this case, for the sake of comparison with the Hemipod (Plate XXV. fig. 5), I have figured the sacrum of the newly hatched Quail (Plate XXV. fig. 4), instead of that of its large relative. The difference between this sacrum and that of the Common Fowl is, that I can in the former only find one pair of uro-sacral riblets; the last uro-sacral of the Fowl corresponds with the first caudal of the Quail; the number of vertebrae is the same in both. The ossification of the neural arches is only imperfectly seen in this lower view, but these osseous centres are to be seen running into the diapophyses in the hinder half of the sacrum. This part is sufficient to illustrate what takes place in the pre-sacral part of the chain; the 1st uro-sacral shows how the remnants of ribs are ossified, the small bony tract soon loses its independence. In the 2nd to the 4th—the lumbo-sacral series—the originally separate riblets have become fused with the thick diapophyses that buttress the pre-iliac; they may have a distinct osseous centre, but I do not find it in these Gallinaceous birds. The spindle-shaped series of centra look, especially in the middle region, as though there were two bony centres in each centrum; this, however, is not the case, the bony matter is just deposited around the notochord, in its sheath, and then affects the cartilaginous mass right and left, in two wings as it were. The distinction of bony centres is gradually lost in the uropygial series.

VII.—*The Vertebral Chain in the last stage, or Adult Fowl.*

Notwithstanding the somewhat lowly position of this type, it has, in common with the much more lowly struthious birds, a vertebral chain of a very high type; this is not to be wondered at when we see the same thing in that extinct toothed bird, Marsh's *Hesperornis*, an archaic "pygopod" in which one would have expected to find vertebrae at least as Reptilian as those of the existing Penguins. This should be borne in mind by those Ontologists who desire to derive all these birds from an *Archaeopteryx*; an hypothesis this, which to me appears to be very hard and difficult and unlikely, for I cannot imagine all the Cretaceous, Tertiary, and modern birds as potentially lying in the loins of that ungainly kind of feathered Fowl.

The vertebral formula of the adult differs from that of the embryo; for the sternal piece of the 16th vertebra becomes absorbed, making that joint the last of the cervicals, and the last five joints of the chain become soldered into one, the "ploughshare" or uropygial bone. The various regions—cervical, dorsal, dorso-sacral, lumbo-sacral, sacral proper, uro-sacral, and caudal—may be put as follows:—

C. 16, two ribs free and last joint ankylosed to the next region; D. 4, the 4th only free; D.-S. 1; L.-S. 3; S. 4; U.-S. 7, the 1st with a riblet; Cd. 10+4, the last five being

fused together: total 49. The proœlous cup of the atlas is deeply scooped for the odontoid process of the axis; neither of these vertebræ have riblets: those on all but the lower cervicals are strong and sharp-pointed.

Small spines are seen from the axis downwards (or backwards); these begin to be larger and square in form near the end of the cervical series, the last of which is fused with the compound dorsal piece; the 15th has a small styloid rib, the 16th a perfect vertebral rib, but no sternal piece. From the 5th to the 10th inclusive, the carotid canal is protected at its sides, but not below. On the 11th, the lower spine, present in the 2nd, 3rd, and 4th, is renewed, and in the first three of the fused dorsal tract these are united below and form a bifenestrate keel; the last fixed and the single free joint have each a small lower spine.

The upper spines of the last cervical and first three dorsals form one continuous oblong plate of bone, which rises from before backwards; the free spine of the last dorsal is the highest of all, and those of the lumbo-sacral become lower again, and the spine dies out on the last sacral proper. The sacral spines are fused together, and to the pre-ilia, and thus form a pair of galleries which open, behind, over the 1st sacral proper. The last, or free, dorsal lies under and supports the pre-ilia. So arbitrary are the terms that we use in describing these parts. The diapophyses of the last cervical and first three dorsals are ankylosed and form, right and left, a strong fenestrate eave over the thorax; the tubercles of the ribs articulate under its edge, and the capitula fit into small parapophysial raised cups at the junction of the neural arches with the centra; these become lower behind, so that those ribs have their forks longer than in front. The spinous carination of the dorsals does not affect the articular facets that form the free joint, they are all cylindroidal or heteroœlous. The "buttresses" are strong, those on the 1st lumbo-sacral are the feeblest; they are high up and feeble on the true sacrals; the 1st uro-sacral has a strong pair of rib-bones, the rest only diapophyses which gradually become like those of the free caudals. The interspaces, right and left, are open between the pre-ilia and filled in with periosteal bone between the post-ilia. The hind part of the sacrum is not fused to the hip-plate; the fore part is largely ankylosed, yet the last two buttresses are free. All these things have been weighed and measured in the balance, and by the rules of Teleology; and the result is a fine combination of strength and elasticity. These firm-footed birds only show their clumsiness in flight.

The caudal vertebræ are seen at once to belong to a bad flier; the interœentra that are developed, as a rule, in relation to the *depressores coccygis* muscles, are absent; the spinal processes are represented merely by a pair of tubercles; the uropygial bone is a long triangle; it is sharp-edged and strong: the articulation of the caudals is gently biconvex, with a fibro-cartilaginous junction, and no synovial cavity, such as is seen in the last two joints in many of the higher kinds of birds.

#### VIII.—*The Sternum and Shoulder-girdle of the Chick, 1st Stage.*

For still earlier conditions of the bird's sternum and especially that of the Chick. I must refer to Miss B. Lindsay's valuable paper (P. Z. S. 1885, pp. 684-716). In my

work on the "Shoulder-girdle and Sternum," I have shown this sternal plate in its two primary moieties in the Lapwing (plate 15. fig. 1). In this 1st stage (Plate XXII. and Plate XXV. fig. 2) the two moieties are becoming fused together, and each is contributing to the formation of the keel. The essential or costal part of the sternal moieties is here seen to be a small crescentic tract of cartilage passing, below, into a much larger tract, which has its teleological meaning very clear: it is for articulation of the sternum with the coracoid and for the "origin" of the huge pectoral muscles. In front, above, a process, the rostrum, grows forwards, the use of which is for the attachment of the ligaments of this part of the trunk; this is separated by a round notch from the projecting sternal keel, which already grows backwards, far behind the proper costal region of the sternum; it has a right and left dilatation below the great notches and ends in a point, behind.

I have already mentioned that the first sternal rib is often transitory; the projection in front of that, the precostal process, properly belongs to those cervical vertebræ which have segmented riblets. There is a traceable abortion of these parts in the Chick, especially in still earlier stages (see Lindsay, *op. cit.* p. 708, fig. 5).

The costal tract ends, behind, in soft tissue, which is beginning to bifurcate; it will form the antero-external xiphoid (metasternal) process and the external *proper*. I shall refer to this point again.

In describing the shoulder-girdle at this stage, I must refer again to Miss B. Lindsay's paper (*op. cit.*), which contains many valuable remarks and observations, but in which she has misread and misconstrued my former work ("Shoulder-girdle and Sternum") to a degree that is humiliating to me, for this suggests that I must be a confused writer.

I must, however, in self-defence, remark that the three main parts of the shoulder-girdle figured by Miss Lindsay (p. 704, fig. 11) are not, in my eyes, true differentiated skeletal elements, but thickened masses of tissue that contain the embryonic cartilage, which will be differentiated into either hyaline cartilage, or be at once developed into bony tracts (parostoses). The latter are exoskeletal structures; the former endoskeletal.

As I have said before, hyaline cartilage is my "cue;" before that is formed, anything may be made of anything; and thus Morphology is at the mercy of each individual worker\*.

The endoskeletal part of the shoulder-plate is a curved bar, partly segmented at its lower third, and then bent backwards considerably; the upper sword-shaped tract is the scapula (*sc.*); the lower, phalangiform bar is the coracoid (*cr.*). There is an antero-inferior tract, but this is not composed of cartilage. In Frogs and Tortoises and in the African Ostrich, there is such an antero-inferior cartilaginous bar (*op. cit.* plates 5-7, and 12 and 17). But the Fowl is like the Crocodile in this respect (*op. cit.* plate 11. figs. 7 and 8). There is at this stage a slight rudiment of a special nucleus in front of the head of the coracoid, but it develops no further, and all the tissue then becomes either mem-

\* I must here refer to what may be called a diseased condition of Biological research. However young and inexperienced the workers, no evidence not obtained by them, individually, is to be taken on trust for a moment; if Science is to run in such narrow ruts, its progress will be slow.

brane or a membrane bone, the simple clavicle (*cl.*)—the early condition of one fork of the Y-shaped furcula. The *almost* hyaline cartilage developed at the top of the clavicle at a later stage (*op. cit.* plate 16. fig. 9, *m.se.s.*), or after 10 days' incubation, does not belong to the antero-inferior bone or precoracoid, but to the acromial region of the upper bar, or scapula. I call it the "meso-scapular segment."

IX.—*Further Development of the Sternum and Shoulder-girdle in the Chick and Adult Fowl.*

Miss Lindsay (*op. cit.* p. 701) says truly that in the Fowl a newer process arises on the outer side of the main lateral metasternal bar, and in the Gull on the inner side. Not only in the Gull is this the case, but in all birds, except the Fowls, that have two pairs of metasternals. Thus the Gallinaceous birds are sharply divided off from their neighbours by this antero-external, or rising, fork of the postcostal part of the sternum; the "Peristeropodes" as well as the "Alectoropodes" show this. The Pteroclidæ and Columbidae do not possess this part, but form a submedian process as in the Gull; whilst the Hemipods and Tinamous have only one lateral process, like the Ostrich on one hand, and the Goose on the other. But orderly as these processes seem, to be giving character to this family and to that in their variation, they arise merely as a creeping backward of the cartilaginous tissue, to be replaced to a great extent afterwards by bone, for the sake of muscular origin and insertion. Single in the Rhea, Emu, and Cassoway, the metasternum may develop four processes on each side, besides the double median plate. For in the Turkey (*Meleagris gallopavo*, Plate XXV. fig. 1) the antero-superior outgrowth is double, for a partial forking takes place, in the form of a fenestra; whilst in the Capercaillie (*Tetrao urogallus*) the median part is separated by a notch from a submedian lobe (Plate XXV. fig. 1a).

Prof. Huxley, in his paper on the Alectoromorphæ (P. Z. S. 1868, p. 303), says:—"It seems to me to be demonstrable that the long xiphial process of the sternum of *Hemipodius* answers to the outer of the two metasternal processes of the *Alectoromorpha*, and not to the inner, as Mr. Parker supposes in his paper on the Gallinaceous birds; or to the inner and outer together, as he suggests in his great work 'On the Shoulder-girdle and Sternum' (p. 187). Thus the sternum of *Hemipodius* is strongly Tinamine." It is seen at a glance that this view of Professor Huxley is set aside by the notched median metasternum of *Tetrao urogallus*, and by Miss Lindsay's researches. Even my second view of these, perhaps, is not really incorrect; and the long *single* lateral metasternal of *Hemipodius* and *Tinamus* is the true morphological representative of the *forked* lateral metasternal of the Fowl. The long process is the same thing in Fowl, Hemipod, Tinamou, Pigeon, and Sand-Grouse; these last two have a new inner, and the Fowl a new outer process.

There is a fact of importance in this matter, namely, that in the Hemipod, Fowl, and Ostrich-tribe, the ossification is by neat and clear ectosteal tracts, and not, as in most birds, by a very generalized endosteal deposit, which only imperfectly separates, even for a

time, the median from the lateral bony centres; also in no other types than Fowls and Hemipods are there *five* definite bony tracts\*.

The old mistake of comparing the *five* bony centres of a Fowl's sternum with the *nine* dermal plates of a Tortoise, is scarcely worth mentioning in these latter days. But so late and so excellent an observer as Miss Beatrice Lindsay has lost her way, now and then, through not clearly seeing the difference between an endoskeletal cartilage and an exoskeletal bony plate; she has relied too much on dissections made before the tissues had become fairly differentiated. We shall see how misleading this error is in what is now to follow.

In my paper on the "Shoulder-girdle and Sternum," I showed that the three simple clavicles of a Lizard were the true homologues of the three foremost plates of the plastron in the Chelonia; and that the three osseous centres that form the furcula in all birds that have a median process to that compound bone belong to the self-same category. But I also showed that the furcula, in most birds, was not merely formed by fusion of these three bones—clavicles and interclavicle, but that in many cases remnants or vestiges of the old Reptilian shoulder-plate—often bifenestrate in its lower part—appear, become ossified, and then coalesce with the thin superficial clavicular bones. For in this part of its structure, as in many others, the bird bears about the same relation to a Reptile that the pupa of a Dragon-fly does to the culminating imago-form.

In my early work, I laid too little stress on the meaning of the "clavicular process" of the coracoid; this part is aborted in the Common Fowl; but, as I have shown in a paper recently communicated to the Zoological Society, it is very large in the Hoatzin (*Opisthocomus*). But besides that continuous remnant of the "precoracoid," there is a separate segment of the same nature, but more external; it is very large in the Cormorant and its allies (*op. cit.* plate 13. figs. 3-10, *p.cr.*); that is *my* precoracoid. Another cartilage is developed in all the Passerines and in some of the Cuculines, namely, a remnant of the acromion, a "meso-scapular segment" (*op. cit.* plate 15. figs. 12-15, *m.sc.s.*). Miss Lindsay makes me call the down-bent head of the main coracoid the "precoracoid;" after speaking of this part in the Struthionidæ, she goes on to say:—"The same uncertainty must exist with regard to the precoracoid of *Diomedea* (plate 44. fig. 1); although there can be little doubt, from comparison with the early stages of the various embryos figured, that we must agree with Sabatier in regarding this region as the avian precoracoid, rather than the precoracoid of Parker, which Sabatier calls an epiphysis" (*op. cit.* p. 705). Anything more confused than this it is impossible to conceive; the downturned bar of the coracoid of *Diomedea* and of other birds may be an *apophysis*; it has no *epiphysis* on it; birds have very rarely more epiphyses than the right and left enomial centres. It certainly is not "the precoracoid of Parker."

My critic does not directly say that all my figures of the interclavicle in my early work (plates 13-17) are incorrect, but this is to be inferred from what she says on

\* The additional pair of bony centres figured by me in *Turdix* (*op. cit.* plate 16. figs. 13, 14), and called "coracostea" (*c.c.*), have no real existence; after many years, re-examining this small sternum, I find that the line thought by me to be a suture was only a fracture!

p. 702, namely, "that the furcula presents a median prolongation is undeniable; but the following statements on two points will show reasons for supposing it to be an out-growth derived from the clavicles only at a late date." For these "reasons," I must refer the reader to the paper itself, and also to my old figures, but more especially to the *new* ones, representing the extremely lacertian condition of these parts in *Opisthocomus*, in which a long styloid interclavicle lies in front, between the thin lower ends of the clavicles, and behind is bound closely to the flat lower surface of the sternum, exactly as in Lizards (see *op. cit.* plates 9-11).

One word more on this subject: the figures given by Miss Lindsay on p. 704 (fig. II., 1-4 not 5) represent the parts of the shoulder-girdle in such a non-differentiated state, that any deduction from them is mere loss of time and labour. Those very diagrammatic figures must of necessity represent, not formed parts, but masses of embryonic cells, which will, in time, become, muscle, fibrous tissue, vessels, nerves, cartilage, and bone.

#### X.—*The Wing of Chick and Fowl.*

In a recent paper on the Wing of the Fowl (Phil. Trans. 1888, B, plates 62-65), I have described the structural changes that take place after the three normal digits of the wing are formed. In plate 62, figs. 1 and 2 of that paper, and in this paper (Plate XXII.), it is shown what a remarkable three-fingered hand the wing is essentially. Now the developmental completion of this part of the skeleton takes place by the fusion of a considerable number of the elements that still remain after the suppression of the 4th and 5th digits. That was the first step, and the most archaic form of bird known—namely *Archæopteryx*—and some of the extinct Reptiles that come nearest that incipient-flying fowl, have only three digits in the fore foot. This practical amputation of the hind part of the fore paw is correlated with a very minute development, as we have just seen, of the shoulder-girdle, which is the "root and foundation" of the limb; part of it indeed—its proximal end!

In the 1st stage (Plate XXII.), the 1st and 2nd digits are perfect, each with its proper number of phalanges, namely, two and three (or three and four, if we count the metacarpals, the proximal elongated elements of the manus). The normal number of carpals for a three-fingered hand would be present if there were three in the proximal series; but the inner or radiale is seldom in two pieces; it is in some types, and then we have an intermedium also.

In the 1st stage (Plate XXII.) the 1st of the distal carpals is ventrally displaced, and lies on the inner face of the head of the 2nd metacarpal; it is a small knob of cartilage when just clearly seen, which is not the case until the 3rd stage (*op. cit.* plate 62, figs. 3, 4, *d.c.*<sup>1</sup>)\*.

After the primary parts are formed, there is a considerable amount of what appears to me to be atavism. In the 3rd stage (*op. cit.* fig. 3, *mc.*<sup>3</sup>) the 3rd metacarpal has attached to it near its hind margin, on the flexor side, a small rod of cartilage; this is evidently the remnant of the 4th metacarpal. Also between the 2nd and 3rd

\* In figs. 1 and 2 of that plate, the soft cartilage inside the carpals is marked off as a 1st distal carpal (*d.c.*<sup>1</sup>); that is not correct, it is not defined until we get to the 3rd stage (figs. 3, 4), after 10 days of incubation.

metacarpals, on the extensor side, a semi-elliptical cartilage has appeared (*mc.*<sup>2</sup>), and, below, a flange of cartilage has grown from the ulnar margin of the proximal phalanx of the index, or 2nd digit (*dg.*<sup>2</sup>); this is not very distinct in the Chick; it is quite distinct and formed later than the main phalanx in many birds. These parts, to say nothing here of others that appear in other kinds of birds, seem to me to be *atavistic remnants or vestiges of an archaic polydactyle or many-rayed fin*. That these parts have a somewhat teleological importance does not help in their interpretation; a very slight periosteal growth from the normal parts would have sufficed for this; there was no reason, from this standpoint, for the appearance of additional parts—parts that appear somewhat late, and lose their independence early, and therefore, as they cannot be accidental, must have a morphological meaning; that meaning I have suggested to be atavism.

But there are so many other unexplainable parts in the wings of Birds, that it will be necessary for me to devote a whole and not a small part of a memoir to this subject. The Common Fowl is, after all, only a sort of initial or tentative bird, as to the matter of flying; it just serves as an introduction to the Carinatae.

#### XI.—*The Hip-girdle and Hind Limb in the Chick.*

The fixed swinging-point of the hind limb, or hip-plate, is not only of extreme interest, morphologically, as forming part of a bird, but Palæontology thrusts itself in here, so to speak, and half the beauty of the piece of the framework is missed unless we become comparative anatomists as well as ornithotomists. The hind-quarters of the Bird and the Iguanodon are modified in a similar manner, as is well known; and this has led to too great an approximation of these extremely different types in the classification of the Sauropsida—extinct and recent. We know, now, that the peculiar rotation backwards of the pubes and ischia, in the Bird, like that in the Iguanodon, takes place during the early growth of the skeleton (see Miss Alice Johnson's paper, *Stud. Morph. Lab. Camb.* vol. ii. plate 5).

I have recently shown the same changes in the Duck (*Mem. Roy. Irish Acad.* 1890). Of course we can only *feel certain* that the same change took place in the pelvis of the Iguanodon in its early growth. This, indeed, is one of the difficulties in comparing those huge extinct Ornithoscelida with the developing bird; and rash, impatient Biologists are always taking it for granted that the structure of these extinct forms is in a primitive state; it is nothing of the kind—any great changes, both in number and in form, must have occurred in the egg, and afterwards in the young, of those types whose structure we only know in the adult state.

In my first stage of the Chick the pelvis (Plate XXII.) corresponds in form with that of an adult Tinamou (*T. Z. S.* vol. v. plate 39); but in the Duck, *Anas boschas (domesticus)*, the embryo at the end of the 1st week is not so much advanced; and the pubis and ischium diverge from each other at a large angle (as in Miss A. Johnson's figure of the Chick, *Stud. Morph. Lab. Camb.* vol. ii. plate 4. figs. 3-6); and whilst the ischium grows downwards and backwards, the pubis grows downwards and forwards, exactly as in the

extinct *Ceratosauros* and *Allosaurus* (Marsh, Amer. Journ. Sci. vol. xxvii. 1884, plate 11), and in the recent Crocodile (Huxley, Proc. Geol. Soc. 1869, p. 27, fig. 3).

At present in this, my first, stage, the ilium has developed two broad lobes; it is no longer a wide fan-shaped plate, but grows forwards and backwards almost equally, and embraces at least a dozen vertebræ out of the fifteen which are covered by it permanently. The whole hip-plate at this time is a leafy growth of solid hyaline cartilage, apparently segmented into ilium, ischium, and pubis, as in its ossified condition afterwards, before the sutures are filled in (see Plate XXV. fig. 12, *il.*, *isc.*, *pb.*). Under a low power, the segmentation seems to be perfect; under a high power, it is seen that on the inner face a thin part about one cell deep is continuous; but externally there are deep chinks, prefiguring the sutures of its bony condition; these chinks are filled with nascent fibrous tissue. Thus it would appear that the primordial hip-girdle of the Sauropsida was composed of three distinct diverging cartilages, the proximal elements of the ichthyopterygium; and that the modern ossification (Plate XXV. figs. 4 and 12) in both Sauropsida and Mammalia is historical or atavistic. The dilated top of the ilium, at first fan-shaped, has soon grown, fore and aft, into two subequal lobes, the pre-ilium and the post-ilium; the fore lobe is concave externally, and the hind lobe is convex. The upper and broader bar that runs, now, parallel with the post-ilium is the ischium; it is still separated by a long notch from the plate above, as in the *Apteryx* and also in the Tinamou (T. Z. S. vol. v. plate 39, *il.*, *isc.*). At this stage the pelvic plate of the Chick is quite Tinamine. The narrow lower bar, the pubis, is much longer than the ischium; it is quite free from it, and the obturator nerve emerges in its fore end. Then these normal parts of the pelvic plate all meet at the edges of the acetabular fenestra (Plate XXII. and Plate XXV. fig. 3, *ac.*). The ischium is forked; the lower fork binds under on the dilated and hooked fore end of the pubis, which hooked lobe fits in between the ischium and ilium; the ascending fork of the ischium ties itself to the lower edge of the fore part of the post-ilium, and thus separates the acetabulum from the sacro-ischiatric space (*s.i.f.*)—ultimately a “fenestra.” At the lower, convex edge of the pubis there is a smallish triangular projection, which looks forwards and downwards, and has most of its root in the ilium; it is somewhat later in growth than the rest. This secondary process is as large as in the adult Tinamou (*op. cit.* plate 41. fig. 3); but less than in the *Apteryx* (Mivart, Trans. Zool. Soc. vol. x. 1879, p. 38, fig. 41, *l.p.*).

As to the nature of this process, which I boldly call “secondary,” there is still a strong controversy. This has arisen from two causes: first, it is very large in the Dinosaurs, and is in them ossified by the rotated pubis (see Marsh, Amer. Journ. Sci. vol. xviii. Dec. 1879, pp. 501–503, plate 3); and the second difficulty arises from the fact that its small counterpart in the Fowl, and in such Carinatae as possess it, is ossified by the ilium. Happily there is an intermediate condition, in which it is ossified by both these bones: this is evident from Prof. Mivart’s figure of a young Ostrich’s pelvis (Trans. Zool. Soc. vol. viii. p. 137, fig. 74, *il.p.*). This figure is imperfect, because the unossified cartilage is not drawn; when present, it projected equally from the ilium and the pubis. The importance of this fact, in an attempt to reconcile the discrepancy between the Dinosaur and the Bird, was first pointed out to me by Mr. Hulke, in a letter written to me on

Dec. 15th, 1887. I had found the bony continuity of this spur with the ilium in the Chick long ago, and Dollo, in his invaluable paper on *Iguanodon bernissartensis* (Bull. Mus. Roy. Hist. Nat. Belg. t. ii. pl. iii. fig. 4, *e.*), shows the same thing. Mr. Hulke, referring to a sketch by me of this part in the Chick, says:—"You represent the pre-pubic spur as wholly iliac. The corresponding spur in *Apteryx* and *Rhea americana* certainly contains a pubic element, for a suture in immature specimens runs through the spur, which thus has an iliac and a pubic component."

In the 2nd stage (Plate XXV. fig. 4) the carinate type of hip-plate is almost reached, but the post-ilium and the ischium are still distinct. For the sake of comparison with the hip-girdle in another family, the Hemipodidæ (Turnicidæ), I have shown the ossifying pelvis in one of the smallest of the typical Fowls, namely, the Quail (*Coturnix communis*) (Plate XXV. figs. 4 & 5). All the osseous centres are present in the recently-hatched Quail (fig. 4, *pr.i.*, *pt.i.*, *pb.*, *isc.*); the ilium has used up all the cartilage in front; but its post-iliac extension still leaves a soft selvedge behind; the same is seen in the pubis and ischium. In both these figures, in this stage, the pubis is hooked upwards and inwards, the hook being wedged in between the ilium and ischium, below the acetabular fenestra. The synchondroses are still large, and the prepubic spur (*pr.p.*) is not yet hardened. Afterwards, in a Fowl of the 1st summer (4 or 5 months old), the ischium, being a stronger ossification, has grown over and hidden the pubic wedge, and thus the ischium meets the ilium, not only behind, but also below the acetabulum (fig. 12). This domination of the larger over the lesser parts can be seen in both the cartilaginous and osseous stages of growth, and has to be allowed for in the determination of homologous parts; a strong element is very apt to "suck the verdure out" of one that is feeble.

The limb is, for convenience' sake, generally studied as something distinct from the limb-girdle; it is, however, only the mobile part of the limb, the girdle being the fixed part, the swinging-point, or "pier." For this additional part of the body of a vertebrate animal is but a sort of "delamination" of the inner, or endoskeletal, layer of the somatopleure, which, forming outside the ribs, works itself outwards to become a free limb-bud, then a flipper or fin, and lastly a paw, a hand, or a foot. This part in a high vertebrate has, as a rule, a broad proximal part, a narrower waist, and a dilated and radiating distal tract; the narrow waist becomes the humerus or the femur, which is the isthmus or the connecting-link between the limb-girdle and the limb. No special morphological names have yet been given to the part above the waist: the old human-anatomy terms cling to the upper elements, and still serve in some degree for the lower. For these, however, even some of the individual elements have had, very profitably, a new and accurate morphological name given to them; but the *regions*, also formed by the transverse segmentation of the skeleton of the limb, have also received a special nomenclature.

Dr. O. C. Marsh, in a paper "On the Limbs of *Sauranodon*," which is to one seeking to interpret the limbs a "golden key" (Amer. Journ. of Sci. vol. xix. Feb. 1880, pp. 169-171, fig. 1), suggests the following terms for the regions of the higher kind of limb (cheiropterygium) (p. 170):—

	<i>Anterior.</i>	<i>Posterior.</i>
Propodial bones.	Humerus.	Femur.
Epipodial bones.	Radius and ulna.	Tibia and Fibula.
Mesopodial bones.	Carpals.	Tarsals.
Metapodial bones.	Metacarpals.	Metatarsals.
Phalangeal bones.	Finger-bones.	Toe-bones.

In the beginning of my work these researches were in their infancy, and the Bird stood out from all other types as an anomalous form, deficient as to many elements of the limb, and, on the hind limb especially, possessing only the ghost of a tarsal bone, and that not in all cases; this is a bone that serves as a sesamoid, but was thought to be a rudimentary "calcaneal ossicle" (see Owen, *Osteol. Catal. Mus. Coll. Surg.* vol. i. 1853, p. 270, no. 1406). On page 258, no. 1355, the bone had already been accurately described as "a small cuneiform tarsal wedged into the outer and back part of the ankle-joint." This great anatomist, however, only saw in this bone a rudimentary os calcis, which it cannot be, being *below* that part. In all the Sauropsida the most flexible part of the ankle-joint is not, as in Mammals, between the astragalus and os calcis (tibiale and fibulare) and the tibia, but between the astragalus and os calcis and the distal part of the tarsus. Thus we have one of the many reasons for classifying the Birds with the Reptiles; and this once done (see Huxley, "On the Classification of Birds," *P. Z. S.* 1867, pp. 415-472), a clear path was opened for fresh workers.

For a long while the bilobate mass of separately ossifying cartilage at the end of the tibia in a young bird had been an anomaly to me. In the year 1843 I dissected out these parts in the chick of the Emu (six weeks old) and in young domestic fowls. The drawings of these parts, still unpublished and still unexplained, led me in 1860 (*Balaniceps rex*, *T. Z. S.* vol. iv. p. 343) to suggest very cautiously that that mass was not an epiphysis of the tibia, but an *astragalus*. For I had then seen *only one epiphysis* in the skeleton of a young bird, namely that on the enemial process of the tibia\*.

But besides the *bony* separateness of the great upper tarsal mass in young birds, I had seen a still earlier and greater distinctness, for the *cartilage* of this mass is distinct from that of the tibia as well as the bone. Happily for science, this subject came across the path of Professor Gegenbaur (see his *Memoir* in the *Archiv für Anat. u. Phys.*, Jahrgang 1863, pp. 450-472), and his researches were followed up by Professor Huxley (see *Proc. Zool. Soc.* 1869, pp. 12-31, and also the paper just referred to in the *P. Z. S.*); and now, at the present time, this subject has attracted a host of workers and no little controversy.

At the end of a full week of incubation, the leg, in my 1st stage (Plate XXII., and Plate XXIII. fig. 1), has already taken on a thoroughly ornithoseclidan condition, and is greatly modified from a normal amphibian or lacertian hind limb. Nevertheless, it can be seen to be pentadactyle, and to have its sharpest line of segmentation between the upper and lower series of tarsal segments; also the fibula is not much shorter than

\* Within the last few years I have found a few more "epiphyses," namely, on the top of the fibula in *Upupa epops*, on the distal end of the radius in some small Passerines, and on the distal end of the ulna in *Turdus merula*.

the tibia. Even now the main shaft-bones are present in the middle third of the long rods—femur, tibia, fibula, and the 2nd, 3rd, and 4th metatarsals (Plate XXIV. *f.*, *t.*, *fb.*, *mt.* 2<sup>d</sup>). Even now, *all* the segments are not composed of hyaline cartilage, they will be in one or two days more.

The rapidity with which the bird-type is developed in the embryo is very marvellous; already the femur has its trochanteric condyle, as well as its round upper and double lower condyle, clearly formed. The enmial process of the tibia is well seen, and the fibula, already falling short of the end of the leg, is at its widest part only half the diameter, and one fourth the substance, of the tibia.

So much for the “propodial” and “epipodial” elements of the hind limb; the “mesopodials” are rapidly forming; the “metapodials” are formed, but are not united, they are a straddling series, like those of a Lizard; the “phalangeals” are all marked off, but the distal segments are not quite chondrified.

The mesopodials, or tarsal segments, are highly modified at their first appearance, and the distal row does not become segmented vertically, but remains as one transverse mass adapted to the three developed metatarsals—the 2nd, 3rd, and 4th (Plate XXII., Plate XXIV. fig. 1, *d.t.*). But the proximal row of tarsals is for a time differentiated into the two normal segments, the tibiale and fibulare\*.

Nevertheless, all observers are now agreed that the mass which was supposed to be the astragalus, merely, or tibiale, represents both astragalus and calcaneum; there is a distinct fibulare on the outer side, determinable both in the early and scarcely chondrified state, and afterwards in the ossification by two endosteal centres of the solid bilobate cartilage that forms the double condyle in this type of ankle-joint.

Miss Alice Johnson (Stud. Morph. Lab. Camb. vol. ii. plate 5. fig. 9, *fbe.*, *tbe.*) showed the double nature of this mass, but failed to find the intermedium (*loc. cit.* vol. ii. p. 25, plate 5. fig. 9). Dr. G. Baur (“Der Tarsus der Vögel und Dinosaurier,” Morph. Jahrb. Bd. viii. plate 20) gives a large series of sections of the ankle of the Chick, but these prove nothing against Dr. Morse’s † views and mine as to the nature of the bony shaft that afterwards appears in the ascending process of the tibiale or astragalus.

In the stages worked out by Miss A. Johnson and Dr. Baur, the tibiale is only partially chondrified; the fibulare solidifies earlier. Thus the cortical part of the tibiale and the ascending growth are in that stage, which is my first (Plate XXIV. fig. 1), still composed of indifferent tissue. In a more advanced stage an ear-shaped process of cartilage grows upwards from the outer and upper corner of the tibiale, and applies itself to the upper and inner edge of the fibulare, mounting up above it (Plate XXIV. fig. 2, *i*; 2nd stage). When this part is bent upwards against the pisiform fibulare, then the band has a thin isthmus, and this is the true segmental part, which, however, keeps its cartilaginous continuity with the tibiale; thus these two normal segments are connate,

\* In my introductory paper “On the Morphology of Birds,” Proc. Roy. Soc. 1887, p. 58, I have spoken of the distinctness of *three* cartilaginous nuclei at this part: this is an error.

† “On the Identity of the Process of the Astragalus with the Intermedium.”—Anniversary Memoirs, Bost. Soc. Nat. Hist. 1880.

as the three distal tarsals are, further down. In the Ostrich, in *Opisthocomus*, and in some others, the ascending process is a long strip of cartilage ending in a point above; in the Chick it is shorter, and it is shorter still in the Alcidae and Pelecanidae.

As for the intermedium being a mere "outgrowth from the tibiale," the view taken by Miss A. Johnson and Dr. G. Baur (Johnson, *op. cit.* p. 25), and by my son, Prof. T. J. Parker, my answer is, that it is almost equally related to both tibiale and fibulare, and that it is *above* both of them, and that no outgrowth or ascending periosteal process to the tibiale is possible at any time, as that part ossifies late and internally, and the whole mass is joined to the end of the tibia, and ankylosed to it as soon as the tibiale and fibulare are perfect. In the Swan the ectosteal sheath of the long and thoroughly chondrified intermedium begins at the middle of the incubating period; it is far advanced in embryos four-fifths ripe. In Cygnets one month old, the tibiale and fibulare are small endosteal nuclei, deeply hidden in the common proximal tarsal cartilage.

After half a century's research in matters of this kind, I never found a secondary part, any periosteal flange, or process to be developed before the part of which it is the mere "outgrowth."

The high position of this epipodial segment, its great relative length in many birds, its early chondrification, its narrow basal isthmus, its early ossification, and that in a manner not like a tarsal, but the same as in the tibia and fibula, *i. e.* by ectostosis and not by endostosis, and its evident homology with the intermedium of the Ichthyosaurs are quite satisfactory to me as to its nature. Dr. Baur ("Ueber den Ursprung der Extremitäten der Ichthyopterygia," Separatabdruck aus dem Bericht über die XX. Versamml. des Oberrh. geol. Vereins) has given outline figures of the upper part of the fore limb of the "Mixosauridae," "Ichthyosauridae," and "Ophthalmosauridae." In the first and second of these there is a "pisiforme," making *four* in the proximal row of carpals. In the third type there are only *three*; and Dr. Baur, for some mysterious reason, known to himself only, letters these three as *r, u, p*. I should letter them *R, I, U*. It is pure conjecture that the pisiforme should get between the humerus and ulnare, and thus be a third "epipodial" segment. To me the pisiforme looks like a stray remnant of some lost ray of the ichthyopterygium. Thus the middle of these three nuclei appears to me to answer to the intermedium, which Marsh finds in *Sauranodon* (Amer. Journ. Sc. vol. xix. Feb. 1880, pp. 169-171, fig. 1). The figure given there is of the hind limb, but that does not affect the question. Professor D'Arcy W. Thompson (Journ. Anat. & Phys. vol. xx. pp. 1-4) gives, in his fig. 1, diagrams showing that in the *Ichthyosaurus* the intermedium may lie close to the "propodium" (femur), between the tibia and fibula. I had satisfied myself that the intermedium of the Chick's hind limb was not a tarsal segment, but a shaft-bone of the leg ("epipodium"), before I saw how this view harmonized with what Marsh has told us of *Sauranodon*, and D'Arcy Thompson of *Ichthyosaurus platyodon*.

Of the three distal tarsals that cap the three developed metatarsals, only that over the third is chondrified in the 1st stage. The tarsal substance is soft, right and left; it is also postero-internally, where the "scaphoid" (centrale) is formed. The tight

fagoting together of the elements of the shank has not yet taken place, but the purpose hidden in the fundamentally reptilian organism is unfolding itself; for on the inner side the 1st metatarsal (*mt.*<sup>1</sup>) is merely a distal rudiment one-fourth the length of the others: the 5th reptilian toe had to be strangled in its infancy; it exists now as a small seed-like grain of true cartilage (*mt.*<sup>5</sup>) outside and above the head of the well-developed 4th (*mt.*<sup>4</sup>). The phalanges of the 1st toe are as well developed as those of the next three; and as in the Seal (*Phoca*), what the phalanges want in number—there are only the *two* normal joints—they make up in length; and this helps to make the 4-lobed amphibian paddle, ordained to become the foot of a creature that not only “on the ground walks firm” but that is capable of perching also, and of sleeping on the perch, strongly pivoted on a single foot.

The four distal phalanges (*dg.*<sup>1-4</sup>) are simple rounded pieces in an amphibian stage; afterwards they push out the skin and receive from the cuticle a horny sheath, both joint and sheath curving into a claw.

In the 2nd stage (Plate XXIV. fig. 2), besides general growth, we can see a further special differentiation of elements:—the scaphoid or centrale is acquiring its curved and yet trihedral form, and the distal tarsal mass (*dt.*) has now acquired a right and left flat outgrowth over the 2nd and 4th metatarsals. The arrested 5th metatarsal is clearly seen in this stage; and so are the two upper nuclei, the tibiale and fibulare, beneath and *in front of* the distal end of the *tibia*; the fibula has now become relatively shorter.

In the 3rd stage we see the result of 48 hours' more growth; this additional time is sufficient to bring out the promised bird much more clearly, in this particular member; the pre-natal transformation is extremely rapid, for the natural stove furnace is very hot.

The true proximal tarsals, the tibiale and fibulare (Plate XXIV. fig. 3, *tb., fbe.*), are not yet fused together to form the shapely condyle; they are still, and for some time to come, quite distinct from the *tibia* (*t.*). The intercalary centrale (figs. 4, 5, *c.*), or “scaphoid,” is well formed, and is wedged postero-internally between the tibiale (astragalus) and the inner region of the distal tarsal mass, a part which corresponds to the middle euneiform bone of our ankle, above the 2nd metatarsal. Clinging to the outer face of the distal tarsal mass, the small remnant of the 5th metatarsal (*mt.*<sup>5</sup>) is still visible; the mass itself is now a thick slab of cartilage, thickest in its oldest or middle part. Behind, this connate slab is showing its true avian nature; the plantar tendons are being provided with grooves and sheaths and pulleys by a downgrowth of the distal tarsal mass (Plate XXIV. fig. 5, *d.t.*). At present, a larger inner and a lesser outer oblong lobe of cartilage is seen clamping the hind face, above, of the 2nd and 3rd metatarsals (*mt.*<sup>2-3</sup>).

The three main metatarsals are rapidly ossifying and cling closely to each other now; the 3rd (*mt.*<sup>3</sup>) is behind the other two above; but, below, it reaches out in front of and beyond them, as it carries the largest toe. Still, however, this limb has not got beyond the ornithoscelidan stage, for the metatarsals are all distinct, at present. The larger phalanges are now beginning to ossify, the distal joints have become hooked and are now invested with a horny sheath.

As the limb here figured (Plate XXIV. fig. 4) was from a Chick of the Dorking Fowl

variety—a variety that gives us a monstrosity that is most certainly not a “new thing,” but an atavistic relapse, and which is very constantly hereditary,—we have the 1st toe (*dg.*<sup>1</sup>) showing the two modes of increase of the rays of an ichthyopterygium, or fish-fin. Here the increase in number takes place as in the Elasmobranchs; an additional ray is added on the inside, and the normal first ray increases, as the rays of the Skate’s huge pectoral fin increase, namely by a single phalanx having a pair of phalanges on its distal end.

Here Morphology and Teratology meet. In perfectly normal Fowls there is an additional element of the limb on the tibial side, namely the spur, so common in the phasianine Fowls, and in one kind is repeated, *Polyplectron* having two spurs.

The Ornithologists who treat only of adult birds in their memoirs, tell us with the utmost confidence that these parts have nothing whatever to do with the normal elements of the foot, and have nothing in common with normal claws or unguis phalanges. A single glance at the fore foot of the Bernissart Iguanodon (Dollo, Bull. Mus. Roy. Hist. Nat. Belg. t. ii. pl. v.) would have cast a doubt upon this confident opinion of Mr. J. Amory Jeffries (Proc. Boston Soc. Nat. Hist. 1881, vol. xxi. p. 301) and Dr. P. L. Selater (see Ibis, vol. iv. 1886, 5th series, pp. 147–151 and pp. 300, 301). Everywhere marginal remnants of mesopodial, metapodial, and phalangeal elements are being discovered in the limbs of Amphibia, Reptilia, Aves, and Mammalia; the cheiropterygium is merely what it is by “natural selection,” and the “old things” are not always done away in the making of this new and more perfect form of limb.

At this 3rd stage, just below the middle of the 2nd metatarsal, on its inner side, one of the scales of the shank is circular; within that circular scale there is a lenticular mass of fibro-cartilage (Plate XXIV. fig. 4, *spr.*); that mass is to me a remnant of a “prehallux;” we shall see how this part behaves in the further stages.

In the 4th stage (Plate XXIV. fig. 6), a little after the middle of incubation, the independence of the intermedium (*i.*) is further shown by an ectosteal cap on its shrunken upper or proximal end. Its broad distal part is not wholly fused with the region of the fibulare (*fbe.*), and its inner angle is continuous with the top of the region of the tibiale: on its tibial side a new band of cartilage is formed; this is the tendon-bridge, and is an addition to the tibia. The true tarsals, or mesopodials, are wholly unossified at this stage after 12 days’ incubation; but the true proximal nuclei are quite fused together, and form the well-made double condyle, which rolls in the connate distal tarsals (*dt.*). The lower end of the fast-ossifying tibia (*t.*) is still distinct from the proximal tarsal mass, and the distal tarsal mass is still quite distinct from the closely-packed metatarsals. Not only so; that connate mass has grown down behind the tops of the approximate rods; the fan-shaped outgrowth, with its ridges and grooves, clamps them together. In its normal place, between and behind the astragalus and the region of the middle euneiform, we see the scaphoid, or centrale, as a thick, solid, subcrescentic wedge of true, or hyaline, cartilage.

In the 5th stage, or Chicks from eggs that have been sat upon for 14 or 15 days (Plate XXIV. figs. 8, 9), the metamorphosis of the elements of the leg is far advanced, and yet they are largely distinguishable. The proximal end of the tibio-tarsal region is

only ossified in two places, both ectosteally; namely, the tibial shaft (*t.*), which now almost reaches the tendon-bridge, and the intermedium (*i.*) in front of, and above, the calcaneal lobe, the unossified region of the fibulare (*fbe.*). Clear of that lobe externally, the internal and lower angle of the intermedium is continuous with the astragalar region, that of the tibiale (*tb.*) by a thin isthmus of cartilage; this band forms the lower border of the passage for the extensor tendon. More than the upper two-thirds of the flat triangular intermedium is now an ectosteal bone—a distal remnant of an intercalary “epipodial” bar. The fibula (see fig. 2, *fb.*) is now far away, proximally; it is the aborted remains of an outer “epipodial” bar. Thus we see the mysterious transformation of the Reptilian hind limb into the single-shafted leg of the Bird—a transformation that culminates in the leg of the Flamingo and Stilt-Plover (*Phœnicopterus* and *Himantopus*).

This unification—not mere fagoting or binding closely together—of the elements of the leg (epipodial, mesopodial, and metapodial) necessitates the localization of the ankle-joint through the middle of the metapodial elements, and its specialization, as a hinge-joint, to a degree of perfection that exists in no other Vertebrate. The locking together of the upper and lower condyloid faces seems to be, at first sight, very loose and free, yet the convexities of the upper face of the joint have corresponding concavities in the lower, and between them there is a very perfect structure of fibro-cartilage belonging to the region of the centralia, and actually developing on its hinder part one good-sized centrale (fig. 9, *c.*), sometimes a second lesser nucleus (T. J. Parker, in *Apteryx*).

But the prepotency of the 3rd distal tarsal has to do with the perfection of this most admirable joint. At first, alone, this part not only sent out its right and left plano-concave lobes—the morphological equivalents of the 2nd and 4th distal tarsals,—but in its copious growth it sends downwards, behind, the mass for the tendon-sheaths and groove, and upwards in front a well-formed intercondyloid lobe, which becomes most developed in the Gallatorial tribes, and is the peg which fits so neatly into the special round fossa on the intercondyloid face of the upper part of the ankle-joint (Plate XXIV. figs. 8, 9). The inner ridge on the posterior outgrowth (fig. 9) is the larger of the two main thickenings; these have not any cartilaginous bridge uniting them; that is formed, afterwards, by a periosteal growth; in the figure (fig. 9) the centrale (*c.*) is shown semi-detached, with its inner face upwards.

In the 6th stage (Plate XXIV. figs. 10–12) the ankle-joint of a Chick two or three days after incubation is shown. Here we see that in Chicks double the age, from the beginning of incubation, of those in which the intermedium had begun to ossify (figs. 6, 7, 12 days), the supposed parent of that element is itself still unossified. The solid cartilaginous mass representing both tibiale and fibulare is being tunnelled, within, by capillaries, but I can see no osseous deposit at present.

In the 7th stage, a chicken 33 days old (Plate XXIV. figs. 13, 14, *tb.*, *fbe.*), there is a considerable internal nodule of bone forming the two proximal tarsals; these deposits come very near the surface of the cartilage, but to have formed the “ascending process” they must have been wholly ossified, and the osseous deposit must have run riot into the periosteum and adjoining fascia above these elements. This 7th stage is profitable,

for it shows a small bud at the top of the intermedium (*i.*), which bud is the remnant of the long band, so well seen in many other birds, whilst the Fowl is very ornithoscelidan in the greater arrest of this part.

Both this and the last stage (figs. 13, 14, and 10-12) show the structure and relations of the massive scaphoid, or centrale—a part continuous with, and formed out of, the massive interarticular plate; no “sesamoid” or even “calcaneum” is this great crescentic wedge of solid hyaline cartilage! The single distal tarsal ossification (figs. 13, 14, *dt.*) is seen most in front, under the intercondyloid peg (fig. 14, *c.*); but it shines through the sides of the cartilaginous mass (fig. 13), having given off side-growths of bony matter that represent the 2nd and 4th distal tarsals of a normal Reptilian ankle-joint. At this late date, in chickens the size of a Quail, the tibia has not yet coalesced with the proximal tarsal mass; its tendon-bridge (*t.br.*) is still soft.

The 8th stage, in young Fowls of the first summer, yields the same instructive facts. In a young Cock, four months old, the spur (fig. 18, *spr.*) is still very little developed outwards. Looked at in the light of general Morphology, we see that this is a solid fibro-cartilage; and its position and relations proclaim it to be a veritable “pre-hallux.” If the spur of a Fowl were merely a spinous, horny scale, its solid core corresponding with the dermal scutes of *Cyclodus*, *Scincus*, *Anguis*, or of the Crocodilia, then there would have been no fibro-cartilage developed. But that special tissue, just one degree lower in the scale than hyaline cartilage, when it is developed, has always some direct morphological meaning; it is no longer a mere tract; it becomes an *element* of the skeleton. It was evident at the end of 10 days' incubation (Plate XXIV. fig. 4, *spr.*); and in the Purple Pheasant (*Euplocamus Horsfieldii*), near the time of hatching (Plate XXVI. fig. 20), it is seen as a considerable disk a little way above the semi-osseous distal 1st metatarsal (*mt.*<sup>1</sup>), as in the Fowl. In the latter (fig. 18) it has raised itself so as to form a hemispherical bud, and the once flat scale has now become like a deep watch-glass.

Later in the season, in young Fowls 7 or 8 months old, there is much soldering to be done before the strong ankle-joint is complete. At this stage (Plate XXIV. figs. 15, 16) there appear to be several epiphyses in the hind limb and two large sesamoids; and nothing but a complete history of the development of these parts is sufficient to correct this first view. There is a sesamoid, the patella (*pt.*), at the knee-joint, and directly below it an epiphysis, or the enemial process (*en.e.*). But at the ankle-joint the apparent sesamoid is the scaphoid or centrale (*c.*), and the apparent epiphyses are the proximal and distal tarsal masses—the upper being the tibiale and fibulare united together, and also to the intermedium in front of and above them; and the lower mass is the distal tarsal common to the 2nd, 3rd, and 4th metatarsals; this mass has developed a huge continuous outgrowth for the plantar tendons\*.

In the adult (figs. 17 and 19) the outer and inner ridges of that outgrowth have been formed into a canal by periosteal growths, and the scaphoid is seen as a strong sub-triangular, somewhat curved bone, which plays upon the back of the region of the tibiale, behind the inner side of the joint.

\* This is the stage in which the Fowl has been compared to the *Iguanodon* by Prof. Huxley (see Proc. Geol. Soc. Nov. 10, 1869, pp. 12-31).

XII.—*On the Morphology of the Young of Turnix rostrata.*

In the region round about the keel-less tribes of birds there lie some Families that come in between these large arrested and degraded types and the numerous existing Families and Subfamilies of Gallinaceous birds. One Family only of the great general Gallinaceous group, the Pigeons, has shot up into the higher type of arboreal birds; they are "Altrices," the high-builders, with tender young. Between them and the true "Alectoromorphæ" (Phasianidæ, Cracidæ, Megapodidæ, &c.) come in the Sand-Grouse—birds that are Præcoeces and exhibit a curious mixture of the Pigeon and the Grouse; they have the intestines of the Grouse and the general form and the sternum of a Pigeon, but belong to the zoological level of the Grouse.

Between the Cracidæ and the Ratitæ we have the nearly extinct Opisthocomidæ; this type is on the same ornithological platform as the Tinamidæ. The so-called "Button Quails" or Hemipods (Turnicidæ) come in between the dwarf kinds of Phasianidæ, the Quails (*Coturnix*), and the semi-struthious Tinamous. The ancientness, or the newness, of all these closely related birds may be determined and measured by their potency in genera and species.

The extremes, therefore, in this respect are the Hoatzin (*Opisthocomus*) on one hand, one species for one family, and the "Alectoropods" among the true Fowls on the other, the high-heeled Gallinacæ; the main family, Phasianidæ, having subdivisions that may be called Phasianinæ proper, Tetraoninæ, Meleagrinaæ, and Numidiinæ.

The Turnicidæ are few in number, are small in size, and are confined to the Eastern Regions; whilst *Opisthocomus* and the Tinamous are Western types—Neotropical indeed.

Now, as I showed long ago, the Hemipods are not merely a link between the Quails and the Tinamous; they also approach, on one hand, to the Sand-Grouse and Plovers, and on the other to the archaic types of Passerine birds. They are not ready-made links to help the Ornithologist to tie together Gallinaceous and Struthious types, for they are rich with an ornithic fulness of Nature; they are so intensely generalized that they have relations in many families. Yet they are a small and a decaying family, and the specialized Fowls are gradually "improving" them out of existence.

In three different places I have already treated of the Osteology of the Hemipodidæ; the present addition will practically give a complete account of their Osteology, both young and adult.

The first description of their skeleton is given in my paper "On the Gallinaceous Birds and Tinamous" (Trans. Zool. Soc. vol. v. plates 34, 35, pp. 172–190). In this paper the osteology of two adults is given, namely, *Hemipodius varius* (see Owen, Osteol. Catal. Roy. Coll. Surg. vol. i. p. 274, No. 1423), and of an unnamed species from the Gardens of the Zoological Society.

The next contribution is in the work "On the Shoulder-girdle and Sternum" (Ray Soc. 1868, plate 16, pp. 184–186). In the figures there given and in the description there is an error with regard to an additional pair of osseous centres in the young of *Turnix rostrata*. The preparation, still in my possession, which misled me, has the "lophosteon" cracked at its upper margin; there is no "coracosteon," but merely the

same number of centres as in the Common Fowl, namely, a "lophosteon" in the centre, a pair of pleurostea and a pair of metosteia laterally.

The third contribution to the osteology of these birds is in my paper "On the *Ægithognathous* Birds" (Trans. Zool. Soc. vol. ix. plate 54, pp. 294-300). That account of the structure of the palate in *Turnix rostrata* showed how near these birds come to the lower kinds of Passerine birds; the palate is almost *ægithognathous* and shows also such vestigial structures as are seen in some other types, especially certain low neotropical Passerines, described in the same paper, namely, *Anæretes* (*ibid.* plate 59. figs. 4, 5) and *Chasmorhynchus* (*ibid.* plate 62. figs. 5-8).

This semi-passerine palate, with remnants\* or vestiges of the recurrent alinasal cartilages that help to protect "Jacobson's organs"—organs that are suppressed in birds—makes the skull of the Hemipod of extreme interest, and suggests that the place of the bird in the Class is very low; it is a truly archaic type. Anyhow, the osteology of this bird, which has been taken up by me again and again during the last twenty-five years, has lost none of its interest.

### XIII.—*The Vertebral Chain of the Chick of Turnix rostrata.*

The hind part of this chain is figured (Plate XXV. fig. 5); the rest may be here described. That of the adult is figured in the early paper just referred to. The presacral vertebræ all remain distinct, and are cylindroidal in the dorsal as well as in the cervical region.

The vertebral formula is as follows:—C. 15, two pairs of ribs free; D. 4; S. 15, two pairs of ribs free; Cd. 6+3. The sacrum, divisible into subregions, has 2 dorso-sacrals, 3 lumbo-sacrals, 3 sacrals proper, and 7 uro-sacrals, the first two of which have separately ossified riblets (Plate XXV. fig. 5). Four of the caudal vertebræ are united to form the uropygial piece.

This chain is very similar to that of the typical Gallinaceous birds; but it has one more dorso-sacral than the Quail (*Coturnix communis*, Plate XXV. fig. 4), and the uropygial piece is smaller, and in this the Hemipod comes nearer to the Tinamou (*Nothura*).

The atlas and axis have no riblets outside the canal for the vertebral artery; in this Chick (a week or two old) the rest of the cervicals have riblets, but that on the 3rd is not yet ossified; from the 4th onwards they are small reniform ossicles, with the "hilus" looking backward. The last two have elongated styloid ribs, that of the 15th being nearly as large as that on the 1st dorsal; and as the first sacral (dorso-sacral) has ribs with a long but not perfect sternal piece, the thorax has actually six pairs of ribs fencing it in. The ribs and these appendages are normal but rather feeble; the whole space partakes of this feebleness; none of the processes, upper or lower, being strong or long. This young bird shows well the composition of the sacral and caudal regions; the proper sacrals are very much extended laterally, as in the Quail (fig. 4), and as in birds generally. The ribs, ever ready to crop up, are absent from the dorso-

\* See Proc. Roy. Soc. vol. xliii. 1888. pp. 397-402.

lumbar and sacral proper; but the first two uro-sacrals have riblets, not separate as cartilages, but with distinct osseous centres; the feeble caudals are very Tinamine.

Referring to my published papers for a description of the shoulder-girdle and sternum (*op. cit.* plate 16), and the wing of the adult *Hemipodius varius* (Trans. Zool. Soc. vol. v. plate 35), I may remark that in the young bird\* the manus is remarkably long, being one-third longer than the ulna; the humerus is one-fourth longer than the ulna. In the adult *Hemipodius varius* the humerus is a little shorter than the ulna, which is of the same length as the manus. In this young bird the intercalary metacarpal behind that of the index is much smaller than in the Fowl, but the rudiment of the 4th metacarpal is as large. The ungual phalanges of the pollex and index are not distinct; the proximal joint of the pollex and the 2nd of the index are rather long and slender; this in the latter is one-third longer than the free joint of the pollex.

The single phalanx of the 3rd digit is short, but has an "elbow" on its hinder side, a vestige of a phalanx of the 4th digit. The vertically displaced 1st distal carpal is remarkably long, and by its free radial end articulates with its own metacarpal, but joins it at a right angle. In the strangely metamorphosed wrist of a bird, this instance is one of the best in proof of the nature of that displaced carpal.

#### XIV.—*The Pelvis and Hind Limb of Turnix rostrata (juv.).*

The pelvis, which in this young bird is just escaping from the Tinamine stage, is less Dinosaurian than that of the Fowl's (Plate XXV. figs. 5 & 4), for the prepubic process is suppressed in *Turnix*. Indeed, this part is seldom quite so completely lost; in this *Turnix* agrees with *Thinocorus*. Even in *Attagis* and *Chionis* there is a rudiment. On the whole this pelvis is more like that of a feeble Plover than of a small Fowl; the absence of fusion of the hip-plate with the sacrum shows this (Plate XXV. fig. 5, and Trans. Zool. Soc. vol. v. plate 35. figs. 5 & 8).

There is one thing in the hind limb that has a Dinosaurian appearance, namely, the length of the femur; it is one of the longest, relatively, in the Class. In the young bird the lengths are as follows:—femur 16.5 mm.; tibio-tarsus 22 mm.; tarso-metatarsus 15 mm. In *Tinamus robustus* (adult) the measurements are:—femur 70 mm.; tibio-tarsus 100 mm.; tarso-metatarsus 67 mm. In *Tatagalla Lathamii* (nearly adult):—femur 90 mm.; tibio-tarsus 125 mm.; tarso-metatarsus 85 mm. And in *Gallus domesticus* (adult):—femur 92 mm.; tibio-tarsus 130 mm.; tarso-metatarsus 88 mm.

In these three other instances the femur in no case is three-fourths the length of the tibio-tarsus; it has exactly that proportion in *Turnix rostrata*, and it has about the same proportions in the adult *Hemipodius varius*. In the Dinosaurs the femur has a very elephantine size, both in bulk and height, and one of the most striking characteristics of the bird's hind limb is the relative shortness of that bone, and it is also the least variable in length of the three main segments of the leg.

The tibio-tarsus (Plate XXV. fig. 7) is remarkably below the average as to ornithic

\* This wing will, I trust, be figured and described in a memoir on the Morphology of the wing in the whole Class.

development of the enemial process; in this young bird the epiphysis has not yet appeared on the head of the tibia (*t.*). At its lower end the three remarkable additions to this bone are in an instructive stage of development, for the cartilaginous mass now shows three distinct ossifications—the tibiale, fibulare, and intermedium (*tb.*, *fb.*, *i.*). The latter, as in the Common Fowl, is very short; it is obliquely placed and notched on its broad upper part; it is an ectosteal tract. The other two are endosteal tracts, formed *later* than the intermedium; the tibiale is twice the size of the fibulare; they are both largely coated with cartilage, the superficial part of which will remain on the bilobate condyle. It is evident that the earlier-formed intermedium cannot be a mere ossification in an "outgrowth" of this condyloid mass; it is, however, instructively like the part which in the Dinosaurs has manifestly become one with the tibiale or astragalus (see Dollo on *Iguanodon*, Bull. Mus. Roy. Hist. Nat. Belg. tom. ii. plate 4. fig. 2, *e*, *g.*). The fibula (*fb.*) is more than two-thirds the height of the tibia. Unlike that of the Common Fowl, the centrale or "scaphoid" (fig. 8, *c*) is small; it is not yet ossified. The distal tarsal mass (*d.t.*) has a limpet-shaped osseous centre in it; this is the tarsal which belongs to the largest or 3rd metatarsal which carries the largest toe; this bony part is growing into the cartilage right and left, just as the cartilage itself grew at first; the bony deposit is a perfect imitation of the primary cartilaginous growth. This does not always take place, and yet the two tissue-stages are intimately related. Of course, in many cases the cartilaginous matrix fails to undergo the normal segmentation, which may, nevertheless, assert itself in the formation of bony centres.

In this young bird we see what is still more remarkably seen in the young of long-legged Wading-birds, namely, the clumsiness, so to speak, of the compound shank. The 2nd and 4th metatarsals (fig. 8, *mt.*<sup>2</sup>, *mt.*<sup>4</sup>) have squeezed the 3rd (*mt.*<sup>3</sup>) backwards, where it supports the special outgrowth of the distal tarsal mass; below, this rod comes to the front, and is the largest of the three developed rods. In this bird it carries a very large middle toe (*dg.*<sup>3</sup>); all these toes are quite normal, both from a reptilian as well as an avian standpoint. The rudiment of the 5th metatarsal is not now evident; that of the 1st (figs. 9–11, *mt.*<sup>1</sup>) is not always present in this species. I have been able to study this aborted element in three individuals from the same batch of nestlings. In one (fig. 9 *a*) I failed to find any remnant; in another (fig. 9) it was a very small oblong ossicle; in a third (figs. 10, 11) it was larger and kidney-shaped.

This abortive development of the hallux or 1st digit in the Hemipods gives them a Plover-like appearance, but it is quite as much a Struthious as a Charadriine character. As most of the Ratitæ have lost this digit, its abortion in this case is quite similar to what we find in many Water-birds, which, when three-toed, are seen to show some remnant of the hallux.

#### XV.—*Summary.*

Amongst the higher Vertebrata, the Bird Class is by far the most potent in genera and species, about twelve thousand species being found in the existing avifauna.

If, instead of this abundance of living forms, this were an extinct Class and we knew

of its members merely by the recovery of a few fossil forms, the value and importance of such relics would be accounted exceedingly great.

Now I contend that the interest attached to this group is not in the least lessened by the numbers it contains, and the fact that they are still living, are present everywhere, and can be obtained for morphological purposes at every stage of their growth. The acknowledged fact that these warm-blooded types are, in a sense, merely Reptiles in a high degree of modification, greatly increases the interest in their structure, and especially as the linking on of the Class is not to the existing Reptilian forms, but to various groups that once held sway, but that are only known to us now by their bony remains.

Thus in themselves, as a Class, when we study them from an ornithological standpoint and for ornithological purposes, they are a group rich in interest, but their ontology takes them far outside the ornithological territory.

A bird is not merely a modified Reptile; and no true abranchiote amniotic Reptile ever gave birth to, or was metamorphosed into, a bird, either slowly or by an evolutionary "leap."

Those branchiate, non-amniotic forms, the AMPHIBIA and DIPNOI, have a prior quasi-parental claim on the bird; its development clearly suggests this, and it seems to me that we must seek for the origin of both Reptiles and Birds amongst imagined forms of those half-fishy sort of creatures.

The resemblance in its structure and development of a Bird to a Reptile is not at first to be understood off-hand easily, it is a very complex matter; for a bird is like one kind of Reptile in one thing, and resembles others in other things. Note one thing, namely, that a bird is extremely unlike a flying Reptile (Pterosaur), and that the types that help most in this comparison are the Ichthyosaur, the Plesiosaur, and the Dinosaur.

If anatomists had gone on in the old way, simply comparing the adult of one type of Vertebrates with the adult of another, the whole subject must have still slept in darkness; the study of the development forces the mind into evolutionary speculation.

Nearly half a century has elapsed since my own attention was arrested by this subject, and to-day, instead of finding any place of rest, the necessity for renewed labour is felt by me more strongly than ever.

In the beginning of this part of my morphological work, which has been taken up again and again, the labourers were few indeed; now one is almost lost amongst a host of esteemed fellow-workers, whose researches are ever shedding new light upon this difficult but delightful subject.

In the present paper I have only lightly touched those regions of the skeleton of the Fowl which have already been figured and described. Nevertheless, the whole skeleton of the Chick is shown, just at the end of the first or beginning of the second week of incubation. The Fowl is but a halfway kind of bird, between an Ostrich and one of the highest types of a songster; and yet the rate of development in it is marvellously rapid, for even this medium kind of bird ripens its young in the egg at four times the rate of that of an embryo Crocodile; three weeks serves for the Chick, three months are required for that Reptile, and six months for a Skate.

It can be seen, even at the beginning of the second week of incubation, that the embryo is that of a bird, for it combines, in one, characters that are diagnostic of three, at least, of the most remarkable types of extinct Reptiles. Thus the upper and lower jaws are growing forwards into a long beak, and the extension of the basi-facial axis is just like what is seen in all rostrate types, *e. g.*, in the Skate, Sturgeon, and *Lepidosteus*, and the embryonic skull of *Ichthyosaurus* must have had the same intense "prognathism." But the elongation of the neck and the shortening of the tail remind us of the *Plesiosaurus*, which type, if it had possessed a long beak, might have done duty, hypothetically, for an early pupal form which was destined to become a bird. But that water-monster never attained to such a dignity.

The newest evolutionary candidates for birdship are the Ornithoscelida—the *Iguanodon* and his kindred; I need not say that none of these ever became a bird; they did grow into something wonderful, and their hind-quarters were modified in the same manner as those of an *embryo* Humming-bird; but a creature weighing twenty tons would have required, in the atmosphere of this planet, wings that would have reached "from sea to sea." Was the bird developed from some small kind of Ornithoscelidan? I think not, nor do I imagine that the fan-tailed normal birds—toothed or with horny jaws—are the proper descendants, slowly or more rapidly modified, of the mysterious *Archæopteryx*. That Oolitic form did duty, hypothetically, for a short time as a parental bird; but Marsh's Toothed Birds of the Cretaceous period suggest that this is a fallacy. The fact that *Hesperornis* had cylindrical vertebræ up to its pelvis, and that it had existed as a type long enough for the abortion of its wings and sternal keel, is proof surely that this short-tailed type had existed for an enormous period of time; that is, if our evolutionary speculations have any solid truth in them.

Anyhow, however long the period has been in which the Bird has arisen from some low form, the time taken, now, in the egg, for the whole of its pre-natal transformation is extremely short—an hour, now, stands for an age, in the past.

At this stage—my first in this paper (see p. 215)—the hind-quarters are already essentially Ornithoscelidan; the ilium embraces a long series of sacral vertebræ, and the pubis and ischium have rotated backwards as in those extinct Reptiles.

The hind limbs correspond very closely at this time with those of the *Iguanodon*, yet they are very partially ossified, and in some things they are evidently in harmony with what existed in the early young, not the adult, of that large extinct Reptile.

The wing, at first, has only three digits; the foot has a proximal rudiment of the fifth, with the first arrested at its upper end. But the ends of the digits are flat and soft, there is no claw at present; they are in an amphibian stage at this early date; all Reptiles pass through that stage, and one Amphibian, namely *Dactyléthra*, does acquire claws.

The *Hemipod* comes in as a very instructive type, tending to connect the Fowls with the Ostrich tribe; it is evidently archaic.

In the present short and very imperfect summary, I, of necessity, refer to the other piece of work on the Fowl and the Hemipod, and also to other papers of mine on the morphology of this bird.

There is no finality about work of this kind; all the old work serves but as the beginning of new; and I have sought here rather to offer suggestions than to repeat the detailed facts:—*they* have but little interest except as links in a long and tortuous chain; they are not things on which we can rest—they serve, however, as stimulants to further research.

EDITORIAL NOTE.—Owing to the lamented death of the author of this paper before it was in type, and to the illegibility of his handwriting, a few errors in the lettering of the Plates have escaped correction. They were lettered from the original figures, and then printed off; but Prof. W. N. Parker, who has been good enough to revise the proof-sheets, has found it necessary to note the following *errata* :—

- Plate XXII. For *ap* read *u.p.*  
 Insert reference-line from *cr* to cartilage just below.  
 Insert reference-line from *dg*<sup>1-3</sup> to digits.  
 For *cw* read *c.u.*
- Plate XXIII. Fig. 4. For *s.r.*<sup>1</sup> read *s.v.*<sup>1</sup>  
 For *s.r.*<sup>1'</sup> read *s.v.*<sup>1'</sup>  
 For *pt.* read *pb.*  
 Fig. 9. For *p.vi.* read *pr.i.*
- Plate XXIV. Fig. 1. For *m.t.* read *m.t.*<sup>1</sup>  
 For *tt.* read *d.t.*  
 Fig. 4. For *m.t.*<sup>2</sup> read *m.t.*<sup>1</sup>  
 Fig. 19. Insert *t.mt.* (tarso-metatarsus) and *spr.* (spur).  
 Fig. 21. Insert *t.* (tibia), *t.br.* (tendon-bridge), *i.* (intermedium), *tb.* (tibiale), and *fbe.* (fibulare).
- Plate XXV. Fig. 3. Delete reference-line from *s.i.f.*

## XVI.—LIST OF ABBREVIATIONS.

- |  |                                   |
|--|-----------------------------------|
| <i>ac.</i> Acetabulum.                     | <i>cd.v.</i> Caudal vertebræ.     |
| <i>ag.</i> Angulare.                       | <i>c.hy.</i> Cerato-hyal.         |
| <i>al.e.</i> Alisphenoid.                  | <i>cl.</i> Clavicle.              |
| <i>al.s.</i> Alisphenoid.                  | <i>c.mc.</i> Carpo-metacarpus.    |
| <i>al.sp.</i> Alisepetal.                  | <i>cn.e.</i> Cnemial epiphysis.   |
| <i>ar.</i> Articulare.                     | <i>cr.</i> Coronoid and Coracoid. |
| <i>at.</i> Atlas.                          | <i>c.r.</i> Cervical rib.         |
| <i>au.</i> Auditory capsule.               | <i>cr.g.</i> Crista galli.        |
| <i>ax.</i> Axis.                           | <i>c.tr.</i> Cornua trabeculæ.    |
| <i>b.hy.</i> Basihyal.                     | <i>c.u.</i> Centralo-ulnare.      |
| <i>br</i> <sup>1</sup> . Cerato-branchial. | <i>c.v.</i> Cervical vertebræ.    |
| <i>c.</i> Centrum and Centrale.            | <i>d.c.</i> Distal carpal.        |

<i>dg.</i> Digit.	<i>pc.p.</i> Pre-costal process.
<i>di.</i> Diapophysis.	<i>p.cr.</i> Precoracoid.
<i>d.t.</i> Distal tarsal.	<i>pg.</i> Pterygoid.
<i>d.v.</i> Dorsal vertebræ.	<i>p.p.</i> Pars plana.
<i>e.n.</i> External nostril.	<i>pr.i.</i> Pre-ilium.
<i>f.</i> Femur.	<i>pr.p.</i> Prepubis.
<i>fb.</i> Fibula.	<i>p.s.</i> Presphenoid.
<i>fbe.</i> Fibulare.	<i>p.s.c.</i> Posterior semicircular canal.
<i>fo.</i> Fontanelle.	<i>pt.</i> Patella.
<i>fr.</i> Fenestra rotunda.	<i>pt.i.</i> Post-ilium.
<i>gg.</i> Ganglion.	<i>q.</i> Quadratum.
<i>h.</i> Humerus.	<i>q.j.</i> Quadrato-jugal.
<i>h.s.c.</i> Horizontal semicircular canal.	<i>r.</i> Rib and Radius.
<i>i.</i> Intermedium.	<i>r.st.</i> Rostrum of sternum.
<i>i.c.</i> Internal carotid.	<i>s.ag.</i> Supra-angular.
<i>i.cl.</i> Interclavicle.	<i>sc.</i> Scapula.
<i>il.</i> Ilium.	<i>s.i.f.</i> Sacro-ischiatic foramen or fenestra.
<i>i.re.</i> Intermedio-radiale.	<i>so.</i> Supra-occipital.
<i>isc.</i> Ischium.	<i>spr.</i> Spur.
<i>i.tr.</i> Intertrabecula.	<i>s.r.</i> Sternal rib and sacral rib.
<i>iv.</i> Investing mass.	<i>st.</i> Columella and sternum.
<i>k.</i> Keel of sternum.	<i>s.v.</i> Sacral vertebræ.
<i>m.c.</i> Metacarpal.	<i>t.</i> Tibia.
<i>mk.</i> Meckel's cartilage.	<i>tb.</i> Tibiale.
<i>m.o.f.</i> Middle occipital fontanelle.	<i>t.br.</i> Tendou-bridge.
<i>m.st.</i> Metasternum.	<i>t.mt.</i> Tarso-metatarsus.
<i>m.t.</i> Metatarsal.	<i>tr.</i> Trabecula.
<i>n.a.</i> Neural arch.	<i>u.</i> Ulna.
<i>n.c.</i> Notochord.	<i>ul.</i> Ulnare.
<i>ob.f.</i> Obturator foramen or fenestra.	<i>u.p.</i> Unciform process.
<i>oc.c.</i> Occipital condyle.	<i>v.r.</i> Vertebral rib.
<i>od.p.</i> Odontoid process.	II. Optic foramen.
<i>pb.</i> Pubis.	

## XVII.—DESCRIPTION OF THE PLATES.

## PLATE XXII.

Skeleton of embryo of *Gallus domesticus*, side view; 1st stage (7 days' incubation). Magnified  $13\frac{1}{2}$  diameters.

## PLATE XXIII.

Fig. 1. 1st stage continued; part of basis cranii and cervical region of vertebral column, lower view. Magn. 20 diams.

2. The same; 13th and 14th cervical vertebræ, lower view. Magn. 20 diams.

3. The same object, upper view. Magn. 20 diams.

4. The same; pelvis and caudal vertebræ, lower view. Magn. 20 diams.

5. 2nd stage (embryo of 8 days); sacral and caudal vertebræ, lower view. Magn. 20 diams.

Fig. 6. Part of same object. Magn. 40 diams.

7. *Phasianus versicolor*, embryo  $\frac{2}{3}$  ripe (=3rd stage of Common Chick); five anterior vertebræ, lower view. Magn. 20 diams.
8. Same object, upper view. Magn. 20 diams.
9. Common Chick, 3rd stage (10 days' incubation); pelvis and caudal vertebræ, lower view. Magn. 10 diams.

#### PLATE XXIV.

Fig. 1. Common Chick, 1st stage; left leg, oblique inner view. Magn. 15 diams.

2. The same, 2nd stage; left leg, front view. Magn. 15 diams.
3. The same, 3rd stage; tibio-tarsus, front view of lower end. Magn. 15 diams.
4. The same (Dorking variety); tarsus and foot, front view. Magn. 10 diams.
5. Part of same object, back view. Magn. 15 diams.
6. Common Chick, 4th stage (12 days); ankle-joint, front view. Magn. 10 diams.
7. Same object, back view of upper part. Magn. 20 diams.
8. Common Chick, 5th stage (14 or 15 days); tibio-tarsus, lower end, front view. Magn. 15 diams.
9. The same; shank, upper view. Magn. 15 diams.
10. The same, 6th stage (Chicken 2 or 3 days old); ankle-joint, inner view. Magn. 8 diams.
11. The same object, back view. Magn. 8 diams.
12. The same, front view. Magn. 8 diams.
13. Common Chick, 7th stage (33 days old); ankle-joint, front view. Magn. 8 diams.
14. The same object, side view of inner face. Magn. 8 diams.
15. Common Chicken (8th stage),  $\frac{3}{4}$  year old; tibia and patella, inner view. Nat. size.
16. The same; ankle-joint, inner view. Nat. size.
17. The same (9th stage), old Fowl; top of shank with "centrale." Magn. 2 diams.
18. The same, old Fowl; first metatarsal and spur. Magn. 2 diams.
19. The same, old Fowl; tibio-tarsus and spur. Nat. size.
20. *Euplocamus Horsfieldii*; near time of hatching; first metatarsal and spur. Magn. 10 diams.
21. ? The same; lower part of tibio-tarsus. Magn. 8 diams.

#### PLATE XXV.

Fig. 1. *Meleagris gallopavo*, ♂; upper xiphoid. Nat. size.

- 1a. *Tetrao urogallus*, ♀; end of sternum. Nat. size.
2. Common Chick, 1st stage; sternum, &c. Magn. 20 diams.
3. The same, 2nd stage; hip-plate. Magn. 20 diams.
4. *Coturnix communis* (ripe); pelvis, lower view. Magn. 10 diams.
5. *Turnix rostrata* (juv.); pelvis, lower view. Magn. 10 diams.
6. The same; femur, front view. Magn. 8 diams.
7. The same; tibio-tarsus, front view. Magn. 8 diams.
8. The same; tarso-metatarsus, front view. Magn. 8 diams.
- 9, 9a. The same; 1st and 2nd metacarpals. Magn. 8 diams.
10. The same; lower end of tarso-metatarsus, hind view. Magn. 8 diams.
11. The same; 1st metatarsal, hind view. Magn. 32 diams.
12. Common Fowl, 1st summer; part of hip-plate, inner view. Nat. size.

VII. *The External Morphology of the Lepidopterous Pupa: its Relation to that of the other Stages and to the Origin and History of Metamorphosis.*—Parts IV. & V.  
By EDWARD B. POULTON, M.A., F.R.S., F.L.S., of Keble and Jesus Colleges, Oxford.

(Plates XXVI. & XXVII.)

Read 20th March, 1890.

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PART IV.—THE PUPAL ANTENNÆ.

1. *The Relation of Pupal to Imaginal Antennæ.*—When investigating the external morphology of the Lepidopterous pupa I had the great benefit of Professor Moseley's kind help and advice. Very early in the investigation he told me of some important observations he had made in 1871 upon the relation between the imaginal and pupal antennæ of *Saturnia carpini*. Corresponding with him on the subject, I received a letter, which is printed in full below. Apart from its great scientific value, the letter is of interest as showing the ready help and sympathy its writer was so pleased to extend to any scientific worker.

“14 St. Giles', Oxford,  
January 1884.

“DEAR POULTON,—I am very glad to hear of the continued success of your researches, and congratulate you on the matter. There is no need why anything should be said about my unpublished observations on the pupæ. I cannot lay my hand even on my drawing now. If, however, you think fit, you might mention that on your informing me of the line of work you had in hand I told you that I had observed that in *Saturnia carpini* the sheaths of the antennæ in the female pupa are large and inflated, with traces of pectination, resembling in this respect those of the male pupa, but in a reduced degree, although the antennæ of the female imago are, as well known, merely filiform. I concluded from this fact that in the ancestral *Saturniidae* the imagos of both sexes must have had large pectinated antennæ, and that they had not been developed as such only

in the male for sexual purposes, but must have been retained in the male and degenerated in the female. Further, it seemed to me that in the form of the pupa of Lepidoptera, and probably in Coleoptera and other forms also, many facts of important ancestral significance might be found preserved. The integument of the pupa, requiring for purposes of protection to be hard and rigid, when once it had assumed a particular shape suited to the contours of the body of the original ancestral insect, would retain that form indefinitely, although the shape of the several parts of the imago formed within it might, by the action of natural selection on it when in the free moving condition, alter considerably. It appears to be of no detriment to the development of the legs and the antennæ of the imago that their pupa-cases are far too big and do not fit. I concluded from the observations on *Saturnia* that probably members of the *Saturniidae* must exist with well-marked pectinated antennæ in both sexes. I did not in the least know that such was the case, but soon saw that it is so on looking at Westwood's drawers of insects. If you think well to refer briefly to any of the above I shall be much obliged. It was in 1871 that I began to look into the matter, but it was cut short by my expedition to Ceylon. Wishing you all success,

“ I remain, &c.,

“ H. N. MOSELEY.”

Other parts of this paper, in addition to the section upon antennæ, bear witness to the general applicability of Professor Moseley's conclusions to the systems of organs which can be traced in the external morphology of Lepidopterous pupæ. At the same time it will be shown that the shrinkage of a part in the imago ultimately leads to the shrinkage of the corresponding part in the pupa. The latter change, however, keeps behind the stage of degeneration reached by the imago, so that an earlier condition of the imaginal organs can often be traced upon the pupa.

Directly my attention was called to the point I looked out for similar facts in many species of pupæ, and always with the same results. When there is much difference between the antennæ of male and female moths, there is always less difference between the antennæ of the sexes of their respective pupæ. I found this to be the case with pupæ of the genus *Smerinthus*, where the difference between the imaginal antennæ is not excessive, and in pupæ such as *Pygæra bucephala*, *Cerura vinula*, and *Orgyia antiqua*, in which the difference is much greater. In all cases we have evidence for comparatively recent increase of the sexual differences in the imago state.

A comparison of figs. 1, 2, 3, and 4 on Plate XXVI. will show the evidence upon which Professor Moseley relied for his conclusions. But the same conclusions are further supported by a more minute examination of the antennæ of the female imago. If these have undergone comparatively recent degeneration, we should expect to find great individual difference in the degree to which degeneration is carried, and we should expect to find traces of structures which were necessary for former functional activity. Figures 5 and 6 (Plate XXVI.) prove that the degree of degeneration varies greatly in different individuals (see description of figures), and that rudimentary sensory hairs are scattered over the reduced equivalents of the highly-developed rami of the male organ.

Corresponding facts come out still more clearly in the European *Aglia tau*, in

which the imaginal sexual differences are even more strongly marked. There is an immense difference between the imaginal antennæ (compare figs. 9 and 10), while the corresponding pupal organs are not widely different (compare figs. 7 and 8). Although the antennæ of the female imago are extremely degenerate, a careful examination reveals traces of the structure which is so elaborately developed in the male (compare fig. 13 with figs. 11 and 12).

*Orgyia antiqua* affords an interesting comparison with *Saturnia* and *Aglia*, in that the antennæ of the female imago are less degenerate, but are nevertheless out of all proportion to the broad antennæ of the female pupa (compare figs. 17 and 15). The male antennæ form most highly complex and expanded sense-organs (fig. 16), while the corresponding pupal antennæ are not much larger than those of the female pupa (compare figs. 14 and 15). The details of the antennæ of both sexes are shown in figs. 18 and 19.

Again, the antennæ of the female *Cerura vinula* exhibit distinct pectination like that of the male, but on a decidedly smaller scale; while the pupal antennæ are more nearly of the same size (compare figs. 20, 21, 22, and 23).

Even the extremely degenerate females of the genus *Fumea* emerge from pupæ with tolerably stout and well-developed antennæ (Plate XXVII. fig. 14). The lowest depth of female degeneration is reached in those Psychids which are a mere bag of eggs, without limbs or sense-organs, and utterly unable to emerge from the pupal shell. Distinct traces of antennæ can nevertheless be made out upon the pupæ of some of them (Plate XXVII. fig. 15, A).

The same facts are well seen among the degraded females of certain *Geometræ*. The wingless female of *Nyssia zonaria* possesses thread-like antennæ very different from those of the male, but the pupal antennæ do not greatly differ in size (compare Plate XXVI. figs. 24, 25, 26, and 27). The similarly degenerate female of *Hybernia defoliaria* emerges from a pupa with comparatively broad antennæ (compare Plate XXVII. figs. 8 and 9).

2. *The History of the Degeneration of the Antennæ in Female Imagines.*—These and other examples could be easily arranged in a series leading from a state of sexual equality through stages of increasing female degradation to the culmination reached in the condition of many Psychids. It appears certain that all such cases of sexual inequality have been gradually reached by the degeneration of one sex attended by a corresponding development of the other. The tendency towards such a change is present in many groups of moths, especially among the Bombyces, and exists whenever the females are less active than the males. When this is the case, the chief competition among the males will be in sense-organs to ascertain the existence of virgin females at as great a distance as possible, and in the power of flight to reach the female before other males. But such competition, ensuring the success of the best-endowed males, and a gradual improvement from generation to generation in their sense-organs and their powers of flight, will therefore cause coitus to take place at a shorter and shorter interval after the emergence of the female from the pupa. But such a result must tend

towards the degeneration of the female sense-organs, because, as the organism becomes more and more sluggish, the necessity for these organs diminishes both for sexual and for other purposes. The reverse takes place in the male, as the sense-organs become specialized for sexual purposes. It is likely that such specialization implies a partial restriction and not an actual limitation of function, the antennæ still remaining sense-organs of very general use, although their high development is related to one out of many possible functions.

It is obvious that the diminution in the activity of one sex must in certain cases involve other organs in addition to the antennæ. These will be considered in the next Part, and will be found to throw further light upon the subject of the present Section.

#### PART V.—THE PUPAL WINGS.

1. *The Relation of Pupal to Imaginal Wings.*—Considering the conclusions already arrived at by the comparison of pupal and imaginal antennæ,—that when an imaginal organ falls into disuse and shrinks, the corresponding pupal organ shrinks at a very much slower rate, and so presents a picture of the long-past condition of the former—it became very probable that a similar relation would be found to obtain in other sets of organs, and especially the wings. I have already shown that the function of the wings bears a close relationship to that of the antennæ.

My attention was first called to this comparison between pupal and imaginal wings in species of which the females possess these organs in a very rudimentary form, by the study (in 1885) of the remarkably degenerate female pupæ and imagines of *Fumea nitidella*. Although the males of this species are active bombyciform moths, the females are exceedingly degenerate, never leaving the case in which the pupa was contained, but sitting upon the end of it for their whole life. In this position they deposit their eggs in the empty pupal shell within the case from which they themselves emerged. Corresponding to this sedentary life, the wings are reduced to minute tubercles, so small as readily to escape detection, and having neither the shape nor appearance of wings. On examining the female pupa I saw at once that it possesses small but distinct wings of characteristic structure and shape, and with the normal relation to the other appendages and to the meso- and metathoracic segments (Plate XXVII. fig. 14). The male pupa is shown in figs. 12 and 13.

This comparison is exceedingly interesting, for it at once disposes of the view that the rudimentary wings of such females as these are not due to degeneration from a winged condition, but are remnants of truly ancestral, partially developed structures. This view is also rendered equally improbable by other considerations. Thus, it has already been shown, by means of the pupal antennæ, that such females formerly resembled the males to a greater extent than at present in one set of rudimentary organs, suggesting that other sets have had a similar history. Furthermore, we must probably look for the origin of wings in some of the suppressed stages which preceded that represented by the pupa, inasmuch as pupæ always possess wings; and it seems certain that these organs originally arose in the phylogenetic development after the manner which is indicated by

the ancestral Orthoptera—namely, that they arose gradually, as their slowly unfolding structure rendered possible the transition from the slight prolongation of a jump—their first locomotive function—into the sustained movements of true flight. If these arguments be correct, it is clear that fairly-developed wings such as pupæ possess are very far from representing the original condition of these organs, while the rudimentary wings of certain imagines are clearly due to degeneration.

In order to test further the conclusions arrived at by studying *F. nitidella*, I made use of another very common species of which the females have rudimentary wings, viz. *Orgyia antiqua*. After emergence from the pupa the female moths sit on the outside of their cocoons, which they never leave, but deposit their eggs upon the surface of the silk. Although very degenerate, they possess distinct wings of the usual shape, though very small and quite useless. The size and shape of the left fore wing are shown in Plate XXVII. fig. 11. I then examined the pupal wings and found that, although very much smaller than those of the male, they are considerably larger than the wings of the female moth, as is seen by comparing figs. 10 & 11, Plate XXVII., both figures being magnified to the same extent. Hence we find precisely the same relation between the wings of the male and female pupa, and between those of the latter and of the female imago, as in *Fumea nitidella*, although degeneration has gone further in the last-named species.

Some of the more degenerate *Psychidæ* were then selected for examination. In these the female imago is a mere bag of eggs, and remains permanently enclosed in the pupal shell. In the majority of female pupæ examined, the lost imaginal parts—wings, legs, antennæ, &c.—are evidently represented by confused creases on the corresponding parts of the cuticle. In one unnamed species, kindly lent me by my friend Mr. W. White, the pupa retained far more distinct traces of structures formerly possessed by the imago. The anterior part of the pupa is represented in fig. 15, Plate XXVII., and it is seen that the wings are distinct as small pouches on the meso- and metathorax, that the legs, antennæ, and even the eyes and mouth-parts can be plainly made out, although of a very rudimentary nature. The moth itself appears to be as degenerate as any Psychid in which the traces of lost parts upon the pupa are far more obscure. The figure also shows that the pupal prothorax splits along the median dorsal line and that the hairs of the enclosed imago are seen through the opening, so that the first part of the process of emergence from the pupa appears to be recapitulated in this most degenerate form.

Further examination of various species in which the female imagines possess rudimentary wings also supported the conclusion that such degeneration is of recent date.

Thus many species of *Geometræ* were investigated. The minute functionless wings of a female of *Cheimatobia boreata* were found to retain distinct traces of the colours and patterns which are characteristic of the functional wings of the male, thus supporting the conclusion that the reduction in size is very recent. The wings of a female of the closely-allied *Cheimatobia brumata* were found to be much smaller, with far less distinct indications of pattern (compare figs. 1 & 2, Plate XXVII.). The wings of the female *Hybernia progemmaria* are less reduced than those of *Cheimatobia*, although quite useless

for flight. The wide individual differences between the females of this species in pattern, shape, size, and character of the fringe are also evidence of recent degeneration (compare figs. 3, 4, 5, & 6, Plate XXVII.). Even stronger evidence is, however, supplied by the closely-allied *Hybernia defoliaria*, of which the female imagines are usually described as entirely wingless. Minute rudiments of wings can, however, be detected (Plate XXVII. fig. 9). Corresponding to the reduction in the wings, the legs are of great size, being of the utmost importance for locomotion. Comparison between *H. defoliaria*, *H. progemmaria*, and the other species of the genus *Hybernia*, proves that the reduction of the wings has been carried to very different points in species which are nevertheless closely allied. The wings of a female pupa of *H. defoliaria* are shown in Plate XXVII. fig. 7, magnified to the same extent as the imago (fig. 9). In spite of the degenerate condition of the imago, the pupal wings are seen to be large and well-formed, and are in fact almost equal to those of the male pupa. The same facts hold for another Geometer, *Nyssia zonaria*, in which the wings of the female are extremely minute (Plate XXVI. fig. 28), although the difference between the wings of the pupæ of the two sexes is quite inconsiderable (compare Plate XXVI. figs. 24 & 25).

When we compare the pupæ of the degenerate Geometers with those of the Bombyces, we find evidence for a more rapid and recent change in the former. Thus the degeneration of the latter is of sufficiently long standing to have caused the wings of their female pupæ, such as those of *Orgyia*, *Fumea*, and especially *Psyche*, to become decidedly reduced in size. This is evident when we compare the pupal wings of, *e. g.*, the female *Fumea* (Plate XXVII. fig. 14) with those of the male of the same species (fig. 12). The immense difference between the results of such a comparison and that instituted above in the case of *N. zonaria* (Plate XXVI. figs. 24 and 25) or *H. defoliaria* proves that the degradation of the latter is of far more recent date.

The comparison between pupal and imaginal wings in species with degenerate females indicates that Professor Moseley's conclusions require some modification; for in some of the species the pupal organs have shrunk as the corresponding imaginal organs have diminished, although the former have changed at a much slower rate. Hence we are driven to conclude that the particular shape and size of a pupal organ, which at any one time fits an imaginal organ developed within it, will not be retained indefinitely upon the shrinkage of the latter, as Professor Moseley was led to believe from his observations upon the antennæ, but that the pupal organ will also eventually become smaller. At any rate, this has been the case with the pupal wings. I do not think that at present there is any evidence for believing that the female pupal antennæ have yet shrunk like the wings; for the former, although smaller than the same organs in the male pupæ, may nevertheless have been at no time larger than at present. Such a conclusion is supported by the arguments in the last division of the subject, in which it was shown to be very probable that the male imaginal antennæ have increased as the female organs have diminished, so that the pupal organs of the former must have undergone recent increase, while the female pupal antennæ may indicate the size of these organs in both sexes, before degeneration of the one, and concomitant development of the other, commenced. Or, considering how very common it is among moths for the male antennæ to be more developed than those of

the female, only part of the sexual differences between pupal antennæ may date from the beginning of the rapid degeneration and development which certain species have undergone in the two sexes respectively. But it is most likely that the general and widespread difference between these imaginal organs in the two sexes is due to precisely similar causes acting slowly and only up to a certain point—due, in fact, to the competition among the males being keener than that among the females. When the two sexes seem to approach most closely in respect of this competition, flying together and both apparently exercising the powers of active selection—when courtship appears to be mutual—then the differences between the antennæ of the two sexes become very small, and in the cases of most complete equality disappear altogether. And it must be remembered that the antennæ are in all probability sense-organs of very general use, although their sexual function is by far the most important, and that free and active flight gives abundant opportunity for their exercise in all possible directions, so that these organs may be sometimes equally developed in the two sexes, when they may be more especially used in courtship by the males.

Returning to the pupal antennæ of degenerate females, the observations upon the wings of the same species render it likely that the former will slowly diminish in size, although they have probably not done so at present, except, indeed, in the most degenerate species, viz. many *Psychidæ*. The pupal wings may have shrunk earlier, because they form organs of considerable size, and their shrinkage therefore especially favours a corresponding increase of other parts. The degeneration of the imaginal sense-organs and organs of locomotion is generally accompanied by an increase in the size of the abdomen, which becomes relatively larger than in the more normal females. Thus the number of eggs is often largely increased, while the additional weight is not too great a strain upon the comparatively passive organism. In certain species the legs are also specially developed in order to bear more than their ordinary share in locomotion—*e. g.* in certain Geometers, such as *H. defoliaria* (Plate XXVII. fig. 9).

## 2. *The History and Causes of Degeneration in Female Imagines of Lepidoptera.*—

It is now possible to give a more complete account of the history of degenerate females than could be advanced from the consideration of the antennæ alone. Starting from the condition of nearly equal powers of flight and equally developed sense-organs in the two sexes, we find the first indications of divergence in the antennæ, which are commonly more developed in the males because of their activity in courtship; but in the majority of moths the females remain active organisms with considerable powers of flight, which are used especially in connexion with the deposition of eggs and for obtaining food. The first of these important functions may be fairly looked upon as balancing the chief necessity of male flight, *i. e.* to reach the females. Nevertheless, there is this important difference, that the flight of the males tends to become very rapid, because of the stress of competition, while there is no such strong tendency in flight which is used for oviposition. On the other hand, in the flight which is employed for food, the females are as subject to competition as the males, and, accordingly, we find that it is the rule among the great groups of feeding moths (the Geometers and

Noctuas) and among the butterflies that the powers of flight in the two sexes are not very unequal.

The same conclusions are supported even more strongly by looking a little further into details. Among the *Sphingina* (adopting the arrangement of Stainton's 'Manual') there is no marked difference between the flight of the sexes in the flower-haunting, day-flying *Zygænidæ*, *Sesiidæ*, and *Ægeriidæ*. In the *Sphingidæ*, which feed, both sexes fly actively; while in the species of the genus *Smerinthus*, which do not feed, both sexes are sluggish, but the females more so than the males. In the *Bombycina* very few of the moths feed, and the males are nearly always extremely active fliers and the females very sluggish: the exceptions are especially interesting. The *Lithosiidæ* feed eagerly and are commonly taken at sugar, and the females fly actively with the males; the same facts are true of a few flower-haunting genera among the *Cheloniidæ*, in which both sexes fly by day. I do not know of any other *Bombyx* which feeds except *Cossus ligniperda*, which, I believe, has been occasionally seen at sugar; and in this species both sexes are sluggish. In the great majority of the rest of this group flight among the females is almost or entirely subservient to oviposition, while that of the males is far more active and in many species has been rendered extremely rapid by competition in the struggle to reach the females. The female moth is nearly always at a disadvantage in flight as compared with the male because of her relatively large and heavy abdomen filled with eggs. This cause, always present to some extent, tends to produce important results as soon as a species ceases to feed in the perfect state, and can therefore dispense with rapid flight in the females. Increase in the size of the abdomen will then be an advantage, enabling the female to lay more eggs or larger ones—in either case benefiting the species in the larval state—while greater sluggishness of flight only affects the rate of oviposition. Furthermore, the danger resulting from slow oviposition may be met in special ways.

By the working of this cause, rendered effective by the cessation of feeding, we meet the first strong indications of degeneration in those females which fly sluggishly to deposit their eggs, but for no other purpose. In such cases it is not uncommon for the females to fly at a different time from the males. Thus the males of *Lasiocampa rubi* fly with great rapidity in bright daylight, while the females sit perfectly motionless, but in the evening they fly slowly and deposit their eggs. I know this to be the case from my own experience, and I have no doubt that it is the same with *Endromis versicolor*, *Saturnia carpini*, and others\*. The only doubt is as to the evening flight of the females; for in other respects these two species are well known to behave in the same manner as *L. rubi*. The flight of such females, although sluggish, is still necessary, except under certain conditions. The *Bombycinæ* are generally large moths, and there would be a two-fold danger in depositing all the eggs in one place—that of insufficiency of food and easy detection by enemies (unless indeed the larvæ were well concealed or defended by a disagreeable taste or smell), and the latter, the chief difficulty, applies to small as well as large moths. But while further degeneration is thus rigidly prevented in most cases, there are certain moths which escape from the limiting conditions.

\* Weismann states that the females of *Agria tau* deposit all their eggs in one spot, being unable to fly on account of the weight of the abdomen. The males, on the other hand, fly swiftly, seeking for the females. ('Essays on Heredity,' Clarendon Press, 1889, pp. 17, 18.)

The two species of the genus *Orgyia* are small moths as compared with the majority of Bombyces: the larva of one species (*O. antiqua*) eats almost anything, while that of the other (*O. gonostigma*) feeds on large trees; and it is known that in the former case the eggs do not all hatch at once, but produce larvæ in batches over a period of ten weeks. Furthermore, the larvæ are brightly coloured, and possess "tussocks" and eversible glands as defensive structures; and it is known that they are disagreeable to certain insect-eating animals. Hence the species of this genus have escaped from the conditions which render flight necessary for oviposition, and the eggs are laid all over the cocoon. The female moth has an immense abdomen, and therefore can lay a very large number of eggs, so as to ensure that many larvæ shall reach some food-plant. The degenerate wings and antennæ of the commoner species have been already described and compared with the less degenerate organs of the pupa, and the antennæ with those of the male. Another family of the *Bombycinæ* are even more degenerate—the *Psychidæ*: many of these escape from the above-mentioned conditions by their extremely small size, and all of them are specially defended because their larvæ live in cases, and are therefore protected against many foes. Furthermore, the larva-case, in or upon which the female moth always remains, is fixed to the food-plant, so that there is no chance of the larvæ wandering. The food-plants (when known) are amply large enough for the small larvæ to feed upon without fear of starvation. The wings of the female of one of the less degenerate species (*Fumea nitidella*) have been described and compared with those of the pupa (Plate XXVII. fig. 14). The examination of the pupa of one of the more degenerate species (fig. 15) renders it equally clear that the female imago has undergone degradation from a more perfect condition.

Hence the causes of degeneration among the females of the *Bombycinæ* appear to be sufficiently clear. Equally degraded forms are also met with among the *Tineina* and the *Geometrina*. Of the former no more need be said, for everything that has been said of the *Psychidæ* applies to them.

Among the Geometers degenerate females with functionless wings are met with in 5 genera—*Phigalia* (1 species), *Nyssia* (2 species), *Hybernia* (5 species), *Anisopteryx* (1 species), and *Cheimatobia* (2 species). The circumstances under which such females appear in this large group of feeding moths support the explanation which is offered above. The first two genera include Bombyciform moths, of which the males have much-feathered antennæ while those of the female are thread-like. I think it is very probable that they do not feed, and the moths make their appearance at a time of the year which does not encourage feeding by providing many different kinds of bloom, although plenty of food exists for those moths which need it; besides, the low temperature itself tends towards inactivity when flight is unnecessary. *P. pilosaria* appears in February and March: its larva feeds on oak. *N. zonaria* appears in September in the North of England: its larva feeds on yarrow. *N. hispidaria* appears in February and March, and the larva feeds on oak. The same explanation (season) holds with even more force for the next three genera. In the genus *Hybernia*, as the name implies, the perfect insects emerge in the winter. *H. rupicaprararia* appears in January and the first half of February: the larva feeds on whitethorn, blackthorn, and oak. *H. leucopheararia*

appears in February and March: the larva feeds on oak. *H. aurantiaria* appears in October and November: the larva feeds on whitethorn, birch, and oak. *H. progemmaria* appears in February and March: the larva feeds on hornbeam; and *H. defoliaria* appears in October: the larva feeds on many trees. In the genus *Anisopteryx*, *A. escularia* appears in April, and the larva feeds on many trees. Lastly, in the genus *Cheimatobia*, *C. brumata* appears in October, November, and December: the larva feeds on nearly every kind of tree; while *C. boreata* appears in October, and the larva feeds on birch. No one of these species appears on the wing before September or after April, while most of them assume the perfect state in the coldest part of the year. Furthermore, the difficulties in connexion with oviposition do not obtain here; for the female moths leave their cocoons and crawl upon the food-plants of the larva, depositing their eggs in appropriate situations as readily, although not as rapidly, as if they were able to fly. The legs of many of these females are specially developed, thus facilitating locomotion (see Plate XXVII. fig. 9). Furthermore, the moths are not large, and generally lay their eggs upon large trees or upon food-plants such as yarrow, which are very numerous, and which grow in close proximity to one another, so that there is little fear of starvation, even when the eggs are laid near together.

Considering all these facts, it appears most probable that the wings became functionless in certain female moths which appeared in the colder months of the year and did not require the use of these organs for feeding, for courtship, or for oviposition. Furthermore, the wings when useless would be encouraged to shrink by a variety of causes, of which a probably important one is the fact that the females would be much more conspicuous during oviposition if they crawled about with a surface immensely extended by means of these organs. But there has also been the same cause acting throughout which was pointed out as of the first importance in the *Bombycinæ*—the advantage which the species gains from the possession of a large abdomen by the female. The difference in size between the male and female abdomen in these moths is far greater than in any other species in the *Geometrinæ*. The last is doubtless the great cause of degeneration in all cases, and among this large group of feeding moths the temperature has indirectly produced such results in a few species by the discouragement of feeding, so that the chief cause could come into operation, receiving accessory aid from the positive protective gain which would result from the loss of functionless wings.

It is hardly necessary to point out that the degenerate condition of the females renders certain a keen competition among the males, which ensures the continued possession of the power of flight in this sex, notwithstanding the low temperature and indifference to food. It is well known, however, that another condition may render the wings functionless, even in the male sex, *i. e.* existence upon islands in very stormy areas where high winds recur constantly. But this cause is not efficient in Great Britain, and no such effect is witnessed in our Lepidopterous fauna.

It is quite clear that the initial stages of diminution, however caused, in functionless wings would not affect the corresponding pupal organs, because the latter are very much smaller than those of the imago, the difference in size being due to expansion immediately following emergence from the pupa. We should not therefore expect any

shrinkage in the pupal wings until the imaginal organs had become smaller than the former. The various stages of shrinkage are well exemplified in the genus *Hybernia* alone. In *H. progemmaria* the wings of the female are certainly far larger than those of the pupa; in fact the expansion does take place, but it is much limited; and the resulting organs are entirely useless. In *H. rupicapraria* and *H. aurantiaria* the wings seem to be as nearly as possible of the same size as those of the pupa: the wings of the female on emergence are of the same size as those of other females, but there is no expansion. Finally, in *H. leucophearia* and *H. defoliaria* the wings of the female are almost invisible and much smaller than those of the pupa. In this last case alone is there any probability of the pupal wings having shrunk, and I should imagine that such shrinkage, if any, would be small, because the transition described above in nearly allied species belonging to one genus seems to show that the whole character is very recent. Since writing this sentence, I have been enabled to obtain evidence of the validity of the conclusion; for I have now shown that the pupal wings of the female *H. defoliaria* remain of considerable size (Plate XXVII. fig. 7).

I wish to point out clearly how much and how little is contained in this explanation and history of degeneration. I have shown the causes which always tend in this direction and the chief conditions which prevent their action. I have pointed out that certain species become partially, others completely, relieved from these conditions, and thus seem to be free to follow the tendencies, and we see that all the instances of degeneration occur among such species. But while it has thus been, I think, sufficiently explained how it is that degeneration of the female wings becomes possible, it is quite a different thing to say why certain species and not others should have availed themselves of the possibility. There are certain other small species of *Bombycinæ* and *Tineinæ* to which degeneration seems to be as possible as to those in which this change has actually occurred. The probable answer is a very general one—that the struggle for existence would prevent a large number of species from taking one uniform line of development, even though it may appear beforehand to be very directly pointed out as the path of least resistance for all of them. Furthermore we may fairly concede that in many instances it is now impossible for us to ascertain the exact conditions which led certain species to take the line we are considering to the exclusion of others, to which it was also open, as far as the general conditions would admit. In the *Geometrinæ*, however, I think I may claim that the demonstration of the cause and course of degeneration has been complete. The number of species to which the line was open being limited, they appear almost without exception to have availed themselves of the opportunity.

3. *The Form of the Imaginal Fore Wing detected on that of the Pupa.*—Although the wing of the imago expands into a size far beyond that reached by the pupal organ within which it is developed, the former does not entirely fill the latter before emergence. The margin of the imaginal wing lies well within the corresponding margin of the pupal wing which encloses it. Not only are the two margins separated by an interval, but their contours are frequently very different. Furthermore, in many species the position of the future margin of the imaginal wing can be distinctly made out on the pupal

surface from the very beginning of the pupal period and long before the imaginal organs have begun to appear. The line which corresponds to the future imaginal hind margin is especially distinct, and is separated from the hind margin of the pupal wing by a very wide interval.

These facts were shown in the plate accompanying my paper in the *Phil. Trans. Roy. Soc.* vol. 178 (1887), B, pp. 311-441, and were briefly alluded to in the description of figure 11 (p. 440), which represented a dark variety of the pupa of *Vanessa Io*, on which the imaginal hind margin is very distinct.

These facts are probably true of the hind wing as well as the fore wing, but they have only been studied in the latter.

Over the part of the pupal fore wing beneath which the imaginal wing will develop, lines which correspond to the future venation are more or less plainly visible. These lines cease at the limits of the area over which the wing will be formed (viz. the line H'.M'. in figs. 18, 22, &c. on Plate XXVII.). Sometimes, however, their direction is continued by irregular lines of pigment across the interval between the pupal and future imaginal hind margins (viz. between H'.M' and H.M.). These irregular continuations are, however, very different in character from the more defined appearance of the lines which represent the venation. When the latter are studied in especially favourable species (e. g. in *Vanessa Atalanta*, fig. 18, Plate XXVII.), they are seen to correspond exactly with the future venation of the imaginal wing. This is all the more remarkable inasmuch as the main tracheæ within the pupal wing, which will ultimately be enclosed as important elements in the imaginal veins, possess at this time an arrangement different from that which they will then assume. Thus fig. 26, Plate XXVII., shows the arrangement of the main tracheæ in the left hind wing of the pupa of *Papilio Machaon*, as seen from within, an arrangement very different in detail from that which will be subsequently assumed and is already mapped out (in the case of the fore wing) upon the pupal cuticle.

It has been already found that indications of earlier imaginal conditions may be traced in the structure and form of the pupa. It was therefore of interest to investigate from this point of view the relation of these pupal markings to the form and appearance of the imaginal wing. The point which I selected as a test was the indented and irregular form of the hind margin of the fore wing in *Vanessa* and allied genera. There is every reason for the belief that such an outline has been derived from the more usual smooth and continuous form of margin. A careful comparison of the imaginal hind margin with that marked out on the pupa supported this conclusion.

The hind margin of the fore wing of the imago of *Cynthia cardui* presents a slight bay in its central part (fig. 17, Plate XXVII.); but the bay is even less marked in the corresponding line upon the pupa (H'.M', fig. 16). In other words, the latter is more normal and is now in a stage through which the imaginal hind margin has passed. Some indications of the black-and-white fringe on the imaginal hind margin (fig. 17) can be made out in the disposition of the pupal euticular pigment along the corresponding line (H'.M', fig. 16). Similarly in *Vanessa Atalanta* the bayed hind margin of the imago is less pronounced on the corresponding part of the pupa (compare fig. 19 with fig. 18,

H'.M'). A similar relationship is witnessed in *Vanessa Io* (figs. 20 and 21), although the difference is rather in the angularity and amount of projection of the cusps than in the depth of the bay. In dark varieties of this pupa the pigment is distributed along the line H'.M' (fig. 20) in such a manner as to suggest a former black-and-white fringe, which is now absent from the imaginal hind margin. The dark parts are diagrammatically indicated in the figure by thickenings along the line H'.M', and their position will be found to correspond with the dark parts of the imaginal fringe in *C. cardui* (fig. 17) and *V. Atalanta* (fig. 19). Inasmuch as these latter species are more ancestral than *V. Io* as regards the comparatively slight degree of indentation of the hind margin, and especially as regards their markings\*, it is most probable that *V. Io* at one time also possessed a black-and-white fringe, which is still indicated in the corresponding part of the dark pupæ of this species. A comparison between the pupa and imago of *V. polychloris* (figs. 22 and 23) similarly shows that the pupal line H'.M' is rather less indented than that of the imago.

Finding these results in our common *Vanessidæ*, I was extremely anxious to test them by an examination of the allied *Grapta C-album*, which possesses a far more jagged hind margin than any other British butterfly. After searching in various directions, I obtained an empty pupal shell of this species, through the kindness of my friend Mrs. Luard. An examination of this pupa supported in the most complete manner the conclusions already arrived at. It is clear that the hind margin of the imago (fig. 25) is far more jagged than that of the corresponding line upon the pupa (H'.M', fig. 24), which indeed is not much in advance of the condition found in the imago of *V. Io* or *V. polychloris* (figs. 21 and 23).

Hence we see that not only are the traces of lost imaginal wings preserved, but the indications of ancestral forms and markings are also fixed on the surface of the pupa. Furthermore, the results of this investigation suggest that further work along the same lines will reveal many other interesting conclusions as to recent changes which have taken place in the imago.

In conclusion, I desire to thank those friends who have kindly supplied me with material for this paper. Mr. W. White especially has lent me many specimens which have been of the greatest service. Professor Meldola has carefully been through most of the manuscript with me, and has offered many valuable suggestions.

\* See Dr. F. A. Dixey's admirable paper "On the Phylogenetic Significance of the Wing-markings in certain Genera of the *Nymphalidæ*." Trans. Ent. Soc. Lond. 1890, pp. 89-129.

## DESCRIPTION OF THE PLATES.

## PLATE XXVI.

The Antennæ of Lepidopterous Pupæ compared with those of the corresponding Imagines.

All the figures are rather smaller than the sizes indicated by the stated amounts of enlargement. The figures were reduced by the lithographer, but the deviation from the originals does not appear to exceed 7 per cent. in any case, and is often much less.

- Fig. 1.  $\times 2$ . The left antenna of a male pupa of *Saturnia carpini*. The transverse markings are more numerous than in the figure.
- Fig. 2.  $\times 2$ . The left antenna of a female pupa of *Saturnia carpini*.
- Fig. 3.  $\times 9$ . The left antenna of a male imago of *Saturnia carpini*, as seen from its upper surface, showing the complexity of this sense-organ. Each joint of the antenna is seen to possess two rami upon each side; these are thickly clothed with sensory hairs (only shown on one side) arranged so as to expose a wide surface to the air. The high degree of development reached by the male antenna corresponds to the size of the pupal antenna within which it is formed (fig. 1).
- Fig. 4.  $\times 9$ . The left antenna of a female imago of *Saturnia carpini*, as seen from its upper surface. The organ is very degenerate in size and structure (the latter studied better in figs. 5 and 6), and is out of all proportion to the pupal antenna within which it is formed (fig. 2). The comparison suggests that the degeneration of the sense-organ of the female imago is comparatively recent, so that the pupal organ has not had time to shrink to a corresponding degree. Only a single much diminished ramus can be seen on each side of each joint of the antenna, but traces of a second can be made out on some of the joints by the use of a higher power (fig. 5).
- Fig. 5.  $\times 50$ . Right antenna of the female imago of *Saturnia carpini*. The sixth and seventh joints above that upon which traces of rami could first be made out in ascending from the basal joint. The joints are represented as seen from below. The longer rami on the left side are directed posteriorly and inferiorly in the natural position of the organ. Thinly scattered sensory hairs are placed upon the rami and the adjacent part of the joints; they are chiefly developed in connexion with the longer rami. In front of (viz., above in the figure) the longer ramus on the lower joint there is a distinct trace of the second ramus in the form of a tubercle bearing a long bristle; a less distinct tubercle without a bristle is seen on the corresponding part of the upper joint. It is therefore clear that the longer rami correspond to the posterior pair on each joint of the male organ.
- Fig. 6.  $\times 50$ . Right antenna of another female imago of *Saturnia carpini*. The joints correspond to those shown in fig. 5, and they are seen from the same point of view. The individual being larger than that from which fig. 5 was taken, the joints are far thicker and larger, although the degeneration has proceeded much farther. Thus the rami are much shorter on both sides, there is no trace of an anterior ramus, and the number of sensory hairs is decidedly smaller, especially on the right side. This great fluctuation in the degree of degeneration supports the conclusion that the latter is of recent date, a conclusion confirmed by a study of the pupal antennæ (figs. 1 and 2) in relation to those of the imago.
- Fig. 7.  $\times 7$ . The anterior part of a male pupa of *Aglia tau*, as seen from the ventral aspect. The enormously broad pupal antennæ occupy a very large area. The character of the surface is only indicated on the left side.
- Fig. 8.  $\times 7$ . The anterior part of the female pupa of *Aglia tau*, as seen from the ventral aspect. The pupal antennæ are very large, although they do not approach the size reached in the male. The median ridge is pronounced, and probably corresponds to the part occupied by the

imaginal antennæ during development and just before emergence. The character of the surface is only indicated on the left side.

- Fig. 9.  $\times 7$ . The left antenna of the male imago of *Aglia tau*, as seen from above and behind. The fine sensory hairs are not indicated. The organ is seen to be even larger than that of the male *S. carpini* (fig. 3). The enormous size of the imaginal organ corresponds with that of the pupal organ within which it is developed (fig. 7).
- Fig. 10.  $\times 7$ . The left antenna of the female imago of *Aglia tau*, as seen from above and behind. Just as the male organ is larger, the female organ is smaller than in *S. carpini* (fig. 4), indicating that the degeneration of one sex has gone hand-in-hand with an increase in the powers of the other. The recent date of the degeneration is well seen when we compare the size of the imaginal organ with that of the pupal organ within which it is formed (fig. 8).
- Fig. 11.  $\times 50$ . The terminal part of one of the posterior rami from a joint of the antenna of the male *Aglia tau*. Each joint bears two pairs of rami (fig. 9), of which the posterior are larger and more complex. The figure shows the long curving sensory hairs and the three terminal bristles. Both hairs and bristles are foreshortened.
- Fig. 12.  $\times 50$ . The terminal part of one of the anterior rami from a segment of the antenna of the male *Aglia tau*. The figure shows the long curving sensory hairs, which are turned towards those of the posterior ramus of the segment in front. The arrangement of the rami is shown in fig. 9, where they are seen to form pairs on each side of the middle line, made up of the anterior rami of one segment placed opposite to the posterior rami of that in front of it. The length of the sensory hairs is more fully shown in fig. 12, because they are seen from the side. Figs. 11 and 12 show that the male antenna of *Aglia tau* is extremely complex, and the arrangement is such as to render it an unusually efficient organ for sifting a large quantity of air, so that the faintest trace of odour may be detected.
- Fig. 13.  $\times 50$ . Two of the most fully developed segments from the right antenna of the female *Aglia tau*, seen from below and in front, in such a position that the rudimentary sensory hairs of the posterior inferior border are in profile. The male antenna is more complex than that of *S. carpini*; but this figure shows that the degeneration of the female has been carried far beyond the point reached by the female *S. carpini* (compare figs. 5 and 6). The rami represent the posterior pairs of the male organ. Those of the posterior inferior border possess two terminal bristles, while those of the other border only possess one. The difference between the size and arrangement of the sensory hairs in male and female is very striking.
- The arguments as to the recent date of the degeneration of the female, derived from *S. carpini*, are thus confirmed and extended by an examination of *Aglia tau*.
- Fig. 14.  $\times 9$ . The outline of the left pupal antenna of the male *Orgyia antiqua*.
- Fig. 15.  $\times 9$ . The antennæ, limbs, &c. of the female pupa of *Orgyia antiqua*. The pupal cuticle had been mounted for the microscope, so that the structures were somewhat flattened. The antennæ are seen to be broad and well developed, although much smaller than those of the male.
- Fig. 16.  $\times 9$ . The antenna of the male imago of *Orgyia antiqua*, showing the great size and complex structure. The development of the organ corresponds with that of the pupal antenna, as in the males of *Aglia* and *Saturnia*.
- Fig. 17.  $\times 9$ . The antenna of the female imago of *Orgyia antiqua*, showing an extremely degenerate condition. As in *Aglia* and *Saturnia*, the corresponding pupal organ has a size which is utterly disproportionate to that of the thread-like and rudimentary structure developed within it.
- Fig. 18.  $\times 50$ . A segment from the middle of the antenna of the male imago of *Orgyia antiqua*. Although inferior in complexity to the corresponding organ of *Aglia* and *Saturnia*, the structure is extremely elaborate. The rami, of which there are a single pair on each segment, are seen to be abundantly covered with sensory hairs, and to possess three terminal bristles.

- Fig. 19.  $\times 50$ . The seventh and eighth segment (from the base) of the antenna of the female imago of *Orygia antiqua*. The structure is seen to be very degenerate; the small rami possess two terminal bristles, but no traces of sensory hairs are seen.
- Fig. 20. Natural size. The left antenna of the male pupa of *Cerura vinula*.
- Fig. 21. Natural size. The left antenna of the female pupa of *Cerura vinula*.
- Fig. 22. Natural size. The left antenna of the male imago of *Cerura vinula*.
- Fig. 23. Natural size. The left antenna of the female imago of *Cerura vinula*. It is very interesting to find that the same relation as that illustrated above, between degenerate female antennæ and the corresponding pupal organs, also obtains in species where the degeneration is comparatively slight.
- Fig. 24.  $\times 5.25$ . The male pupa of *Nyssia zonaria*, as seen from the left side and also somewhat from the ventral aspect. The pupal antennæ are seen to be large.
- Fig. 25.  $\times 5.25$ . The female pupa of *Nyssia zonaria*, seen from the same aspect. The pupal antennæ and wings, although smaller than those of the male, are seen to be well developed.
- Fig. 26.  $\times 9$ . The left antenna of the male imago of *Nyssia zonaria*, as seen from above. The upper rami are distinctly shown, the lower only for part of the length of the organ.
- Fig. 27.  $\times 9$ . The left antenna of the female imago of *Nyssia zonaria*, as seen from above; the number of rings indicated is only approximately correct. The curvature of the antenna was the reverse of that in the male, although this difference is compensated in figs. 26 and 27 by the base of the male antenna being placed over the tip of that of the female and *vice versâ*. The degeneration of the female antenna is seen to be very complete, although the corresponding pupal organ is by no means small.
- Fig. 28.  $\times 5.25$ . The left fore wing of the female imago of *Nyssia zonaria*. The minute size of the structure is well shown, especially when it is compared with the corresponding part of fig. 25, which is magnified to an equal extent. Here also we meet with evidence that the degeneration of the female wing is very recent; for the pupal wing is but little smaller than that of the male, within which fully formed and functional wings are developed.
- Fig. 29.  $\times 50$ . The antenna of the larva of *Pieris brassicae*. The figure is added for comparison with the details of the imaginal and pupal antennæ shown upon this Plate.

## PLATE XXVII.

The Wings of Lepidopterous Pupæ compared with those of the corresponding Imagines.

All the figures have been unavoidably reduced by the lithographer, and are much smaller than the sizes indicated. The deviation from the originals appears to be about 15 per cent.

- Fig. 1.  $\times 7$ . The left wings of the female imago of *Cheimatobia boreata*. Although the wings are very small and of course utterly useless, the figure shows that they retain distinct traces of a pattern which suggests that developed upon the functional wings of the male. This is an indication of recent degeneration.
- Fig. 2.  $\times 7$ . The left wings of the female imago of *Cheimatobia brumata*. The wings being far more degenerate than those shown in the last figure, the pattern is much less distinct.
- Figs. 3, 4, 5, & 6: all  $\times 7$ . The left wings of four female imagines of *Hybernia progemmaria*. The individual differences in size, shape, and in the length and character of the fringe are seen to be very marked. The markings, not represented in the figures, were also very different. This great individual difference also points to recent degeneration from a more highly developed condition.

- Fig. 7.  $\times 8$ . The outline of the left wings of a female pupa of *Hyberia defoliaria*. Although the imaginal wings are very unusually degenerate (see fig. 9), those of the pupa are seen to be well formed and of considerable size. The margin of the hind wing is distinctly seen in its normal position, parallel with the dorsal margin of the fore wing, and occupying the right side of the figure. A comparison of figs. 7 and 9 points to the very recent date of the degeneration of the wings in the females of the genus *Hybernia*.
- Fig. 8.  $\times 8$ . The outline of the left antenna of the female pupa of *Hyberia defoliaria*, shown in the last figure. The antenna is seen to be broad and well developed, and out of all proportion to the filiform degenerate structure which is formed within it (compare fig. 9).
- Fig. 9.  $\times 8$ . The head and thoracic segments of the female imago of *Hybernia defoliaria*, as seen from the left side. The moth represented in this figure emerged from the pupa, parts of which are represented in figs. 7 and 8. The antennæ are thread-like and degenerate, and the wings are so small that they are usually considered to be altogether absent. They are shown in the figure as minute pouch-like extensions of the body-walls, which are closely applied to the sides. The fore wing is more distinct than the other, its surface being marked by a large squarish dark spot. In contradistinction to these rudimentary organs, the wings and antennæ, the unusual size of the legs is very striking. This extreme development of the legs is rendered necessary in order to enable the insect to move about and deposit its eggs.
- Fig. 10.  $\times 7$ . The outline of the left fore wing of a female pupa of *Orgyia antiqua*. The wing was somewhat flattened.
- Fig. 11.  $\times 7$ . The outline of the left fore wing of a female imago of *Orgyia antiqua*. Here also we meet with proof of recent degeneration; for the imaginal structure is much smaller than the pupal structure within which it develops.
- Fig. 12.  $\times 14.5$ . The male pupa of *Fumea nitidella*, as seen from the left side. The parts shown in the next figure were detached from the pupa. The drawing was made from an empty pupal shell, so that the ventral margin of the fore wing is rolled inwards to some extent. The pupa is well formed, and contrasts in a remarkable manner with that of the female (fig. 14).
- Fig. 13.  $\times 14.5$ . The head, antennæ, and limbs of the male pupa of *Fumea nitidella* represented in the last figure, as seen from the ventral aspect. These parts also are seen to be extremely well developed.
- Fig. 14.  $\times 14.5$ . The female pupa of *Fumea nitidella* as seen from the right side. The difference between the sexes is very marked (compare with figs. 12 and 13). The female pupa is nevertheless far less degenerate than the imago which emerges from it. The imaginal wings are minute tubercles, so that the insect is described as "wingless"; those of the pupa are seen to be small but quite distinct. Their small size leads to the uncovering of the first abdominal spiracle, which is concealed in all pupæ with normally-developed wings. The pupal antennæ are also larger than those of the imago. Although the degeneration of the female *Fumea* is doubtless far older than that of *Orgyia* or *Hybernia*, a comparison between pupa and imago clearly shows that it is not very ancient; for the pupa, although degenerate, is still a long way above the condition to which the imago has sunk.
- Fig. 15.  $\times 14.5$ . The anterior part of the female pupa of an unnamed Psychid, as seen from the ventral aspect and somewhat from the right side. The wings are distinct, although very rudimentary; they are in the form of small pouches. The first abdominal spiracle is uncovered as in fig. 14, and is shown on the right side (left side of figure). The three pairs of thoracic legs and the antennæ (A) are distinct, although very small. The eye (E) is extremely minute, and the mouth-parts are in a very rudimentary condition. The female moth does not emerge from the pupal shell, and is a mere sack full of eggs, bearing no traces of limbs, wings, &c. Nevertheless the pupal prothorax splits in the middle line, and some of the hairs of the included

moth project from the opening (see figure), so that the initial part of the process of emergence is still preserved in this degenerate form. The comparison between pupa and imago confirms the conclusion already arrived at, that the degeneration of female imagines of Lepidoptera is comparatively recent in date. The male pupa of this species is well developed.

- Fig. 16.  $\times 7$ . The left pupal wings of *Cynthia cardui*. The hind wing (H.W.) is seen at two points along the dorsal margin of the fore wing, which covers it elsewhere. Well within the hind margin (H.M.) of the pupal fore wing is seen a hind margin (H'.M') which corresponds to that of the imaginal wing. It is clear that the imaginal wing is only developed over a part of the space enclosed by the pupal wing. Thus the venation extends up to the future imaginal hind margin (H'.M'), and there abruptly ceases (compare fig. 18), while the arrangement of the pigment also undergoes abrupt modification at the same limits. Some traces of the alternation of black and white which is so conspicuous in the fringe of the imaginal hind margin (fig. 17) may also be detected in the disposition of the pigment along H'.M'. In this and the succeeding figures of pupal wings, the cuticle was flattened as far as possible in order to facilitate the drawing.
- Fig. 17. Natural size. The outline of the left fore wing of the imago of *Cynthia cardui*, for comparison with the last figure. The hind margin of the wing is seen closely to resemble the corresponding line upon the pupa (H'.M'), the only difference being that the bay is *slightly* deeper in the imago. A smooth continuous hind margin is far commoner than a bayed or indented margin in Lepidoptera, and is probably more ancestral. It appears therefore that, as in other structural changes of recent date, the pupa presents us with an earlier stage of the process of modification.
- Fig. 18.  $\times 7$ . The left pupal wings of *Vanessa Atalanta*. The venation is remarkably distinct, and the parts which are represented correspond precisely with that of the imaginal wing. This is all the more remarkable because the tracheæ of the pupal wing possess at first an arrangement entirely different from that which they will assume in the imago. The abrupt termination of the veins at H'.M' is extremely distinct.
- Fig. 19. Natural size. The outline of the left fore wing of the imago of *Vanessa Atalanta*, for comparison with the last figure. The position of the dark markings on the fringe is indicated by thickenings. The bay is seen to be somewhat deeper than in the corresponding pupal line (H'.M', fig. 18).
- Fig. 20.  $\times 7$ . The left pupal wings of *Vanessa Io*. In the dark varieties of this pupa the pigment is distributed along H'.M' in a manner which suggests a former fringe. The dark parts along the margin are diagrammatically indicated by thickenings, and it is seen that they correspond in number and position with the dark parts of the fringe of the imago of *V. Atalanta* and *C. cardui* (compare figs. 17 and 19). This is all the more remarkable because the imago of *V. Io* does not possess a black-and-white fringe like the other allied forms. Inasmuch as the two former are the more ancestral, as shown by their less indented hind margins, and especially by the arrangement of their markings, it is probable that the condition of the dark pupæ of *V. Io* points towards the former existence of a black-and-white fringe in the imago of this species.
- Fig. 21. Natural size. The outline of the left fore wing of the imago of *Vanessa Io*, for comparison with the last figure. The imaginal hind margin is seen to be decidedly more sharply indented than the corresponding part of the pupa (H'.M', fig. 20).
- Fig. 22.  $\times 7$ . The left pupal fore wing of *Vanessa polychlorus*. The cuticular pigment is represented as accurately as possible. The relation of the pigment and the traces of the venation to the future imaginal hind margin (H'.M') are very distinctly shown.
- Fig. 23. Natural size. The outline of the left fore wing of the imago of *Vanessa polychlorus*, for comparison with the last figure. The hind margin is seen to be *slightly* more indented than the corresponding line upon the pupa (H'.M', fig. 22).

Fig. 24.  $\times 7$ . The left pupal wings and adjacent parts on the dorsal side of *Grapta C-album*. In the previous figures of pupal and imaginal wings (figs. 16-23) the general sequence leads from species with a comparatively simple and continuous hind margin (figs. 16-19) to those with a more indented hind margin (figs. 20-23). The sequence being from more generalized to more specialized and recent types, it was found that the mark representing the imaginal hind margin on the pupal wing, when it differs from the hind margin of the imago, always varies in the direction of greater simplicity. This being the case, I was very anxious to test these results by an examination of the pupal representative of the imaginal hind margin in *Grapta*, which possesses a far more jagged and indented hind margin in the imago than any other species found in this country. The pupal line is shown at H'.M', and comparison with the corresponding part of the imago (fig. 25) shows at once that a more ancestral condition of the imago is preserved in the pupal sculpture and markings. Fig. 25 shows us a hind margin which is the culmination of specialization in this direction, while the corresponding part of the pupa is not widely different from the condition met with in the imago of *V. polychlorus* (fig. 23) or *V. Io* (fig. 21). The white areas surrounded by pigment on the metathorax and first abdominal segment correspond to two of the golden spots upon the living pupa.

Fig. 25. Natural size. The outline of the left fore wing of the imago of *Grapta C-album*, for comparison with the preceding figure.

Fig. 26.  $\times 7$ . The arrangement of the main tracheal system in the left hind wing of the pupa of *Papilio Machaon*, as seen from within (viz. corresponding to the underside of the imaginal wing). Comparison with the imaginal wing shows that, although the venation of the latter corresponds in a general way with the arrangement of the pupal tracheae, the details are widely different. The same facts hold for the fore wing of pupa and imago. We therefore see that the tracheae of the pupal wings do not by any means follow the arrangement mapped out on the pupal cuticle, an arrangement which they will afterwards assume when enclosed in the veins of the wing of the developing imago.



VIII. *The Development of the Head of the Imago of Chironomus.* By L. C. MIALL, F.R.S., F.L.S., Professor of Biology in the Yorkshire College, Leeds, and A. R. HAMMOND, F.L.S.

(Plates XXVIII.—XXXI.)

Read 17th December, 1891.

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I. INTRODUCTION.—*Sketch of the Life-History of Chironomus.*

IT will be desirable to begin by describing very briefly the life-history of *Chironomus*. The larva abounds in ditches, water-butts, and dirty streams, feeding upon decaying vegetable matter. It makes burrows of particles of earth or leaves, which it weaves together with the very abundant secretion of its salivary glands. The confined situation in which it lives and the scanty supply of oxygen to be found at the bottom of deep pools probably explain the red colour of these larvæ, which is due to hæmoglobin contained in the blood. The larva often leaves its burrow, and swims through the water with a well-known looping movement. It sometimes rises to the surface, no doubt for respiratory purposes. It is careless about finding its way back to its burrow, and in a short time glues together enough fresh fragments to conceal its body. The red larva, twisting itself into figures of eight, suggested the name of *Chironomus*, which means *harlequin*.

The body of the larva (Pl. XXVIII. fig. 1) consists of a head and twelve segments. The prothorax carries a pair of appendages, armed with numerous hooks for grappling, which are particularly useful when the larva advances or retreats within its burrow. A pair of somewhat similar appendages is carried on the last segment of the body, together with two pairs of anal processes. The last segment but one bears two pairs of respiratory tubules. The head, which is small in proportion to the body, bears a pair of short antennæ, two pairs of eye-spots, a labrum, strong toothed mandibles, a pair of maxillæ, and a labium. The lower exposed surface of the labrum is furnished with a very elaborate set of teeth, hooks, and spines, some of which are probably concerned with guiding the filaments of silk which issue from the salivary glands.

As the time of pupation approaches, the thorax becomes swollen and its segments lose their distinctness. The wings and legs of the future fly may now be seen indistinctly through the larval skin (fig. 2).

The pupa (figs. 3 & 4) is distinguished from that of most other aquatic Diptera by the tufts of respiratory filaments which project from the prothorax. It lies half buried in the mud at the bottom of the water, with the thorax and respiratory filaments projecting; these are swayed and bent to and fro by the alternate flexion and extension of the abdomen. After two or three days the tracheal system, which was rudimentary in the larva, but is now greatly enlarged and extended, becomes filled with air, secreted from the water by the help of the respiratory tufts, and the pupa floats at the surface. Some of the air passes through the spiracles and inflates the pupal skin. At length the skin of the back splits, the fly extricates its limbs and appendages, pauses for a moment upon the floating pupa-case, as if to dry its wings, and then flies away.

The fly (figs. 5 & 6) is a common object on our window-panes, and would be called a gnat by most people. It can be easily distinguished from a gnat by its habit of raising the fore legs from the ground when at rest. It is entirely harmless, and the mouth-parts can neither pierce nor suck. Like many other Diptera, the flies of *Chironomus* associate in swarms, which are believed to consist entirely of males. The male fly has large plumose antennæ, with their dilated bases almost in contact. In the female fly the antennæ are smaller and simpler, and the bases are separated by an appreciable interval.

There are many species of *Chironomus*, and they are often hard to distinguish. Much of our work has been done upon a species which has been identified as *C. dorsalis*, Meig. (*C. venustus*, Zett.). For the identification of the species we are indebted to Mr. R. H. Meade, of Bradford. *C. nigroviridis*, which is probably the species investigated by Weismann, is regarded by Van der Wulp as merely a variety of *C. dorsalis*. Our species is also that mainly employed by Meinert in his researches\*.

## II. *The Imaginal Disks of Weismann.*

All biologists are acquainted with the remarkable discoveries of Weismann † on the development of the appendages of the fly of the Muscidae. He originally maintained that the new appendages arose altogether independently of the larval cuticle and its generating epidermis (hypoderm), from structures which he called *imaginal disks*. These were described as internal ganglion-like masses of cells, each mass being enclosed within a special membrane.

A few years later Weismann added ‡ a description of a quite distinct mode of formation of the imaginal appendages in Diptera. In *Corethra*, as he then showed, the parts of the imaginal head are developed in close relation to the corresponding organs of the larva, and *Corethra* was accordingly set up by Weismann as the type of a mode of transformation distinguished from that of the Muscidae "in the sharpest manner" (*am schärfsten*) by the absence of imaginal disks.

\* 'De Eucephalo Myggelarver,' 1886.

† "Ueb. d. Entstehung d. vollendeten Insekts in der Larve u. Puppe," Abhandl. Senckenb. Ges. iv. 1862-3.

‡ "Die Metamorphose d. *Corethra plumicornis*," Zeitschr. f. wiss. Zool. Bd. xvi. 1866.

This clear division of Metabolic Insects into two groups, with names, typical examples, and definitions, was only possible when little was known of the subject. Dewitz \* showed that the imaginal disks of the Muscidae originate in deep invaginations of the epidermis, and differ rather in degree than in kind from the shallow invaginations of such insects as *Corethra*. They are, in fact, imaginal folds rather than imaginal disks, and it would be convenient so to describe them in future †. It is the purpose of this paper to describe a Dipterous type intermediate in certain respects between *Corethra* and *Musca*, and one which throws not a little light upon the origin of the extremely complex invaginations of the Muscidae. Other types might be named which are less specialized even than *Corethra*. We have to get rid altogether of the hard-and-fast lines laid down by Weismann when the subject was being explored for the first time, and endeavour to see the origin and history of those complex imaginal folds which characterize the more specialized Diptera.

### III. Description of the Larval Head of Chironomus.

We must first give a short description of the head and its appendages in the larva of *Chironomus*. The head (Pl. XXVIII. fig. 7) is relatively small and of oval figure, widest behind. The dorsal border of the occipital foramen projects backwards near the middle line, while the ventral border is cut away so as to allow of flexion upon the thorax. The middle of the dorsal surface of the head is occupied by a narrow plate—the clypeus, which tapers to a point behind, and extends to the bases of the antennæ in front. External to the clypeus are lateral tracts, which carry the eyes. There are two pairs of these eyes, which in *Chironomus* are apparently little more than pigment spots.

The labrum (fig. 8) is bent round to the ventral side of the head, so that its free border is directed backwards. This is armed with ten or more fine denticles. In the centre of the ventral surface of the labrum is a squarish space, *x*, surrounded by a thickened rim, and fringed by paired setæ and hooklets. The whole surface of the labrum is furnished with complicated organs of this kind, which are probably concerned with the operations of spinning.

The appendages of the larval head are the antennæ, the mandibles, the maxillæ, and the labium. The antennæ are short, and consist of about five joints, which diminish rapidly in size towards the tip. From the free end of the first joint proceeds a long seta. A little below the middle of the basal joint and on its inner side is a roundish space enclosed by a chitinous rim ‡. This is probably sensory, and may perhaps be a simple auditory organ. The details of the antennary joints vary according to the species examined.

\* "Beitr. z. postembryonalen Gliedmassenbildung bei den Insecten," Zeitschr. f. wiss. Zool. Bd. xxx. (Suppl.), 1878.

† This is recognized in all recent works on the subject. See, for example, the very interesting discussion of imaginal disks in Graber's 'Insekten,' or Mr. Lowne's new book on the Blow-fly (part i. 1890). One clerical error in this last (footnote to page 77) requires to be noted here. The insect described by Weismann in the memoir quoted by Mr. Lowne was not *Chironomus* but *Corethra*.

‡ Described and figured by Meinert, 'De Eucephale Myggelarver,' p. 436. pl. iii. fig. 78.

The mandibles are long, pointed, and toothed. They do not, as is the case with most mandibulate insects, work in the same plane, but in planes at right angles to each other (fig. 9), and when closed their toothed extremities meet at the centre of the serrated plate described below as the submentum. The internal margin of each mandible is fringed with long setæ.

The maxillæ are stunted processes lying just behind the mandibles. The basal piece is of irregular shape, sometimes produced internally into a setose prominence; it bears a stunted palp, which is flexible and setose.

In the labium, which represents the second pair of maxillæ, all signs of the coalescence of paired organs have disappeared. A comb-like plate (*sm*, fig. 8) is conspicuous on the ventral surface of the head, its denticles being directed forwards, so as to suggest that they oppose the teeth of the mandibles. This comb-like plate one is at first sight inclined to regard as the true labium, and this is probably Weismann's interpretation\*. But this plate is at least not the whole labium. On its dorsal surface, and wholly concealed by it, is a soft process (fig. 10) with free anterior margin. It is beset with minute chitinous plates and setæ, and with papillæ, some of which may perhaps be taste-organs. Above this, again, lies the lingua, and between the lingua and the last-mentioned soft process is the opening of the salivary duct. It would seem that in the course of development the labium, which was originally bifid †, becomes doubled upon itself. The basal joint encloses the rest of the organ, and its fore edge becomes denticulate. This basal joint, though usually named mentum, appears to correspond more closely with the submentum of orthopterous insects. The soft process referred to above may be the mentum. On each side of the submentum is a radiately striated plate or flap (*y*, fig. 8 & fig. 13).

The accompanying figures will explain many details which can hardly be made intelligible by the most lengthy verbal description.

#### IV. *Description of the Head of the Imago of Chironomus.*

The head of the fly (Pl. XXIX. fig. 14) exhibits large crescentic compound eyes, surrounding the bulbous basal joints of the antennæ, in front of which are the rostrum and mouth-organs.

The antennæ differ materially in the two sexes. In the male (Pl. XXVIII. fig. 11) each consists of twelve joints, the basal one being nearly spherical, and very large in comparison with those which succeed. The next ten joints are short, and at first sight appear to be cylindrical. These form, together with the elongate twelfth joint, the shaft of the antenna. On closer examination it is found that the shaft is really a split tube, with a double wall enclosing a central cavity (figs. 11 *a* & *b*). This striking peculiarity is a modification of the more usual cylindrical form of antenna, and is attained during pupal life by a doubling in of the wall of the organ upon itself throughout almost its whole length, as will be seen further on. The exposed surface bears the long sensory hairs, while

\* "Entwicklung der Dipteren im Ei," Zeitschr. f. wiss. Zool. xiii. 1863, p. 131, Taf. ix. fig. 45.

† Weismann, *loc. cit.* figs. 41, 42, & 43.

the surface which adjoins the enclosed cavity is beset with very minute elevations of the cuticle. A similar structure occurs in more than one species of *Chironomus*, and is found, though less marked, in the female. The basal joints of the antennæ are closely approximated in the male.

The antennæ of the female (fig. 12) scarcely reach half the length of those of the male. They consist of seven joints only. The basal joint has the same shape as in the male, but is much smaller. Each of the next five joints is enlarged in the middle. The terminal joint is elongate, but much shorter, both absolutely and relatively, than that of the male. The sensory hairs upon the five intermediate joints are comparatively few and short, and the last joint only takes the form of a split tube. The basal joints are much more widely separated than in the male.

On the vertex, and between the posterior angles of the eye, are seen a pair of minute tegumentary processes (see also Pl. XXIX. fig. 14 *c*), probably of little, if any, functional significance. We find, however, that in the pupa they are connected with the brain by a single median nerve. It may be of interest in this connection to recall a statement of Dufour\* that in *Tipula oleracea*, an insect belonging to a genus characterized by Meigen and Macquart as devoid of ocelli, he found at the posterior border of each compound eye a minute ocellary nerve terminated by a subglobular violet-coloured retina. He further found behind the insertion of each antenna a minute subhemispherical tegumentary prominence. Although failing to trace with certainty the connection between the nervous and tegumentary structures so described, he hazards the conjecture that they are really associated, and regards them as the functionless vestigiary representatives of the ocelli of other Dipterous genera.

The mouth-parts of the fly (fig. 14) are carried on a projecting process of the head (rostrum), and consist of a labrum, tongue (lingua or hypopharynx), a pair of maxillary palps, and a labium, subdivided into labellæ. All these parts are imperfectly developed, and almost or altogether functionless, except the maxillary palps.

The rostrum corresponds to the fulcrum, or basal joint of the proboscis, in the Blow-fly. Its upper surface is the part known as clypeus in Orthoptera and other insects. A transverse suture divides this from the paired epierianial plates, which carry the eyes and antennæ. The rostrum ends below in a remarkable vaulted prominence, furnished with sensory hairs—the epistome, to which the labrum is articulated.

The maxillary palps are four-jointed, the basal joint being short and the other three long. They retain in the imago the bent position in which they were developed within the larval head. The labellæ are devoid of pseudotracheæ.

At the base of the rostrum and on the dorsal surface are situated the superior orifices (*or*) of a pair of large irregular, chitinous cavities, which extend through the head (figs. 15 & 16), each opening by a second minute slit-like orifice on its lower membranous surface or gula. We are unable to give any explanation of these curious structures, but note the existence of similar tunnelled cavities in the head of certain Culicidæ, especially in *Anophiles maculipennis*.

\* "Recherches anatomiques sur les Diptères," Mémoires présentés à l'Institut de France, tom. xi. 1851, p. 178.

V. *Imaginal Folds in the Head of the Larva of Chironomus.*

In larvæ about half an inch long the epidermis of the top of the head begins to be infolded along two nearly longitudinal lines (*lf*, fig. 17, Pl. XXIX), which run forwards from the junction of the head and thorax, diverging a little as they do so. These lines correspond to the margins of the clypeus in the larval head. The epidermis, thus carried into the interior, gives rise to new cuticular organs, first to the pupal cuticle, and subsequently to the various external organs of the head of the fly. The cuticle of the head of the pupa is of less interest, and its formation need not be particularly described. The compound eye and antenna of the fly originate in these epidermic folds, and are therefore developed at a distance from the larval cuticle, though they are from the first external in their morphological position. The outer wall, the bottom, and ultimately the inner wall of each invagination (Pl. XXIX. figs. 19, 20, 21, & 22, and Pl. XXX. figs. 24 & 25) develop facets, and thus give rise to the compound eye of the fly. In the larva this compound eye looks into the cavity of the invagination, and its concavity as well as its deeply sunk position contrast strongly with the convexity and exposed position of the imaginal eye. The imaginal antenna originates as a secondary duplication of the invagination around the antennal nerve of the larva, which duplication in all stages of growth is continued up to the larval antenna.

In larvæ which are not far from pupation the folds are no longer confined to the region of the head. They extend backwards into the prothorax, and the part which forms the compound eyes comes to lie wholly behind the larval head. This backward extension is not brought about by any infolding of the epidermis of the dorsal surface of the prothorax, for the folds, though they lie deep in the prothorax, belong to the larval head exclusively. Weismann has shown that in *Corethra* the integument of the head of the fly is formed from the epidermis of the larval head, and the same thing is true of *Chironomus*, though here the cephalic invaginations are deeper and more complicated. Their backward prolongation is rendered possible by a transverse fold (*tf*, *tf'*, Pl. XXIX. fig. 17, Pl. XXX. fig. 24, &c.) which runs back from the junction of the larval head and prothorax, and is overarched by the uninterrupted epidermis of the latter. But for this transverse fold, the longitudinal folds could not have extended into the prothorax without implicating the prothoracic epidermis. The transverse fold is derived from the epidermis at the junction of the head with the thorax, and forms a sort of pocket, crescentic in transverse section (Pl. XXIX. fig. 19, *tf*) and tapering behind (fig. 17, *tf'*). The enclosed space is very inconsiderable, and appears in section like a thin slit. The prothoracic prolongations of the longitudinal folds, which give rise to the compound eyes and antennæ of the fly, open into the floor of the transverse fold (fig. 19).

As the longitudinal folds gradually deepen, the growing antennæ of the fly, still enclosed within the pupal skin, grow with it. Their basal parts recede further and further into the thorax, remaining all the time attached to the wall of the longitudinal invaginations already formed (figs. 21 & 22). The tip of the imaginal antenna is never withdrawn from the short larval antenna, which it is destined to replace. If we suppose

a cloth to be spread out between two rails, then a hand grasping the cloth at one place may be made to push downwards and backwards until both hand and arm become buried in a deep fold. The fist will correspond to the bulb of the antenna, the arm to its shaft, and the fold in the cloth to the longitudinal invagination. This rude model will also show how it becomes necessary to introduce a transverse fold, if the longitudinal fold is to extend beneath an undisturbed surface of cloth or epidermis. In all stages of larval growth the imaginal antenna\* encloses the larval antennary nerve, the invagination being, in fact, formed about the nerve, but in the pupa this nerve becomes no longer traceable and new structures appear to take its place.

The proportions of the male and female head differ materially in the adult fly. In the male the antennary bulbs are larger and closer together than in the female. This difference is already apparent in the antennary invaginations of the larva (Pl. XXIX. figs. 21 & 22). We have found it possible to determine with certainty the sex of living larvæ by observation of the form of the incipient generative organs. Having marked several specimens as male or female, we have cut sections through the growing heads of the larvæ so marked. In the female the invaginations are wider apart, and the antennary bulb projects from the *inner* wall into the interior of the invagination. In the male the invaginations are so close that they almost or actually touch behind, and the antennary bulbs are at first connected with their *posterior* extremities. As the development of the imaginal head advances, the antennary bulb, even in the male, becomes to a great extent internal (*i. e.* facing the middle line) rather than posterior (Pl. XXX. fig. 25). In this stage it may be distinguished from that of the female by its larger size, and by its extending backward up to, and even a little beyond, the hindermost extremity of the compound eye, which it never does in the female.

In the compound eye of *Chironomus* before pupation the epidermic cells of the so-called vitreous layer are often much elongated and resemble fibres. They retain their power of forming cuticle to a late stage, ultimately producing lenses which are not biconvex, but hollow, convex externally and concave internally. The retinal cells are pigmented and form retinulae of seven cells each. No crystalline cones are formed, and the eye of the fly is therefore *aconic*.

Simultaneously with the formation of the compound eyes and the imaginal antennæ, new mouth-parts are developed. As in *Corethra*, they develop within those of the larva. On either side of the salivary ducts and their common opening into the mouth, the epidermis of the larval head becomes infolded, and the pouches ultimately extend backwards to the back of the head (fig. 26). From the inner side of each pouch, and close to its hinder extremity, a secondary invagination pushes forwards and downwards, and this ultimately gives rise to the labella † of the fly. In larvæ ready to change into pupæ the tips of the labellæ are bent inwards, towards each other, at a right angle. The invagination for the maxillary palp forms on the side of the larval head. The mouth of the primary fold is at first nearly equidistant from the larval maxilla and the

\* We do not at present distinguish between the imaginal and the pupal antenna.

† See Meinert, 'Fluernes Munddele,' 1881, or Dimmock, 'Anat. of Mouth-parts of Diptera,' 1881. In Orthopterous insects what is apparently the same part is named *paraglossa*.

occiput. The secondary forward-directed fold is long and narrow, and extends from the back of the head into the larval maxilla. As it lengthens it becomes coiled, and much resembles one of the developing imaginal legs (fig. 27). The new parts thus formed are those of the pupa, and the imaginal rudiments are enclosed within them. The pupal integument of the head, like that of some other parts of the body, recedes considerably from the larval cuticle, and the imaginal integument recedes again from that of the pupa, so that in sections of the pupal head a tolerably wide space separates the mouth-parts of the fly from the empty cuticle which represents the corresponding organs of the pupa.

The history of the invaginations which give rise to the head of the fly can be followed in a series of larvæ of different ages. They are not to be discovered even in a rudimentary state until after the last larval moult\*. Weismann† has given reasons for supposing that invaginated imaginal rudiments could not come into existence before the last larval moult in an insect whose life-history resembles that of *Corethra* or *Chironomus*. If the epidermis were invaginated in any stage before the ante-pupal one, the new cuticle, moulded closely upon the epidermis, would become invaginated also, and would appear at the next moult with projecting appendages like those of a pupa or imago. This is actually the way in which the wings are developed in some larval insects with incomplete metamorphosis. In *Museidæ* the invaginations for the head of the imago have been traced back to the embryo within the egg‡, but the almost total subsequent separation of the disks from the epidermis renders their development independent of the growth of the larval cuticle and of the moults that probably take place therein§.

Very soon after the last larval moult, when the *Chironomus* larva is about half an inch long, the first indications of the invaginations can be discovered by means of sections. They form rapidly, and among larvæ quite similar in size and outward appearance some are found to exhibit tolerably advanced invaginations, while others do not possess even the rudiments of such structures. Fig. 23, Pl. XXIX., represents a moderately early stage. Here the invaginations are restricted to the larval head, and form comparatively simple paired folds of the dorsal epidermis. Behind and on the ventral side is a short extension (*Y''*), which will subsequently give rise to the compound eye and the antennary bulb. As the invaginations do not as yet extend into the thorax, the transverse fold described above is wholly wanting. In this early condition the invaginations of *Chironomus* are essentially similar to those of *Corethra* at the time of their fullest development.

The prolongation of the cephalic invaginations into the thorax gradually advances as

\* There are probably four larval moults in *Chironomus*, as in *Corethra*, but the burrowing habits of the insect render it difficult to be quite certain of the exact number.

† "Metamorph. der *Corethra*," loc. cit. p. 115.

‡ Lowne on the Blow-fly, new edition, pp. 2, 41 (fig. 7).

§ Leuckart and Weismann have inferred the occurrence of at least two moults in the larva of the Blow-fly, from the changes observed in the stigmata and the hooks. Weismann suspects that as many as four moults may take place (*Entw. der Dipteren*, p. 104).

the larva is nearing the time of pupation. The formation of the transverse fold already described is a necessary consequence. This fold may be regarded as an exaggeration of the slight fold which in so many insects forms in the new cuticle and epidermis at the junction of the head and thorax, as well as between other segments of the body shortly before a moult. While the backward extension of the invaginations is taking place considerable histological differentiation is in progress, and some change takes place in the form of the future sense-organs. The compound eye forms at first a vertical layer, not far from flat, occupying the outer wall of the invagination (fig. 19). Later on, the facets extend round the much bent floor of the cavity, and reach to a certain height upon the inner wall (Pl. XXX. figs. 24, 25, & 28). This change appears to be due to a modification of the shape of the invagination rather than to a development of new facets, for in late stages there is a marked change of shape in transverse sections of the invaginations (compare Pl. XXIX. figs. 18, 19, & 20, with Pl. XXX. fig. 28, and Pl. XXXI. figs. 31 & 32). The antenna also undergoes, especially in the male, a considerable change of form. At first the bulb is posterior (Pl. XXIX. fig. 22) and the shaft takes a nearly straight course to the larval antenna, within which its tip is included; subsequently the bulb becomes internal, and the shaft is arched upwards in a bend of gradually increasing sharpness (Pl. XXX. fig. 25).

#### VI. *The Process of Pupation in Chironomus.*

Larvæ about to undergo pupation can be easily distinguished by the thickened thorax. If a number of such larvæ are observed continuously for a few hours, the process of pupation can be studied without serious difficulty. The first distinct sign of change is the retraction of the epidermis and soft parts from the old cuticle of the prothoracic feet. Very shortly after this (about a minute) the same process takes place in the anal papillæ, the respiratory tubules, and (a little later) in the anal feet. After a further interval of a few seconds, or at most a minute or two, the head and prothorax of the pupa protrude from the dorsal surface, between the larval head and prothorax. The larval head, which has been suddenly emptied by the retraction of its contents, then slips round to the ventral surface. The exact order of these events is not quite constant. Now and then the anal feet and other posterior appendages are seen to be unchanged in a larva which has already slipped off the larval head, but this is unusual. It is probable that the contraction of the prothoracic and anal regions sets up a blood-pressure, which is the immediate agent in the protrusion of the head. An independent indication of the existence of such blood-pressure at the time of pupation is given by the occasional escape of a large quantity of blood, which fills the space between the old cuticle and the retracted epidermis. In such cases we have found that the pupa dies within a short time. The complete removal of the larval cuticle from the body is a matter of time, and may occupy several hours. The old cuticle becomes much wrinkled, and is ultimately torn into shreds, being gradually rubbed off by the almost incessant movements of the pupa.

Sections taken through the pupal head a little after the time of change illustrate the eversion of the imaginal head. The compound eyes, which were deeply invaginated,

become bit by bit convex, not by any gradual widening of the fold, but by a steady extension of the convex surface at the expense of the concave fold (Pl. XXXI. fig. 33). The process is hard to describe, but may be closely imitated by cutting a hollow india-rubber ball into halves, and everting one of the hemispheres with the fingers. During the process of eversion the compound eyes are drawn downwards and backwards, so that they get behind and beneath the bases of the antennæ (Pl. XXX. fig. 29). The morphologically external surface of the eyes, which was previously turned towards the lumen of the invagination, now looks outwards (Pl. XXXI. fig. 33); the optic nerve, which was distributed to the (temporarily) convex and outer surface of the eye, still takes its course to the same surface, now become concave and internal; and the walls of the head now for the first time enclose the brain. The inner walls of the paired invaginations, which were very long and enclosed a narrow median space or sinus (*s'*, Pl. XXIX. figs. 18-22), contract more and more, and give rise to the central parts of the head of the fly.

Sections taken through the pupal antenna indicate the change resulting in the formation of the split in that organ to which reference has been made (page 268). The portion of the wall destined to form the hollow of the shaft projects in a marked manner, and is much more delicate than the remaining portion (see Pl. XXX. fig. 30).

The muscles of the larval head, as well as of some other parts of the body which become completely transformed, disappear by a process which leaves behind a number of more or less empty sheaths. This process reminds us strongly of the histiolysis which takes place in Muscidæ, as well as in many other animals. We have not, however, in spite of many efforts, arrived at such proofs of histiolysis as can readily be obtained in Muscidæ. We have never, for example, seen unmistakable sarcoytes within the supposed phagocytes, and cannot therefore appeal to any of our preparations as furnishing a demonstration of the process of histiolysis in *Chironomus*, which is on general grounds highly probable.

#### VII. *Comparison of Chironomus with some other Insects.*

In the larva of *Culex*, as we find from Dr. C. H. Hurst's partly unpublished descriptions and preparations, there are no deep invaginations for the compound eyes or antennæ of the imago. The compound eye forms beneath the larval eye-spots, and is at first relatively simple and of few facets. The number increases by the gradual formation of partial and marginal invaginations, each of which forms a new element. The imaginal antenna grows to a much greater length than that of the larval antenna, and its base is accordingly telescoped into the head while the shaft becomes irregularly folded\*. *Culex*, though more modified than *Chironomus* in many respects, *e. g.* in the mouth-parts, is relatively primitive with respect to the formation of the imaginal head, and shows a mode of development of the eye and antenna which we may suppose to have characterized a remote and comparatively unspecialized progenitor of *Chironomus*.

\* "The Pupal Stage of *Culex*" (Studies from Biol. Lab. Owens Coll. vol. ii. 1890). See also Manch. Micr. Soc. 1890.

In *Corethra*, as Weismann has shown, the compound eye develops in immediate proximity to the larval eye, but the imaginal antenna forms by an invagination, reaching far back into the larval head.

In order of complexity of the invaginations which give rise to the head of the imago we should arrange the Dipterous types already mentioned as follows:—

1. *Culex*. Relatively simple. Invaginations shallow.
2. *Corethra*, *Simulium*.
3. *Chironomus*, *Ceratopogon*. } Intermediate.
4. *Muscidæ*. Relatively complex. Invaginations deep, and apparently, but not really, unconnected with the epidermis.

The development of the head of the fly of *Chironomus* appears therefore to furnish a useful middle term between the *Adiscota* and the *Discota* of Weismann: that is, between the types in which the parts of the head of the fly are developed in close relation to those of the larva, and the types in which deep invaginations lead apparently to the formation of similar new parts far within the body, the seeming independence of the new parts being intensified by thorough-going histiolysis. Other Dipterous types intermediate between *Corethra* and *Chironomus*, or even simpler than *Corethra*, yet require description, and possibly types may be discovered intermediate between *Chironomus* and *Muscidæ*. It will also appear, when the subject is fully gone into, that insects of other orders, *e. g.* Lepidoptera, present good examples of the origin of imaginal organs by foldings-in of the larval epidermis\*.

Mr. Poulton † has pointed out that it is entirely erroneous to speak and think of the various parts of the Lepidopterous pupa as mere cases for the corresponding parts of the imago. "If we examine a section of a pupal antenna or leg (in Lepidoptera) we shall find that there is no trace of the corresponding imaginal organ until shortly before the emergence of the imago. In the numerous species with a long pupal period the formation of imaginal appendages within those of the pupa is deferred until very late, and then takes place rapidly in the lapse of a few weeks. This also strengthens the conclusion that such pupal appendages are not mere cases for the parts of the imago, inasmuch as these latter are only contained within them for a very small proportion of the whole pupal period."

It would appear from this passage and from what we have seen of the development of the imago of *Chironomus* that there is a strong superficial contrast, as to the formation of the imaginal organs, between Lepidoptera and Tipularian Diptera. *Chironomus* and *Corethra* exhibit an early and protracted metamorphosis, which extends through the last larval stage, as well as the relatively short pupal stage. Before the larval skin is shed the compound eyes, the antennæ, the wings, the legs, and reproductive organs, both external and internal, are far advanced, and though not complete in all points (the corneal facets,

\* J. Dewitz has shortly described (Biol. Centralblatt, Bd. iii. 1883-84) the formation of the imaginal antenna of *Pieris Brassica* by a process essentially the same as that described in *Chironomus*, though far simpler.

† "External Morphology of the Lepidopterous Pupa," Trans. Linn. Soc., 2nd ser. Zool. vol. v. p. 188 (1890).

for example, are not yet formed) they are substantially those of the imago, the museles and other internal tissues being already differentiated, and in some cases highly specialized. With the exception of the prothoracic respiratory appendages and the tail-fin, there is little in the pupa of *Chironomus* which does not relate to the next stage.

The ancestral history of the pupa is so completely disguised by adaptive peculiarities, that in this insect it is reduced to little more than a transitional form, effecting the difficult passage from a wholly aquatic to a wholly aerial mode of existence. At the same time there is no reason to doubt the morphological equivalence of the Tipularian and other insect pupæ. All of them represent a stage comprised between two moults, which has become subordinated in various degrees to the succeeding imaginal stage. Their morphological correspondence is as well marked and as interesting as their adaptive differences.

#### VIII. Conclusion.

The most striking feature of the development of the fly of *Chironomus* is the formation of paired invaginations extending far into the thorax, and giving rise to a great part of the imaginal head. *Chironomus* furnishes, not the most complex, but the most intelligible case of equally extensive invaginations hitherto described. When we inquire, as we cannot help doing, why such invaginations exist at all, the obvious facts suggest themselves that the head of the fly is utterly unlike the larval head in shape and that it is of larger size. The lengths are as 12 (male fly) to 11 (larva); the breadths as 5 (male fly) to 3 (larva). As a mere matter of dimensions, such a head as that of the male fly of *Chironomus* could not be developed within the larval head. This explanation at once provokes a further question: Why should any such disproportion exist between the head of the fly and that of the larva? We may say in reply that the fly is a nimble aerial insect, requiring keen senses and some degree of intelligence that it may escape danger, find a mate, and lay its eggs in a suitable position. The larva, on the contrary, is an animal of very simple mode of life, feeding upon dead vegetable matter at the bottom of dark and slow streams. The abundance of its food, and the ease with which it can be appropriated, have led in this, as in many other cases, to some degree of degeneration, which is particularly apparent in the larval limbs and head.

We should be glad to be in a position to show in what way and to what extent the invaginations of *Chironomus* lead up to those of the Muscidae. But this is at present hardly feasible. We look forward to a time when a well connected series of thoroughly investigated Dipterous types can be arranged so as to lead up to and explain the formation of the fly in the Muscidae, and the hope of contributing to such a result has been a principal motive of the present study.

## EXPLANATION OF THE PLATES.

## PLATE XXVIII.

- Fig. 1. Half-grown larva. The numerals indicate the numbers of the body-segments. *p.app*, prothoracic, and *a.app*, anal appendages; *r.t*, respiratory tubules; *a.p*, anal processes.  $\times 10$ .
- Fig. 2. Full-grown larva. Letters and numerals as before. *r.f*, respiratory filaments of the pupa; *l*, leg of fly; *w*, wing. All seen through the transparent cuticle.  $\times 10$ .
- Fig. 3. Male pupa, front view. *r.f*, respiratory filaments.  $\times 10$ .
- Fig. 4. Ditto, in profile. *ant'*, antenna; *v.p*, processes on vertex.  $\times 10$ .
- Fig. 5. Male fly.  $\times 10$ .
- Fig. 6. Female fly.  $\times 10$ .
- Fig. 7. Head of larva. *cly*, clypeus, the diverging margins of which are strongly marked, inasmuch as they indicate the course of the longitudinal invaginations or folds which lie beneath them; *lr*, labrum; *ant*, antenna; *md*, mandible; *o*, eye-spots.  $\times 70$ .
- Fig. 8. Ventral surface of ditto. *m.x.p*, maxillary palp; *x*, square marking on ventral surface of labrum; *sm*, submentum; *y*, striated flap flanking the submentum.  $\times 70$ .
- Fig. 9. Front or anterior view of ditto, showing the position of the mandibles at right angles to each other; letters as before.  $\times 90$ .
- Fig. 10. The mentum.  $\times 300$ .
- Fig. 11. Antenna of male fly:  $\times 30$ . 11 *a*. Portion of the shaft:  $\times 150$ . 11 *b*. Diagrammatic section of the same:  $\times 150$ .
- Fig. 12. Antenna of female fly.  $\times 30$ .
- Fig. 13. One of the striated plates flanking the submentum.  $\times 300$ . (For convenience of arrangement this has been placed in a vertical position.)

## PLATE XXIX.

- Fig. 14. Head of the male fly. The antennæ are removed with the exception of the bulbous basal joints *b*, in the centre of each of which is a hollow with radiate markings whence the shaft has been taken out. *v.p*, processes on the vertex; *s*, transverse suture; *or*, orifice of chitinous cephalic cavity; *e*, epistome; *lr*, labrum; *l*, labella; *m.x.p*, maxillary palp.  $\times 60$ . 14 *a*. Extremity of labrum:  $\times 300$ . 14 *b*. Extremity of lingua:  $\times 300$ . 14 *c*. One of the processes on the vertex:  $\times 300$ .
- Fig. 15. Section showing one of the chitinous cephalic cavities, *c.c*. *e*, epistome; *l*, labella; *b*, bulb of antenna.  $\times 100$ .
- Fig. 16. Dissection showing the cephalic cavities, *c.c*, in front view, attached behind the epistome.  $\times 90$ . 16 *a*. Posterior extremity of one of the cavities showing the slit-like opening.  $\times 90$ .
- Fig. 17. Diagram showing the newly forming epidermis within the head and thorax of a larva in the last period of larval life, as it would be revealed by the removal of the cuticle which is still indicated in outline at *l.c*. Below the orifice, *t.f*, of the transverse fold, the external epidermis of the prothorax has been further removed, revealing the upper wall, *t.f'*, of the fold (compare *t.f'*, figs. 19, 20, 24, & 25), the cut margin of the removed epidermis being indicated by the jagged line *m*; the nerve-centres and the œsophagus are also seen. *l.c*, larval cuticle; *ant*, larval antenna; *a.n*, nerve of the antenna, around which the imaginal antenna is in course of formation; *l.f*, longitudinal folds; *ep*, surface of the exposed epidermis; *t.f*, orifice or cavity of transverse fold; *t.f'*, its upper wall exposed; *m*, cut margin of epidermis; *o*, extremities of the longitudinal folds seen beneath the

transverse fold and showing the optic elements in course of formation; *o.n.*, optic nerve distributed to the convex surface of the eye, which surface afterwards becomes the concave inner surface; *a.n'*, root of antennary nerve; *br.*, brain; *æ.s.*, œsophagus; *d.v.*, dorsal vessel.  $\times 50$ . The letters *sec*, *sec'*, *sec''*, indicate the levels of the transverse sections shown in figures 18, 19, and 20 respectively. The lettering used in this figure will be repeated in those following.

- Fig. 18. Early condition of the invaginations. Transverse section at the junction of the head and thorax (*sec*, fig. 17). The longitudinal folds, *l.f.*, only, are cut through. *ant'*, first trace of the imaginal antenna.  $\times 50$ .
- Fig. 19. Early condition of the invaginations. Transverse section through the broad part of the transverse fold (*sec'*, fig. 17). The cavity, *t.f.*, of the fold appears as a thin crescentic slit, and the prolongations of the longitudinal folds are seen opening into its floor. The eyes, *o.*, are seen on the outer walls of the longitudinal folds. *s'*, median space or sinus.  $\times 50$ . The great thickness of the larval cuticle is partly due to the oblique passage of the section through it caused by the convergence of the body-walls toward the head.
- Fig. 20. Early condition of the invaginations. Transverse section through the narrow posterior part of the transverse fold (*sec''* fig. 17).  $\times 50$ .
- Fig. 21. Horizontal section through the head and thorax of a female larva, showing the formation of the eyes and antenna within the longitudinal folds. The bulb of each antenna, *bb*, is seen in two parts projecting into the cavity of the lateral fold from its inner wall. The parts lightly shaded in this drawing and marked *s*, *s'*, *s* represent body-cavity of the insect, the invaginations being left white. The central one, *s'*, is the median sinus referred to on p. 274; it contains muscles connected with the labrum and the œsophagus, into it also project the frontal ganglion and the termination of the dorsal vessel. The lateral ones contain the great muscles of the mandibles, &c. The remaining letters as before.  $\times 50$ .
- Fig. 22. Horizontal section through the head and thorax of a male larva. Condition tolerably advanced but not ready for pupation. The antennary bulbs are as yet posterior (p. 271).  $\times 50$ .
- Fig. 23. Earliest observed condition of the invaginations. Internal view as exposed by a median vertical section. Only the longitudinal fold, *l.f'*, is as yet present, the short extension of which, *l.f''*, is referred to on p. 272.  $\times 50$ .

#### PLATE XXX.

- Fig. 24. Female larva. Diagram showing the newly forming parts in a somewhat advanced condition as laid open by a median vertical section. The inner wall, *l.f'*, of the longitudinal fold is seen, and in its backward prolongation beneath the transverse fold, *t.f.*, a large orifice is represented as having been made exposing its cavity, *l.f.*, and the passage through it of the newly forming antenna, the further course of which can be traced beneath the wall of the fold. The pigmented facets of the eye are indicated on both the inner and outer wall of the fold, more especially on the latter, which is seen through the opening. *ant'*, imaginal antenna; *b.*, its bulb; *f.g.*, frontal ganglion; *d.v'*, dilated extremity of dorsal vessel; *s.g.*, subœsophageal ganglion. The other letters as before.  $\times 70$ . Note that the faceted inner wall of the longitudinal fold is continuous with the antennary bulb.
- Fig. 25. Male larva. Same view as in the preceding figure. The bulb of the antenna is much larger and projects towards the eye and towards the middle line of the head from the surface of the longitudinal fold, instead of being sunk within it as in the female. The course of the shaft has become arched upwards as described on p. 273.  $\times 70$ .

Fig. 26. Labial fold or invagination.  $\times 70$ .

Fig. 27. Maxillary ditto.  $\times 70$ .

Fig. 28. Transverse section through the prothorax of a male larva in an advanced condition, passing through the eyes and in front of the antennary bulbs. The longitudinal folds, *l.f.*, have lost their original form as illustrated in figs. 18–20, and have become more complicated. Lettering as on fig. 17, &c., with the following additions:—*s'*, central blood-sinus; *p.s.*, pupa-skin surrounding the shaft of the antenna, but separated therefrom by a considerable interspace; *s.d.*, salivary ducts.  $\times 90$ .

Fig. 29. Horizontal section through the eyes and antennary bulbs in a larva about to pupate, illustrating a stage in the process of eversion as described on p. 274. The small folds, *l.f.*, represent the originally deep longitudinal invaginations. The eyes are drawn back behind the antennary bulbs within, which certain newly forming nervous structures are now conspicuous. *l.c.*, larval cuticle of the prothorax.  $\times 120$ .

Fig. 30. Transverse section of the male pupal antenna showing the imaginal antenna surrounded by the pupa-skin. The part marked *x* is that which becomes invaginated to form the slit. *h*, sensory hairs.  $\times 120$ .

#### PLATE XXXI.

Fig. 31. Transverse section through the prothorax of a male larva in an advanced condition, passing through the antennary bulbs and the ascending curvature of the shaft. The antennary nerve, *a.n.*, of the larva is seen passing through the bulb and into the shaft, but there is reason to think that it subsequently to a great extent disappears and is replaced by new nervous structures within the bulb. *r.f.*, respiratory filaments of the pupa. Other letters as before.  $\times 90$ . This figure should follow fig. 28 in proper sequence, but it has been separated for convenience of arrangement.

Fig. 32. Transverse section through the posterior portions of the bulbs. Lettering as before: *r.p.* are probably the minute processes on the head of the pupa seen in figs. 3 & 4, covering those of the fly alluded to on p. 269.  $\times 90$ .

Fig. 33. Transverse section through the head of a recently emerged female pupa, showing the last traces of the folds, *l.f.*, and the facets of the eye beginning to extend themselves around the convex surface of the head.  $\times 90$ .



- IX. *On the Variations in the Internal Anatomy of the Gamasinæ, especially in that of the Genital Organs, and on their Mode of Coition.* By A. D. MICHAEL, F.L.S., F.Z.S., F.R.M.S.

(Plates XXXII.–XXXV.)

Read 3rd March, 1892.

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INTRODUCTORY OBSERVATIONS.

THIS paper records the results of a series of investigations extending over the whole of the years 1890 and 1891 and the early part of the year 1892. They have been conducted partly in London, through the kindness of friends, from whom I have received frequent supplies of fresh material from which I could obtain living specimens of the various species I was studying; partly at the Land's End, Cornwall, during an autumnal stay there; partly near Ragaz, in Switzerland, during the summer of 1890; and partly near Innsbruck, in Tyrol, during the summer of 1891. In the two last-named localities I had the advantage of conducting the work jointly with my cousin, Mr. M. J. Michael, who has cut the very numerous serial sections which have formed one of the methods of investigation; he also drew fig. 68. In Tyrol I also had the assistance of Mr. E. Bostock, of Stone, in collecting specimens. I beg to tender my thanks to both those gentlemen.

This paper is not intended as a general treatise upon the anatomy of the Gamasinæ; it is confined, as strictly as may be, to those parts which I believe to be new or to vary from existing records—previously-known organs, which do not vary, being only so far referred to as seems to me desirable in order that the new matter may be clearly under-

stood. The same remarks apply to the Plates; for although many organs are necessarily drawn, particularly in the sections, as to which I have little or nothing new to say, yet it is only in order to show their relation, or position relatively, to those which are new or which do vary from known forms. It will, I hope, be found that there is not any drawing which does not contain something not hitherto known or figured.

The Gamasinæ are the typical subfamily of the Gamasidæ, the other subfamilies being the Uropodinæ, the Dermanyssinæ, and the Pteroptinæ; the two latter subfamilies are wholly parasitic, and their anatomy, so far as it is at present known, is, as might be expected, not so highly developed as that of the other two subfamilies. The Uropodinæ differ considerably in internal organization from the greater part of the Gamasinæ, and their internal anatomy has been dealt with by myself and others, as mentioned below.

Mégnin has claimed that the Gamasinæ are the most highly organized of all the Acarina; and although they are devoid of eyes, which are possessed by several other families, the great development of the so-called brain—*i. e.* the circumoesophageal ganglion, for such it is, all commissures being lost in one mass—the elaboration of the trophi and muscular system, the existence of a heart or dorsal vessel, &c. probably entitle them to that position. They are mostly very active creatures, having fully chitinized dorsal shields and legs, and a ventral surface either entirely or partially covered by chitinized plates, the arrangement and form of which is often characteristic of species or of genera.

It used to be supposed that the Gamasinæ fed upon vegetable matter in process of decay. In the year 1880, however, when investigating the life-histories of some of the species for the purposes of a paper in the 'Journal' of this Society, I found, as there stated, that they would not live in my cells on vegetable matter, but that they thrive admirably on a diet of live cheese-mites (Tyroglyphidæ), and since then I have had frequent opportunities of observing the predatory nature of many of the species. I believe also that Col. Blathwayt, of Bath, who had also been unsuccessful in rearing Gamasinæ upon a vegetable diet, has been perfectly successful over a considerable period since he has adopted the mode of feeding suggested in that paper; he also uses small insects\*. Some of the species apparently feed upon small dead insects and other creatures.

A general idea exists that the Gamasinæ are parasitic. This, however, is not by any means universally the case; the greater number of species are free-living, and not parasitic in any stage; some are parasitic in immature stages, but not in the adult. The adult male is very rarely parasitic, and where parasitism exists, even in the young, it is often very doubtful whether they require anything from their hosts beyond conveyance.

The presence of some amount of moisture in the atmosphere and surroundings is essential to the existence of most, if not all, of the species.

#### BIBLIOGRAPHY.

The anatomy of the Gamasinæ is not by any means a new subject. The memoirs regarding it are few, but some of them are very good.

\* "On some common Species of Gamasidæ," *Journal of Microsc. and Nat. Sci.* n. s. vol. ii. (1889) p. 102.

First in order of date must be mentioned the paper by M. Mégnin, of Versailles, in which he expresses the opinion before referred to\*. This contains a careful description of the external anatomy and trophi of some of the species of *Gamasus* and *Uropoda*, particularly the latter. The paper also deals, to some extent, with the internal anatomy, but in a far more general and slighter manner, and this portion of the description is far from being entirely correct, particularly that portion which refers to the genital organs—*e. g.*, he attributes to the male the possession of a penis, which does not exist—and the description of the female reproductive organs is still slighter than that of the male; while the information given as to the time and mode of coition was, as will be seen in this paper, entirely incorrect; still M. Mégnin's paper was the beginning of our knowledge of the anatomy of the group, and a large part of the external anatomy especially still stands as quite correct and as the best existing description.

Almost at the same time as M. Mégnin's memoir, Dr. P. Kramer, then of Schleusingen, now of Halle, published a paper on the Gamasidæ †. This paper contains, *inter alia*, considerable information as to the internal organs; chiefly, however, such as might be obtained by a careful study of more or less transparent specimens without actual dissections or sections. The drawings of the internal anatomy are few, and are chiefly confined to outlines of general form, some of which scarcely correspond with anything yet known to me; but the variety of internal organization in the Gamasidæ, and, indeed, in the Acarina generally, is so considerable in different species that I should be sorry to say that they may not be correct. It is in this paper that the existence of a heart in the Gamasidæ was first made known.

In a subsequent paper (1882)‡, which is chiefly devoted to the Uropodinæ, Dr. Kramer gave considerable information as to the various chitinized plates of the external skeleton of the Gamasidæ, but did not add to the then existing knowledge of the internal anatomy.

In a still later memoir § upon *Halarachne Halichæri*, a remarkable parasite belonging to the Gamasinæ, found originally by Prof. Allman in the nares of the Seal ||, the same author carried the knowledge of the internal organization much further; he described and figured the curious tendinous platform in the middle of the body (episternite), which is suspended from the dorsum by muscular bands, and which forms a kind of inner skeleton, whence arise the powerful muscles that move the legs, &c. He also treats correctly of many other matters, which, although described only for the particular species, prove to be of much wider range.

In the following year (1886) Herr Willibald Winkler, with the assistance of Prof.

\* "Mémoire sur l'organisation et la distribution zoologique des Acariens de la famille des Gamasidés," Robin's Journ. de l'Anat. et de la Physiol., May 1876, pp. 298-366.

† "Zur Naturgeschichte einiger Gattungen aus der Familie der Gamasiden," Archiv für Naturg. 1876, Bd. i. pp. 46-105.

‡ "Ueber Gamasiden," Archiv für Naturg. 1882, Bd. i. pp. 375-434.

§ "Ueber *Halarachne Halichæri*, Allm.," Zeitsch. für Naturwiss. Bd. lviii. (1885).

|| "Description of a new Genus and Species of Tracheary Arachnidans," Ann. & Mag. Nat. Hist. 1847, vol. xx. pp. 47-52.

Claus, not knowing of Dr. Kramer's paper, independently discovered the existence of the heart in Gamasidæ, and published the result of these investigations in a short but excellent paper \*, in which the heart and its accessory organs were described far more exactly than Kramer had done, and which was illustrated by a very good plate, where the surrounding organs, &c., were also shown.

It was possibly his studies for this purpose that drew Winkler's attention to the group; at any rate, in 1888 the first paper was followed by a much more important treatise †. This admirable and beautifully illustrated paper is incomparably superior to anything else which we have upon the internal anatomy of the Gamasinæ; indeed, it may practically be said to comprise all that is, up to the present, recorded on the subject, and it is most clearly explained and carefully figured. The principal types which he takes are what he calls *Gamasus crassipes*, Linn., and *Uropoda scutata*, Koch (?); he, however, less fully refers to and figures *G. fucorum*, De Geer, a nymph of *Pæcilochirus carabi*, Canestrini, and *Hyoaspis nemorensis*, Koch. He also states that he has examined specimens of the genera *Holotaspis*, Kol., *Sejus*, Koch, and *Epicrius*, Can. Still I think the principal stress of the paper must be considered to be laid upon the species called *Gamasus crassipes*. As to this, I have been enabled to follow him, and have frequently dissected this creature, and as a result I wish to express my admiration for the excellence and accuracy of Winkler's work and the beauty of his drawings. I have not myself dissected the other species which he names except *Gamasus fucorum*, and in three genera he does not name the species, so that I cannot say anything about the matter; but I have not any reason to doubt his being as correct with regard to them as with regard to his *Gamasus crassipes*.

It will be observed that I say above, "what he calls *Gamasus crassipes*." I use this expression because it seems to me that the species is not the *Gamasus crassipes* of Linnæus. This is really quite immaterial, and Winkler does not claim to be a specialist in the identification of species of Gamasidæ. I only mention it to avoid confusion in case anybody should at some future time dissect the true species and not find it quite agree with Winkler's description.

When I say that it is not the *Gamasus crassipes* of Linnæus, it must be explained that Linnæus's own description would not enable anyone to identify the species or even the family; it would be equally applicable to a very large number of creatures widely different from each other. Schrank's description in 1781, might enable the student to identify the family, but nothing more. In 1804 Hermann published a description with figures ‡, which are good. This must really be looked on as the first definition of the species; it certainly is not the *Gamasus crassipes* of Winkler.

With regard to the Uropodinæ, I cannot say that I can confirm Winkler's views quite as exactly as I do respecting *G. crassipes*; the larger part of what he says is undoubtedly correct of the species to which he refers, and which again I think is not the *Uropoda*

\* "Das Herz der Acariden," Arbeit. d. Zool. Inst. zu Wien, T. vii. (1886) Heft 1, pp. 111-118.

† "Anatomie der Gamasiden," *ibid.* T. vii. Heft 3, pp. 317-354.

‡ "Mémoire aptérologique," Strasbourg, 1804.

*scutata* of Koch, but the *Uropoda ovalis* of the same author—an error which did not arise with Winkler, but is copied by him with a (?) from one of the systematists.

Besides the literature above referred to, there are two memoirs of my own on the internal anatomy of *Uropoda* \*. In these I explained in what particulars I was not able to agree with Winkler's description of the anatomy of his species, or perhaps I should rather say what additions I should make to it, and I also showed how widely the internal organization, particularly of the female reproductive organs, varied in different species of the genus.

The Italian works upon the Gamasidæ are chiefly systematic or biological; they contain very little information relative to the internal anatomy.

#### OBJECTS OF THIS PAPER.

In the paper spoken of in the last section, Winkler, besides treating of the anatomy of his *Gamasus crassipes* (I shall drop the "so called" in future for the sake of brevity) and one or two other species, proceeds to generalize and to take it for granted that other species are similar. I have usually found it unsafe to generalize in matters connected with the Acarina; this probably is partly due to our imperfect knowledge of the group, and partly to the extreme tendency to vary in an unexpected manner which is found on investigation, not only between different families, but even between different species of the same genus when the internal organs are examined. One of the principal objects of this paper is to show that, although, of course, there is a general resemblance between the viscera of the various species of Gamasidæ, which often becomes so marked as to constitute a degree of similarity almost amounting to identity, and although some organs vary but little, yet many most important organs and even systems of the body vary so greatly in different members of the group, and even of the same genus, that whole sets of organs are found in one which are absent in the other, and that the parts which are strictly homologous are often so developed as to be remarkably different from one another; this is especially true of the reproductive organs. It has also been my endeavour to delineate and give definite information with regard to such variations and new organs, which have come under my notice, as appear to me to be of sufficient importance and interest to make them worthy of remark. Again, both on account of its great intrinsic interest and, incidentally to the anatomy, in order, as far as possible, to make certain of the exact functions and mode of employment of some of the organs, a series of observations have been made as to the mode of coition in the species of Gamasids which I have been dealing with. This has not been by any means easy; it has required great care and patience; it is not every species of *Gamasus* which will copulate in confinement under circumstances which render observation possible; and even when such a species is obtained and the requisite surrounding conditions successfully maintained, observation is difficult, and the student must be content to bear with

\* "Observations on the special Internal Anatomy of *Uropoda Krameri*," Journ. R. Microsc. Soc. 1889, pp. 1-15.

"On the Variations of the Female Reproductive Organs, especially the Vestibule, in different Species of *Uropoda*," *ibid.* 1890, pp. 142-152.

many disappointments. The result, however, has been the gaining of considerable information on the point, and I think the process observed is sufficiently curious to make it by no means the least important part of this paper; it is, I believe, totally unrecorded except so far as some portions of it are treated of in my own notice, referred to below, of *Gamasus terribilis*, when I discovered that species, which was the first upon which I made observations that have induced me to follow out the subject.

Finally, there are unrecorded facts tending to prove that in some cases the internal organs are important in the classification of the Gamasidæ by showing relations between subfamilies or genera not previously understood.

Of course it is in the highest degree improbable that in the limited number of species to which my attention has been turned I have found more than a small proportion of the variations existing in this large family of Acarina; doubtless numerous others remain to reward future research.

#### MODES OF INVESTIGATION.

The methods which I have employed in the present inquiry have been three, viz. 1. Dissection; 2. Serial sections; 3. Observation of the living creature. Of these methods actual dissection has been chiefly employed; I have endeavoured, as far as possible, to confine myself to species where I could obtain an ample supply of specimens; and although I could not altogether succeed without neglecting many interesting cases, yet it has been the rule; and where I have had a sufficient supply I have not confined myself to a few dissections, but have repeated them over and over again, until I had either thoroughly satisfied myself upon the points in question, or else found it impossible to carry the inquiry further by this means. I have not ever relied upon a single dissection. All the figures of whole organs in the Plates illustrating this paper have been drawn from such dissections.

I have found that with these delicate and minute creatures I have not been able to dissect specimens which have been treated with hardening agents such as alcohol or picric acid, or any other of the well-known reagents, as successfully as fresh specimens; I have therefore usually dissected them immediately after death. I at first employed boiling water to kill with, but have subsequently abandoned it in favour of the fumes of chloroform, when the specimen was intended for dissection. Staining has been done either after or during dissection. All dissections have been done by the aid of Stephenson binocular microscopes.

Serial sections, sagittal, horizontal, and transverse, of each species have been employed, both to check the dissections and to trace out points not ascertainable by dissection; here again I have endeavoured, in each instance, to have several series of sections of each species in each direction. The sections have been chiefly cut with a Cambridge rocking microtome. The creatures used for the purpose were either killed in the same manner as those for dissection, or else by boiling after Prof. Lowne's method to solidify the blood-plasma around the organs; some were then treated with dilute picrosulphuric acid, and subsequently passed through alcohol, of gradually increased strength

up to absolute, before imbedding. Latterly, in numerous cases, the picro-sulphuric acid has been omitted, and the creature passed direct from boiling water to dilute alcohol, I think with advantage.

Both dissections and sections have been stained either with picro-carmin, borax carmin, or hæmatoxylin.

The observations on living specimens have been made by the aid of the cells I have usually employed in rearing and observing Acarina, viz. glass rings cemented to ordinary 3×1 in. microscopical glass slips and covered by another similar slip which is kept on by two elastic bands or a clip; the bottom of the cell thus formed is covered with moist blotting-paper, and the whole apparatus is placed on the horizontal stage of a Stephenson microscope for observation.

#### THE SPECIES USED.

A number of species have been examined of which no record appears in this paper, because I did not find them vary sufficiently from Winkler's type to render it necessary to mention them.

In selecting the species of those that departed far enough from that type I have given the preference to sorts which I could obtain in considerable numbers in one place and in a particular class of material, so that I could get it sent me by country friends when I was in London, or collect them myself when I was in the country, without the great loss of time involved in hunting for solitary wandering species of these active creatures. For this reason *Laelaps stabularis*, Koch, was one of those chosen, because it can be obtained in large numbers in the chaff and fodder in farmhouse stables; my principal supplies of this Acarid came from Cornwall. For the same reason a species which I believe is *Holotaspis montivagus*, Berlese\*, was also used because the females of it can be obtained in large numbers in cucumber and other hot-beds and in similar places. Most of my specimens of this species were found and investigated at Ragaz in Switzerland. I, however, did not succeed in finding a single male of this Gamasid, although I was anxious to do so. Another species found with it in the same place, but far less abundantly, was *Holotaspis marginatus*, Herm., of which I obtained one male, but one only. In the other species investigated the males were nearly in as great numbers as the females.

For the same reasons Gamasids which lived in the nests of other animals were very convenient, and indeed were chiefly utilized, not from the variations in organization being in any way connected with parasitism, for the larger number were not parasitic, but only used the nests as a convenient place to live in, or as one that attracted small

\* My species closely resembles Berlese's drawing and description; but it is impossible to be certain, because we neither of us found the male, and that is the distinctive sex in Gamasinæ. Although he names his species, he suggests that it was a nymph: mine certainly was not immature, as the female constantly contained a fully-developed egg with the embryo formed and almost ready to emerge (Pl. XXXV. fig. 71). I have drawn the epistome of my species (Pl. XXXII. fig. 18), as it perhaps varies a little from Berlese's plate.

insects upon which they fed, or else were commensalists\*. The nest of the mole was most serviceable, because it contained several suitable species in large numbers, and I could almost rely on finding them in any good fresh nest; and because I was able to make arrangements to have fresh moles'-nests sent me at regular intervals all through the winter, and, indeed, whenever I was in London. From this source I obtained the following species, viz.:—1. *Gamasus terribilis*, a large, well-marked, and interesting species, which I first discovered in moles'-nests some few years since †, and which is specially favourable for dissection and section-cutting. 2. *Hæmogamasus hirsutus*, Berlese, at least I believe my creature to be that species, which was found upon the mole, and with which mine agrees thoroughly in size, general appearance, and in almost all other respects; but as the mandible of the male and the epistome vary a little from Berlese's figure, I have given drawings of those organs in my creature (Pl. XXXII. figs. 9, 10, 11), so that if by any possibility there should be two almost similar species, mine may be known; however, the mandible as figured by me differs from Berlese's figure principally in possessing some additional parts, which are very hyaline and might possibly be overlooked; the epistome is a very variable organ. 3. Another species bearing considerable resemblance to *Hæmogamasus hirsutus*, but having well-marked differences both in general appearance and in its organs, the mandible of the male being entirely different; this species is unrecorded; I propose calling it *Hæmogamasus horridus*, and have described it below; it is also drawn (Pl. XXXII. figs. 1 to 5 inclusive). I have taken this as the best type of the most important variations in the female genital organs described below. 4. I have also found and investigated two other species coming from the same nests, both somewhat allied, and both unrecorded; these I propose calling *Laelaps oribatoides* and *Hæmogamasus nidi*; the descriptions will be found below, and are illustrated, as far as necessary, by figs. 6, 7, 12, 13, 14, 15. Another class of nests which provided me with numerous specimens for examination were those of ants; the researches on the myrmecophilous species took place in Tyrol: the species were *Laelaps cuneifer*, Mich., *Laelaps levis*, Mich., *Laelaps vacua*, Mich., and *Laelaps acuta*, Mich.

Some other species will be found noticed in this paper for special variations or points of interest; but those named above have been the principal species which I have used in tracing out types of organization which seem to me to be common, although to a varying extent, to larger or smaller groups of Gamasinæ.

Before leaving the subject of species I think it would be well to say a few words on the principal points by which species are distinguished in this subfamily, in order that the sufficiency of the details of species which I have given may be understood.

Beyond the general appearance, size, style of motion, and the general distribution of the hairs or spines, these characters are—1. The relative length of the legs with regard to the body, the thickness and shape of the respective legs, and their armature; the two latter points especially in the male. 2. The form of the mandibles of the male where

\* "On the Association of Gamasids with Ants," Proc. Zool. Soc. 1891, pp. 638-653.

† "Observations upon a Species of *Gamasus* supposed to be unrecorded," Journ. Quekett Microsc. Club, ser. ii. vol. ii. (1886) pp. 260-268.

the sexes show differences in this respect. 3. The form of the epigynum (or external genital plate) of the female. 4. The number, form, and distribution of the other chitinous plates of the ventral surface in both sexes. 5. The shape of the epistome (the "Randfigur" of Kramer).

Of these numbers 1 and 2 are, I believe, perfectly reliable; number 2 is extraordinarily different in different species, and is often most strange and characteristic in form. Numbers 3 and 4, according to late classifications, are more generic than specific differentiations. Number 5, the epistome, is a more doubtful question, and one not fully settled. Dr. Kramer (*suprà*, p. 283, note †) and Prof. Canestrini \* were, I think, of opinion that it was a reliable character. Mégnin said that the epistome was not useful in distinguishing species because it was variable, and was different both in the two sexes and in different individuals of the same sex; Kramer replied that it did not vary so widely as to impair its value as a guide to species. My own opinion is that although it is usually similar in the two sexes, yet it sometimes is markedly different—e. g. *Gamasus terribilis*, *G. crassus*; and also that, although the general characters are usually alike in specimens of the same sex of the identical species, the details and exact form of the organ vary considerably in different individuals, e. g. *Hæmogamasus hirsutus* (see Pl. XXXII. figs. 10, 11); and that, consequently, the epistome is useful in identifying species, but only to a limited extent. It should, I think, always be figured; but too much reliance should not be placed on it; it is only an aid, and where it is known to vary as a secondary sexual character the sex from which it is drawn should be stated.

#### THE MALE GENITAL SYSTEM.

The first departure from Winkler's type which I will mention is the male genital system of *Gamasus terribilis*. I do not for a moment suppose that the form found in that species is confined to it alone, but I select it as an excellent example, and one which I am exceedingly familiar with.

According to Winkler's description and figure (his fig. 18) (the latter stated to be "schematisch") of the sexual organs of *Gamasus crassipes*, they consist of—1, a single, azygous, globular testis with a trifling swelling on the hinder side, which he considers to be the true spermatoblastic region (Keimlager); 2, two paired vasa deferentia, the length of which is about five diameters of the testis, while their own diameter is not above one seventh that of the testis—thus they are long and thin; they arise quite sharply from the testis, preserve an almost even diameter throughout, and terminate in 3, an azygous ductus ejaculatorius (Ausführungsgang) of about the same diameter as the vasa deferentia and about one fifth the length; 4, a large azygous accessory gland lying between and underneath the vasa deferentia and entering the ductus ejaculatorius close to where it springs from the vasa deferentia. This description I believe to be absolutely correct; I have carefully dissected Winkler's species and agree with him in all respects.

\* "Osservazioni intorno al genere *Gamasus*," Atti d. R. Ist. Ven. di Sci. &c. (1881). "Nuove specie del genere *Gamasus*," *ibid.* 1881. 'I Gamasi italiani,' Padua, 1882.

There is not any intromittent organ known in the Gamasinæ; the ductus ejaculatorius communicates directly with the exterior by a roundish opening (Pl. XXXIII. figs. 29, 31, 33, *ga*), which, in most genera, is placed in the median line immediately in front of the sternal plate, and thus in the soft cuticle which is found between that plate and the hypostome, *i. e.* the ventral side of the oral tube (or rostrum). Immediately in front of the genital opening is a curious narrow flap of chitin truncated and terminated by two slightly feathered setæ (figs. 2 & 36, *bp*); it is hinged by its proximal edge to the cuticle, is hollow, and has a fine nerve distributed to it. It is found in both sexes, although the female genital aperture is distant from it. Kramer calls this organ the breast-palpus; Winkler considers it to be the homologue of a labium; I feel doubtful about this homology, and therefore speak of it in this paper by the neutral name of "the bipilate appendage." It is usually found in the Gamasinæ, and does not cover the genital aperture.

The genital organs of the male of *Gamasus terribilis* are delineated by fig. 29; a glance at that drawing will show how widely they differ from those of Winkler's species: that difference is not in any degree a question of time of year or surrounding circumstances; I have examined the organs in large numbers of specimens at all seasons, but invariably with the same result. The unpaired, globular, central testis is entirely absent; in its stead we have two very large doubly-pyriform organs, *i. e.* each testis is more or less of the shape of two pears with their thick ends placed together; but the hinder pear stands somewhat perpendicularly, and leans and curves inward and somewhat forward, while the anterior pear lies nearly horizontally, but curves inward. It must not be supposed that these two pear-shaped pieces are in any way separate organs; they are thoroughly continuous; only there is an external, not very deep, rounded constriction at the point where the somewhat perpendicular part ceases and the horizontal commences. The hinder and upper ends of the two bilaterally symmetrical testes are joined together by a very thin connection near the dorsal surface, just in the situation (as regards the genital organs) where the single testis is in Winkler's species; although in that species, with its long vasa deferentia, the testis is much nearer the anal end of the creature. It will be seen from the drawing that the long, thin, well-marked vasa deferentia of *G. crassipes* are not to be found in *G. terribilis*; indeed, vasa deferentia can scarcely be said to exist at all in the latter species: a minute portion of the organ on each side, close to the ductus ejaculatorius, may be called a vas deferens; but there is not any real demarcation between that and the testis. Of course it might be said that the whole horizontal portion of the organ, on each side, was a vas deferens; but the form of that part, its entire continuity with the hinder part of the testis, the solidity of its contents, and their steadily progressive development from the hinder to the anterior end of what I call the testis seem against that view.

The ductus ejaculatorius and the great accessory gland are practically similar to those of *G. crassipes*, except that the former is perhaps a little longer in proportion, and not quite so uniform in diameter as in *G. crassipes*; and that the latter is without the curious narrow recurved portion at the posterior end figured by Winkler.

Doubtless, in spite of the extreme dissimilarity between the above described organs in

the two species, both are developments of the ring system upon which the genitalia of both sexes in the Acarina, and, indeed, in other groups of the Arachnida, are so frequently based; but this is not saying much, for the varieties which nature gives us in this ring are so numerous and so diverse that they would scarcely seem greater if based upon a separate plan.

Winkler mentions that the distal portion of the ductus ejaenlatorius is coated with chitin. In *G. terribilis* this chitinous coating rather assumes the form of a short chitinous trough, not entirely surrounding the mouth of the ductus, but in which the latter lies; while a partial chitinous ring, like one of those in a pseudo-trachea of the blow-fly's tongue, is found within the mouth of the tube; the reason for this difference may possibly be the size of the bodies that have to pass through the ductus ejaenlatorius of *G. terribilis*.

It may be as well to say a few words as to the maturation of the sperm-elements in this testis, particularly as it affects later portions of this paper.

In the attenuated end of each testis, from the part where it joins its fellow of the opposite side for a short distance onward, we find, inside the tunica propria, &c., which covers the whole organ, a closely-packed quantity of cells, which at the narrowest part are extremely small and gradually increase in size; but in each cell, wherever it is amenable to the microscope, we see the nucleus quite clear and distinct; although in the smaller cells it is scarcely possible to see a nucleolus. As we examine the testis, proceeding toward the ductus ejaenlatorius, the cells gradually and steadily increase in size, until we arrive nearly at the point where what I have spoken of as the more perpendicular portion joins the horizontal part. Near this point the cells, which we may call "sperm-mother-cells," have attained a remarkable size, some of them measure as much as  $170\ \mu \times 125\ \mu$ ; each cell still retains a large clear nucleus, which in a cell of the above measurement would be about  $58\ \mu$  and would possess a well-marked nucleolus of about  $25\ \mu$ . Before the mother-cell had attained this size a number of minute, nearly globular bodies, clear but highly refractive, and not at first measuring more than  $1\ \mu$  to  $2\ \mu$ , will have formed in contact with the inner side of the peripheral protoplasm; these I consider to be the true spermatozoa in an early stage. When the cell has attained its full size the interior of the peripheral protoplasm is nearly coated with them; the cell, however, still remains fairly transparent, or at least translucent. The nucleolus has already shown signs of breaking up.

On passing from the perpendicular to the horizontal part of the testis a great change takes place in the sperm-mother-cell, its nucleus breaks up entirely, or sinks into the centre of the cell; the spermatozoa break off from the peripheral protoplasm and collect in a mass in the middle of the cell; this mass is closely agglomerated and no longer transparent, and a clear space is left between it and the peripheral protoplasm; the whole cell now presents the appearance of a partially-filled spermocyst. The spermatozoa continue to increase slightly in size, until in the ripe cells nearest to the vasa deferentia they may measure  $3\ \mu$  to  $4\ \mu$ ; the sperm-mother-cell itself has, however, shrunk a little, and in a testis where the largest mother-cells were of the above measurement those fully ripe would not exceed about  $135\ \mu \times 89\ \mu$ . These measurements are taken all through from

one freshly killed creature, after examining it with a number of others, so as to assure myself that it was a good average specimen. I may state here, though possibly it belongs rather to a later branch of my subject, that these spermatozoa after being discharged from the mother-cell, and as found in the female, where in this species they occupy the recess in the vagina described by Winkler, have increased in size from what they were in the mother-cell and have become slightly elliptical bodies of about  $6\mu$  to  $7\mu$  long diameter. There are a very large number of spermatozoa in a mother-cell in this species. The large sperm-mother-cells often adhere in groups of 3 or 4 in the testis, which thus seems divided into separate masses.

In *Laelaps cuneifer*, a very much smaller species, we have a nearer approach to what occurs in Winkler's species: there is a single, unpaired, central testis; but instead of being globular, it is pine-shaped, and lies almost transversely in the body (Pl. XXXIII. fig. 30); from near one of the rounded angles at the base of the pine proceed two longish vasa deferentia, which are of nearly even diameter throughout, and start quite suddenly from the testis (fig. 31). The great accessory gland in this species, although placed as in *G. crassipes* and *G. terribilis*, is different in form (fig. 31, *gla*). It widens out towards its distal extremity and is slightly flattened; but its hind margin is deeply indented, so that the posterior portion of the organ becomes bifurcate, each side being a large rounded lobe. In this species the testis is, as in *G. terribilis*, constituted of large sperm-mother-cells, gradually increasing in size (fig. 32); they are much smaller actually than those of *G. terribilis*, but are large relatively to the size of the species. They are not so tightly packed as in *G. terribilis*, and are considerably different in the average class of form, as may be seen from the figures; the individual spermatozoa are larger in proportion and less numerous, the nucleus seems to disappear at an earlier stage, and the mother-cell is less smooth and transparent.

In *Laelaps levis* the process which we have seen commencing in the last species by the bifurcation of the hinder portion of the accessory gland has gone vastly further; here we find (fig. 33) not one central gland, but two totally separate elliptical glands, discharging by extremely short duets, which coalesce only where they enter into the ductus ejaculatorius. The same arrangement is found in *Hæmogamasus hirsutus* and in *H. horridus* (see Pl. XXXV. fig. 72, which is a transverse section cutting the two accessory glands (*gla*) just at the point where the large columnar secreting-cells, which form the hinder parts of the glands, are fading into the looser reticulate tissue found in their anterior portions, and which appears more adapted to the collection and storage of secretion). A longitudinal section through the testis of *Laelaps levis* is drawn at fig. 34 (Pl. XXXIII.). It will be seen that the formation of the ripe sperm-mother-cells is somewhat different from that in the species above described; the spermatozoa are less distinctly formed, and lie in scattered amoeboid masses in a looser and more reticulated substance. This drawing was very carefully made from the actual section, but in consequence of the very small number of specimens which I was able to obtain I could not investigate this species as fully as I should have liked.

What struck me as an interesting case of spermatogenesis, which I believe is novel, in the Acarina at all events, although it may possibly bear some slight analogy to

the mode of development in the Crayfish, is that of *Gamasus crassus*, Kramer; at least I believe that this is the species, but as there is a little difference in the epistome from his figure, I have drawn that organ and the mandible of the male (Pl. XXXII. figs. 20, 19)\*.

The process of development in this species is delineated by fig. 35; the different stages are numbered successively; it commences with a single very minute cell (1), which gradually enlarges until the nucleus can be clearly seen (2); this then divides into two (3), then into four (4), eight, &c., in the ordinary manner, the cell continuing to enlarge all the time, so that each contained sphere, after numerous divisions, is as large as one of the original two spheres. In this manner a small nuclear-aggregate (Winkler's "Morula von Kernen") is formed inside and detached from the peripheral protoplasm (5). So far, of course, there is not anything unusual; but now commences what strikes me as singular: the whole cell becomes slightly flattened and more discoidal; four, or more rarely three, slight rounded projections appear on the margin at equal distances (6); these projections continue to increase in length (7), and this goes on until the whole thing presents curiously the form of an *Ophiocoma*, except as regards number of rays (8). The contained spherules arrange themselves chiefly in the arms, and either break up or are no longer distinctly visible; an indentation appears in the edge of the disk between each two rays, which deepens until the four rays are only joined by their points (9). In this manner each ray has become a long tubular spermatocyst with a slightly clavate head; this head, however, becomes indented on one side, and the inner end bends outward so as to form a hook (10). This stage is interesting because it is the permanent form of the spermatocysts, or spermatozoa, in some other species, e. g. *Sejus togatus* (see Pl. XXXIII. fig. 45, which represents a group taken from the testis of the female in that species; those from the spermatheca are similar). Finally the hooked end straightens out; both ends of the cell become pointed, and the whole cell might then, as far as appearance is concerned, well be a single spermatozoon were it not for its size (11); it is in this form that it is found in the vasa deferentia; I am not sure that it does not split longitudinally into two spermatozoa. Certainly the single semen, be it spermatozoon or spermatocyst, is often very much finer and thinner even than 11; it becomes quite filamentous, particularly those found in the female and capsule (see explanation of the word "capsule" in the part on the mode of copulation). I think these filaments are the mature spermatozoa.

Before closing this section it is perhaps well to refer to what Winkler says of the spermatogenesis in *G. crassipes*, in order that by describing the whole process for the sake of clearness I may not be supposed to claim the discovery of anything which he has already observed.

The spermatophores, as he finally calls them, are smaller in his species than in many others, and I believe his description to be quite correct. He says that the primary cells divide and form daughter-cells; the nucleus of the daughter-cell divides frequently and becomes what he terms a morula within an envelope or cyst (Umhüllung); the divided nuclei arrange themselves in a strip; the cell becomes clavate, then lengthens out, but

\* Prof. Berlese says that this species is identical with *G. coleopratorum*; but this is an error on the Italian Professor's part; the two species are very different.

retaining the club-shape; it contains minute highly refractive particles, which are to be regarded as the true spermatozoa, the whole cell being, he considers, a spermatophore, although he usually calls it a spermatozoon; he also thinks that the cell breaks up and is transformed within the female.

#### THE MODE OF COITION.

I place this here, apparently somewhat out of order, because I think it will enable some part of what I have to say relative to the female organs to be more readily understood.

The coition has been carefully watched by me in four species, viz. *Gamasus terribilis*, *Laelaps cuneifer*, *Hæmogamasus hirsutus*, and *Gamasus crassus*, not only once but in several instances, more especially in the cases of the firstly and thirdly named species.

In 1886, in the paper upon the then newly discovered *Gamasus terribilis* (p. 288, note †), I for the first time described this process, which I think will be found exceptional in nature and of considerable interest. I had, however, then only observed it in a single species and during the short period that elapsed between the discovery and the publication of the paper. I have since investigated the matter more thoroughly and have compared other species, with the result that I am able to describe it much more fully and in some respects more accurately; and that I find that this very singular process is not confined to *Gamasus terribilis*, but is common to at least a section of the family. Of course I cannot say whether it is universal, but it has been the method in all species which I have been able to observe sufficiently well since I first noticed it; but these species are much too few to generalize upon.

I will describe the process in *Hæmogamasus hirsutus*, a species in which I have watched it several times, and have been fortunate in obtaining clear observations and in killing and examining the creatures at different stages.

The male, which is smaller than the female, approaches her usually from the side; he occasionally jumps upon the dorsal plate of the female, but the other is the commoner mode. In either case the male clasps its legs round two of the legs of the female, both on one side; the legs seized have usually been the 3rd and 4th, but sometimes the 2nd and 3rd. The male, having secured a firm hold of the legs of the female, slowly turns over so that his dorsal surface is downward, then slips right under the female, keeping further back than the female, so that nearly half the body of the male projects behind the female; the male passes its fourth pair of legs upward behind the posterior edge of the abdomen of the female and lays its tarsi on the dorsal surface of her abdomen, thus obtaining a firm hold. What looks like a hyaline sac or bubble then appears in the mouth of the genital aperture of the male; this sac is somewhat rapidly distended, but still takes some little time, varying in different cases, before it attains its full size. If the creatures be now suddenly killed (which must be done in an instantaneous manner either by chloroform ejected from a pipette or else by boiling water), this sac, which I propose calling the spermatie capsule (capsula spermatis) and shall refer to in future by that name, is found in the mouth of the genital opening of the male, the end of the capsule only being attached to the opening, and the other part of

the capsule standing free in air in a longitudinal or diagonal, nearly horizontal, line between the ventral surfaces of the male and female. The capsule itself is an elongated flask almost parallel-sided and with a rounded distal end; it narrows rather suddenly to a short neck near the genital opening. This capsule, while still small compared to what it will become, but already large in proportion to the creature, is drawn *in situ* (Pl. XXXIII. fig. 36) from a specimen of the male killed at this stage of coition; I have not found sperm-mother-cells in it at this period. If the Gamasids be not killed so soon the capsule continues to distend until it is as long as the body of the male, or even longer; it still preserves nearly its original shape, but is rather broader in proportion to its length than it is at first. If the creatures be killed at this precise moment, which is not very easy to catch, the flask will be found still with its small end in the genital opening of the male; but it will be astonishingly large, and will consist of a tolerably thick but clear and structureless exterior wall surrounding a large number of spermatocysts precisely like the ripe sperm-mother-cells found in the proximal part of the testis, and undoubtedly the same bodies. The capsule is filled up by a clear but thickish fluid, and contains a multitude of minute granules; the small end is closed by gummy and granular matter. A capsule taken in this stage is delineated (fig. 37).

If the creatures be not killed so soon, but are allowed to complete the coitus, the male now exerts both its mandibles and passes them one on each side of the spermatocapsule; the capsule, which apparently has about it viscid material which more or less sets on exposure to the air, adheres to the inner sides of both mandibles, usually to the small brush or row of hairs on each mandible which is inserted close behind the articulation of the movable arm of the chela; the mandibles are now moved away, carrying the spermatocapsule, the small end of which is near the mandibles, but is left free; this small end is applied to the female. The capsule is evidently highly elastic, so much so that it is very difficult to preserve it full; its elasticity usually drives the slight stopping out of the small end and the whole contents of the capsule are discharged upon the slide; when this process takes place in nature of course the coitus is complete. After the contents have been discharged the capsule remains attached to the mandibles; it retains its shape, but has shrunk to about the size shown in fig. 38. If the creatures be killed at any time after the capsule has become attached to the mandibles of the male and before the separation of the two creatures, the capsule will probably discharge if it has not already done so; the empty capsule, still retaining its form but not its size, will be found attached to the two mandibles. Fig. 38 shows the rostrum of a male *H. hirsutus* killed at this stage with the capsule still in the mandibles. Fig. 39 shows the rostrum of a male of *Laelaps cuneifer* killed under similar circumstances. If the creature be not killed at all, the male may be watched cleaning his mandibles, and getting rid of the capsule and other matter which adheres to them.

It will be seen that the form of the capsule in *L. cuneifer* is different from that of *H. hirsutus*, being a much shorter and rounder flask; each form is quite constant in the species to which it is referred; otherwise the process is similar. *Gamasus terribilis* has a capsule also constant in form, but almost the same as that of *L. cuneifer*, for which

reason I have not figured it. In *G. terribilis* the genital plate (epigynum) of the female is lifted by the mandibles of the male and the capsule applied to the vagina; in this species the large spermatocysts are not ever found inside the female, only minute spermatozoa in the recess of the vagina which exists in this species as in *G. crassipes*; the spermatocysts break up inside the capsule, which discharges only minute ovoid spermatozoa imbedded in a thick viscid fluid. The outer walls of the spermatocysts are left in the capsule or about it, and do not enter the female. In four cases of *Gamasus crassus* killed during the coitus, the mandibles of the male were actually inside the vagina of the female. This is a species very like *Gamasus terribilis* in general appearance, but the female, although constructed on the *G. crassipes* type, has not merely the domed recess in the vagina to act as a spermatheca; it has a well-marked, almost globular spermatheca, joined to the vagina by a short chitinized tube with a narrow opening (see fig. 42, *spt*).

The mode of formation of the spermatocapsule in this species is really astonishing. The lower or movable arm of the chela of the male mandible has a large foramen or hole in it, shaped rather like a lemon-pip (fig. 19); the spermatocapsule passes right through this hole and folds over. Each end is a sac, the anterior pyriform, the posterior globular; neither sac would pass the hole, but they are joined by a long tubular portion which does pass. It seems to me, therefore, that the capsule must be blown like a bubble right through the hole; the globular end of the capsule emerges last from the genital aperture. Fig. 40 is drawn from a specimen killed *in coitu* and the mandibles then freed from the vagina of the female; the anterior sac of the capsule broken. Fig. 41 shows the posterior end of the capsule emerging from the male genital aperture. This species is one with filamentous spermatozoa. The mode in which the sperm is applied to the female in other species will be discussed in dealing with the female genital organs.

I am of opinion that the more liquid contents of the capsule, other than the spermatocysts, are the produce of the great accessory glands of the male (*gla*, figs. 29, 31, 72); but whether the wall of the capsule itself is the product of a separate gland or of a special part of the main gland and is blown out like a soap-bubble by the rush of liquid and other contents at the moment of formation, or perhaps it is a more apt simile to say as a glass-blower blows a flask, or whether it is simply the hardening of the exterior part of the general mass on exposure to the air, I have not been able to determine; I incline to the former hypothesis in consequence of the regular form which the capsule assumes and its elasticity. If this be so, the formation of the narrow tubular portion of the capsule in *G. crassus* would be easily understood; after the anterior end of the flask has been blown through the foramen in the movable arm of the chela, the mandible might, and probably would be, quickly extruded; the effect of this would be to draw out a long tube of even diameter, as will be readily understood by anyone who has seen glass-blowers draw barometer-tubes by fixing one end of the molten flask and then moving rapidly away.

## THE FEMALE GENITAL SYSTEM.

It is in this group of structures that we find the widest variations in the Gamasinæ; we here not only have great differences in the same part in distinct species, but we also meet with a whole set of organs in a large section of the family which are absent from those hitherto described, and these new organs present considerable variety amongst themselves. I will now proceed to describe them, but first for comparison I will shortly take from Winkler's memoir the principal features of the organs as hitherto known and described by him.

The female genital system in *Gamasus crassipes* consists of the following parts, viz. :—  
 1. An almost globular ovary \* fairly corresponding to the single globular testis of the same species; in this ovary the germinal portion is the central, and the more developed eggs are found round the periphery in saes, the walls of which are so fine as not always to be readily seen. These saes are temporary outpushings of the outer investing tunic of the ovary, and may be called oöcysts or oövicells. 2. A short unpaired nearly straight oviduct. 3. A larger continuation of the same, with more glandular walls, which Winkler calls the uterus, and where he says the egg attains much of its development. 4. The vagina, which is a largish chamber, open below, but with a domed recess above just over the opening, which recess usually or frequently contains a ball of spermatozoa. 5. Two small vaginal glands which open into the vagina just at the base of this domed recess. And finally 6. The epigynum or external genital plate, which in this species is a large, almost triangular, plate, with its straight edge backward, and is hinged by that edge to the ventral surface; it occupies most of the space between the two hind pairs of legs, and entirely closes the genital aperture. Within this plate is a somewhat elaborate structure of chitinous pieces, the precise function of which is not known.

I will contrast with this the organs which I find in *Hæmogamasus horridus*. I select this species as a type, and as that to be first described, because in it the organs which I believe to be entirely undescribed are found in about their simplest form.

It will be most convenient to commence in the reverse order from that used in regard to *G. crassipes*. The epigynum (genital plate) in this species (fig. 2, *epg*), and indeed in all species of the same genus which I have hitherto examined, is no longer a separate plate working on a ginglymous hinge and closing the genital opening; it is a plate, truncated in front, firmly attached by its whole surface to the ventral cuticle; precisely like the other chitinous plates of the underside of the creature, or probably it would be more correct to say that both it and the others are actually portions of the ventral cuticle, only differing from the other portions by the deposition of chitin in the cells. The genital opening is only a long, somewhat curved, slit placed in the flexible cuticle between the epigynum and the sternal plate; it is, however, somewhat protected by a very delicate and narrow flexible border which runs along the anterior edge of the epigynum.

\* I use the word ovary in this paper in the sense in which it is used by all writers on the Acarina, viz., as the whole organ in which the eggs originate, and that solid part in which they are developed in oöcysts (as above defined) before they pass into the free and tubular oviduct.

This class of border, although I do not remember its having been described, is frequently found on the movable genital plates of the Gamasinæ; and is attached to the lower (ventral) part of the edge where the plate is movable, so that it lies under and close against the ventral surface; but it is usually so fine and transparent that it cannot be seen until the plate is lifted.

In *H. horridus* there is not a trace of the chitinous structure of *G. crassipes* inside the epigynum, nor is there any sign of the domed recess which practically functions as a spermatheca in *G. crassipes*: the vagina (Pl. XXXV. fig. 68, *va*) is an extremely simple chamber, with soft and thin walls, leading without vaginal glands or other complication to the oviduct; I have not even found spermatozoa or spermatozooids in it. There is not here any marked difference between uterus and oviduct; the whole appears one organ without distinction of structure or constriction between, unless it be considered that in this and allied species the whole represents Winkler's uterus, and that his oviduct is here sunk in the ovary, which would be a theory requiring some evidence. I have therefore used the expression "oviduct" for the whole (figs. 49, 68, *od*). The oviduct leads to the ovary (figs. 48, 49, 68, *ov*), which is placed near the ventral surface and much as in *G. crassipes*, and may be said to fairly agree with the same organ in that species, except in being rather smaller, more flattened, and less regular in form; it fades into the oviduct without its being easy to say exactly where one commences and the other leaves off, although there is a considerable constriction between the two, through which a tracheal trunk passes. The oviduct runs backward and forms a kind of pocket (Pl. XXXIV. fig. 49).

Now commence the undescribed organs. In the centre of the ovary on its upper surface is a rounded elevation which does not show actual eggs developing; from the sides of this elevation spring two great paired flattened arms or branches; the whole structure, including the root and two arms, is somewhat lyre-shaped, and I propose calling it "the lyrate organ" (*organum lyriforme*)\*, and shall so speak of it in future; it is irregular in form, never quite agreeing in two individuals or on the two sides of the same individual, but still preserving the same general form in each species; so that, after becoming well acquainted with them, it would, I think, be possible to tell what species a dissection was from by the form of the lyrate organ alone. This organ is one of the largest and, as regards the arms, one of the most solid in the body; it stains deeply and is wholly composed of largish clearly-marked cells averaging about 30  $\mu$  diameter, without any intercellular space or tissue; each cell has a well-defined nucleus averaging about 7  $\mu$  diameter, but I have not been able to see nucleoli with certainty. The size and appearance of the cells and nuclei is extremely regular all over the surface of the organ, except just near the root, where the cellulation is lost: if the organ be cut into sections the interior cells are found to be similar to the exterior; the cells are not larger near the root than at the distal ends of the arms, nor are the nuclei more distinct or larger in one place than the other. A portion of one arm of the lyrate organ of a closely-allied species, *Hæmogamasus hirsutus*, is drawn on a larger scale, fig. 47, in order to give an idea of the cellulation, &c. The central rounded elevation from which the arms arise does not exhibit the same cellulation and is not solid—it is hollow, with

\* The full name should probably be the lyriform portion of the ovary, but I use "lyrate organ" for brevity.

thick fleshy, but probably slightly distensible, walls. At the point where the arms join this portion the cells appear to separate from each other and become loose. This organ exists in the nymph, but is then very small. When the female is adult, but lately emerged, the lyrate organ, although much larger than in the nymph, is still not so large as it will become; it is when the impregnated eggs are attaining (one by one) the immense size and highest state of maturity which they arrive at within the body of the mother, that the lyrate organ is at its greatest size and development, but the cells of which it is composed are not larger than, nor different from, those in the smaller gland.

With regard to the function of the lyrate organ, I think that it must clearly be regarded as a portion of the ovary. Speaking first of the arms only, they remind me in many respects of the terminal chambers of the ovarian tubes in such Coleoptera as *Platysoma frontale*, *Hydrobius fuscipes*, *Byrrhus pitula*, &c. It may of course be questioned whether they are the true germ-bearing portion, or whether they are composed of vitelligenous cells only; it is not perhaps easy at the present time to answer this question with certainty, as biologists do not appear to be entirely agreed as to the office of what are probably the most nearly allied structures in other creatures. Certain considerations would at first seem to favour an idea of their being yolk-glands: these are *inter alia*, firstly, their large size in creatures which do not appear to lay many eggs, but it is not uncommon in nature for the number of germs in the ovaries to be enormously in excess of the ova eventually matured; secondly, the very large size and high state of development which the egg attains within the body of the mother. In this and allied species only one egg is really matured at a time, and the size and state of maturity which it arrives at before deposition may be judged of from Pl. XXXV. fig. 71, which is a sagittal section carefully drawn to scale from an actual preparation of *Holotaspis montiragus*; in the species I am describing, *Hæmogamasus horridus*, I think the mature egg is even larger in proportion, but the embryo is not so highly matured within the maternal body. There is generally a second, much smaller and flatter, but still large, egg showing a moderately forward state of yolk-division, but not any signs of the embryo forming. The other eggs are usually much less advanced, although in various younger stages.

Notwithstanding the above considerations I do not see any sufficient evidence of the vitelligenous nature of the arms of the lyrate organ, and I think they must, at present at all events, be looked upon as the germiniferous part of the ovary; and this view would bring the various organs of the female genital system most into harmony, and explain in a reasonable and probable manner their relations to each other. As far as I know there are not any structures in any other family of the Acarina at all resembling these lyrate organs, so we cannot be guided by any analogy with other members of the order.

The central domed elevation (*cms*), from the sides of which the arms spring, is, as before stated, unlike them both in histology and otherwise: it is a hollow, shallow recess with fleshy walls, and communicates with the arms, the portion of the ovary in which the oöcysts are developed and the eggs matured, with another organ to be mentioned further on, and probably with the oviduct. It is occasionally empty, but is much more frequently more or less filled with matter which closely resembles that found (as before mentioned) in the spermatic capsule of the male *Gamasus terribilis* at the moment of

coition, and which is discharged from thence into the vagina of the female. Had I been forced to rely upon this resemblance alone I should not have felt confident of the function of the organ, because this minute cellular matter and glutinous fluid are not so distinctive but what other products of the body might be mistaken for them; but luckily a closely allied species, *Hæmogamasus hirsutus*, enabled me to decide the question; it has the domed elevation larger than in *H. horridus*, and usually full of unmistakable filamentous spermatozoa, which often crowd the chamber as full as it will hold. These spermatozoa measure about  $30\ \mu$  in length by about  $1\ \mu$  in breadth.

It certainly seems strange that in two species so nearly related as *Hæmogamasus horridus* and *H. hirsutus* the spermatozoa should in the first case be minute ovoid bodies, and in the other long and filamentous; it is impossible not to suspect that the latter is the ultimate form into which the former at some time and under some circumstances develops; and this seems all the more probable because in *H. hirsutus* the spermatozoa retain the ovoid form until nearly the last, and it is only when they are about to enter this chamber that they assume the filamentous form. The filament may be formed within the ovoid, but it cannot be distinguished. Although one cannot help being impressed by this obvious idea, yet the facts are that the two species live together in the moles' nests under precisely similar circumstances; that I have examined them at practically all seasons of the year, and have made extremely numerous dissections and sections in all directions of both species, and yet in all cases where the chamber has not been empty it has contained the minute ovoid bodies in *H. horridus* and the filamentous in *H. hirsutus*. It cannot be suggested that they are the same species in different stages; the extremely dissimilar mandibles of the adult males (Pl. XXXII. figs. 3, 9) and the epistomes (figs. 5, 10, 11), to say nothing of the internal anatomy, would put this out of the question; and the females in both have mature eggs.

I propose calling this domed chamber the camera spermatis. It will be seen later on that spermatheca or receptaculum seminis, in the ordinary sense, would scarcely be applicable.

Between the arms of the lyrate organ, but somewhat above and totally detached from them, is another large and wholly undescribed organ, which is found only in the female; there is not a trace of it in the male. It is difficult to give the measure of this because it is dilatable and more or less elastic, and subject to endosmosis and exosmosis; and it is difficult to be sure what is exactly its normal size, if it have any; but in every dissection or section of a mature female *H. horridus* which I have made it has been a large organ, often one of the largest in the body. It is a closed sac or vesicle with hyaline, transparent, but not excessively thin, walls. The form is that of a cone with curved sides and rounded apex, or a bell with a closed mouth (Pl. XXXIV. figs. 48, 49, *sa*). It extends almost to the dorsal surface (Pl. XXXV. fig. 68, *sa*), is more or less horizontal, has the base of the cone (or mouth of the bell) directed toward the rostrum, and the apex toward the posterior end of the Acarid. It is generally slightly coated outside, either wholly or partially, with loose granular matter, but this is not in any way a portion of the organ; it is easily cleaned off, and is to be regarded as embedding matter. I propose calling this organ the sacculus fœminicus. Its apex is not permanently closed, it is simply constricted, and

may for the moment be either wholly closed or slightly or considerably open ; when open it forms the entrance to a much smaller pyriform sac (figs. 48, 49, *cs*), joined to the first by a short wide neck ; or, rather, perhaps the second is to be regarded as a continuation of the first, but the neck between is usually slightly twisted. I propose calling this second sac the "cornu sacculi," as after examining its forms in various species I consider it as in effect a prolongation of the sacculus ; the histology is identical. The broader end of the cornu is toward the sacculus, but it turns almost perpendicularly downward (fig. 49), so that its apex is the lowest part ; this again is not absolutely closed, only constricted, but the constriction is very close. The apex is attached to the camera spermatis, which it enters low down, practically at the base or from below. The wall of the cornu spreading out after the constriction, and being in fact continuous with the tunica propria of the chamber, thus there is an entrance from the cornu through the camera spermatis to the ovary, although it often requires long and careful examination of many specimens to make sure of the fact ; as not only is the constriction close, but the point of junction is small and the parts so fine and delicate that they break with a touch, and nothing but the finest hair can be used in manipulating them.

At the opposite end of the sacculus from the cornu, namely, at the base of the cone, which is the anterior end, there are two branches which I propose calling the "rami sacculi." These rami are bilaterally paired structures, really diverticula of the sacculus, forming wide tubes springing from the lateral edges of the base (figs. 48, 49, 67, *rs*) ; their length is nearly equal to the width of the sacculus, but they vary in proportion in different specimens, and even on the two sides of the same creature ; their histology is identical with that of the sacculus, and their lumen continuous with it without any constriction ; they are of about even diameter throughout, and run forward somewhat sideways and a little downward. The distal ends are almost closed and are rounded. From the distal end of each ramus springs a much smaller tube longer than the ramus (figs. 48, 49, *ta*) ; these I propose calling the tubuli annulati, or ringed tubes. They spring from and open into the rami, without any valve or other closing apparatus that I have yet been able to discover between the two ; I mention this because it is not the case in many other species. The histology by no means agrees with that of the rami : they appear to have two tunics, which seem almost, if not quite, detached from each other ; the outer, which is the thinner, is much the looser and more flexible, and is distinctly ringed or wrinkled transversely, the ringing being rather irregular ; this tunic does not pass within the ramus, but stops at or immediately before the point of junction. The inner tunic seems of a closer and more substantial texture, but neither show cellulation. It must not be supposed from the fact of these tubuli being ringed that they are tracheæ ; they never by any chance contain air, and they do often apparently contain fluid ; moreover, the ringing is not at all like that of tracheæ ; and finally the tracheæ of Gamasids, with which they are abundantly supplied, resemble those of most other Acarina in not presenting an appearance of ringing or spiral threads, although they might probably be made to break up into spirals by properly applied pressure as in the Oribatidæ. The ringed tube on each side commences, as before stated, at the termination of the corresponding ramus, and it ends, with a more or less trumpet-shaped mouth, in the thin

connective cuticle which binds the coxa of the third leg to the more chitinous part of its acetabulum.

Thus it will be seen that this series of organs or parts—the cornu sacculi, the sacculus fœmineus, the rami sacculi, and the tubuli annulati, all of which are strictly confined to the female—form an unbroken connection, varying enormously in size and capacity, but absolutely continuous, between the sperm-chamber in the ovary and the acetabulum of the third leg on each side.

The position of these organs as regards the other viscera may be well gathered from fig. 46, which was carefully drawn immediately after death from a female of *Laelaps lævis*, after the dorsal plate, &c., had been removed.

It will, I think, be convenient to describe some at least of the somewhat numerous and wide variations of these organs which I have found in different species before treating of their contents and supposed function.

In describing all these parts, and, indeed, the internal anatomy generally, I cannot too strongly insist upon the fact that two specimens are never really alike, and that the same specimen varies with age and condition; it is therefore only what may be called a type-form in each case that can be described; but this type is never so widely departed from but what it may be easily recognized in any dissection of the species, and may probably therefore be considered as constant as could be anticipated.

*Hæmogamasus nidi* (Pl. XXXII. figs. 6, 7) is a smallish new species allied to *H. horridus*, and in which the female genital system is so similar that it is not necessary to give a separate description of it.

*Laelaps stabularis* is a species in which the new organs above described correspond more closely to those of *H. horridus* than in any other I have found, except *H. nidi* (see Pl. XXXIV. fig. 51). The differences, as will be seen by the figure, are that the lyrate organ of *L. stabularis* is much more enlarged at its distal ends than that of *H. horridus*, and forms broad, somewhat recurved plates; that the cornu is wider in the lumen and much less plainly marked off from the sacculus; and that the rami are much longer, and the ringed tubes consequently very much shorter, than in *H. horridus*.

*Hæmogamasus hirsutus* is a species closely allied to *H. horridus*, belonging to the same genus, and found with it under similar conditions; and yet the organs we are discussing differ far more widely from the same parts in *H. horridus* than those in *L. stabularis* do, although the latter is a very different creature, belonging to a separate genus. The lyrate organ of *H. hirsutus* (fig. 52) does not vary in any remarkable manner from that of its ally, but when we examine the sacculus (fig. 53, *sa*) the contrast is very striking. Instead of the large, simple, bell-shaped sac we have a small, more or less rhomboid, organ placed transversely across the body; the whole central part of the anterior side of this is occupied by a shortish but very wide caecal prolongation running straight forward between the rami. From the posterior corners of the sacculus proceed two paired, almost globular, diverticula, immensely larger than the sacculus itself, and joined to it by almost imperceptible necks, with sharp lines of demarcation where they issue from the central portion of the organ. These diverticula extend almost to the dorsal surface and are quite clear and hyaline; the position of one of them is shown in Pl. XXXV. fig. 70, *sd*.

Between the diverticula the cornu arises; it is smaller than in *H. horridus*, but of somewhat similar shape, except that it is generally joined to the sacculus by a small, almost globular chamber with a narrow neck. The rami are short but wide; and the ringed tubes much of the same nature as those before described, but they do not terminate exactly where they reach the rami with a simple opening into the latter, as in *H. horridus*; they enter the rami and continue within for a minute distance, then each ringed tube terminates in a very small, almost globular enlargement within the ramus (fig. 54); this sphere is so clear and delicate that it can only be seen under favourable circumstances and with a highish power, but it certainly exists. I have not been able to determine to my own satisfaction whether this and similar, or more or less similar, terminations of ringed tubes in other species are really permanent closings, or only in the nature of valves; the latter is the more probable, although I have not hitherto detected any openings, but they are so small and fine that proper examination is almost impossible, and I have not been able to trace them in the sections.

*Laelaps oribatoides* (fig. 56) is another allied species much of the *H. hirsutus* type, but with considerable differences. The two globular diverticula are present, but in this species are smaller than the sacculus, while the central anterior diverticulum of the last species is entirely absent: the cornu, however, in *H. oribatoides* assumes much greater importance; it is an organ containing nearly as much space as the sacculus and winds over and round the lyrate organ down to the underside of the camera spermatis, where it enters. The lyrate organ in this species is singular in form, the distal ends being much enlarged and forming irregular hatchet-shaped pieces, which are much reflexed.

*Laelaps vacua* is a very small species; in it we find a widely different development of the sacculus organs (fig. 57); that viscus itself is a small globular sac without rami; the ringed tubes enter the sacculus itself and project within it, with a slight bulb, which I do not think is closed; the cornu is a large, more or less discoidal or ovoid body, not regular in form, but considerably larger than the sacculus, to which it is joined by a long fine tube, larger than the ringed tubes, but not much so; the difference in the figure is a trifle too great. This tube springs sharply from the sacculus and from the cornu, with a well-marked line of demarcation; it is shown stretched out in the figure, but *in situ* it winds round the other organs, and is slightly embedded in fatty and loose cellular matter. The cornu lies with a portion of its substance almost embedded in the camera spermatis and ovary. I could not, however, trace the entrance in this species, although it probably exists; I had not a sufficient number of specimens for investigation, and the creature is very small and delicate (extreme length about .5 mm.).

Fig. 58 represents the sacculus and cornu of a small species very like *L. vacua* externally, and with these organs similar in principle.

*Laelaps acuta* is a smallish and very swift species, which again presents novelties in the set of organs we are considering; it has an elliptical sacculus (fig. 59, *sa*), without any rami: the ringed tubes enter the sacculus itself as in *L. vacua*; they enter it on the underside. The cornu in this species, instead of being a separate sac attached by a long tube as in the last, is a mere short conical projection in the middle of the anterior surface of the sacculus, thus being almost at right angles to the ringed tubes; the apex

of the cornu is not closed, but a long fine tube runs from it to the camera spermatis; this tube also is shown extended in the figure, but *in situ* is wound round the sacculus and is difficult to see.

*Holotaspis marginatus* is a rather large and powerful species; in it the lyrate organ has a rather different appearance from what it has in the above-described species; the arms are comparatively very thin, but have sharply clavate ends (Pl. XXXIV. fig. 60, *ol*). The cellulation of these arms is apparently similar to that of other species, except that I am not able to detect the nuclei which are so very conspicuous in the others. On the other hand, the camera spermatis (*cms*) is extremely large, and its surface seems to be composed of cells similar to those of the arms, which is unusual; it appears as if it had taken upon itself part of the function of the arms in consequence of the small size of the latter. The sacculus is of the usual class of tissue, but is a long roughly-elliptical sac, with its long diameter transverse to the body. The cornu is not at all of the usual type; it is short, wide, and rather fleshy, and passes straight to the underside of the camera spermatis. In this species there appears a new complication of the organs which is far from easy to understand; the ringed tubes (*ta*), instead of terminating at or shortly after their entrance into the sacculus, continue in an almost straight line nearly to the middle of that organ, and there the two are joined, within the sacculus, by a small oval sac which communicates with each tubulus. There is, springing from the middle of this inner sac, a short, straight, and extremely fine tube running to the cornu.

Fig. 61 represents the sacculus of a small species found in Tyrol, and bearing considerable external resemblance to *Holotaspis montivagus*, but which I am unable to identify, because I dissected the one or two specimens which I found. I mention it because the structure of the organs I am describing is in some respects intermediate between the species last described and the next. Here the sacculus is rather small and bag-shaped; it stands free without cornu or rami or any apparent communication with the camera spermatis or the ovary; its only attachment seeming to be the ringed tubes which enter it at the corners, and terminate by bulbous endings within the sacculus.

*Laelaps cuneifer* (fig. 62) is constructed much on the same model; the sacculus is free, without cornu or rami; the ringed tubes, however, enter close together on the underside of the sacculus, and terminate where they enter it without continuing inside.

*Holotaspis montivagus* is the species where neither Prof. Berlese, who originally described it, nor I have ever found the male. I have considerable doubt whether the mode of classification, which includes this and *H. marginatus* in the same genus, be not an artificial one; but this is not the place to discuss that question. In this species there is a new and puzzling complication; it seems to partake of some of the characters of *Holotaspis marginatus* and some of those of *Laelaps cuneifer*. The lyrate organ (fig. 63, *ol*) is large and well-developed; it shows the ordinary cellulation with strongly-marked nuclei; these extend on to a portion of the exterior of the camera spermatis, but not all over it. The sacculus (*sa*) is rather small and globular; it is entirely free, not attached except by the ringed tubes; these enter the sacculus as in *H. marginatus*, and continue until near the centre; but there, instead of both terminating in a single oval sac as in *H. marginatus*, each ringed tube ends in a little hollow ball with rather

chitinized walls, the two not quite touching. The strangest part of the construction, however, is that between these two little globes, and attached to both, and I think (but of this I am not certain) communicating with them, is a third little hollow, slightly chitinized, vesicle, which is not quite a sphere, and from the outer end of which proceeds a fine serpentine tube, with a bulbous end, which tube is wholly within the sacculus and does not emerge at all. The sacculus, with the spheres and spheroid looking together like a trefoil, and the third tube are seen *in situ* in fig. 63, and the trefoil, &c., dissected out at fig. 64; both are carefully drawn from actual dissections; a sagittal section through the sacculus, showing one globe and the central spheroid and tube, will be found at fig. 71, *sa* (Pl. XXXV.).

The last species in which I shall describe these organs is a new one found in Tyrol. I propose calling it *Laelaps ligoniformis* (fig. 65). In this curious creature the lyrate organ is fully developed, but there is not any sacculus, cornu, or rami, only the ringed tubes; these run direct to the camera spermatis, and the two tubes join just at the point where they enter the camera. In this species there exists something not found in any of the others, viz., at or about the point where each ringed tube has its mouth in the acetabulum of the leg there is a small elliptical receptacle (fig. 66), about 40  $\mu$  in long diameter, communicating with the exterior by a short stalk about 17  $\mu$  long. I had not enough specimens to investigate this species properly.

All the sacculus organs in all species are apt, when empty, to shrivel up and be almost impossible to find; but they may then often be found by placing the creature, after the dorsal plate has been dissected off, in water, when they fill by endosmosis and expand.

It is to be remembered that the sacculus organs and ringed tubes are apparently correlated with the lyrate organ. I have not found the one without the other in any species; *L. ligoniformis* is the nearest approach, but even there the ringed tubes are present, while none of the species of the *G. crassipes* type, which I am acquainted with, show any trace of either organ.

We now come to the question of the contents and function of the sacculus fœminæ and its associated parts or diverticula. Of course the first obvious suggestion of function, from the ending of the ringed tubes in the acetabula of the third legs, would be that the whole structures were coxal glands; but, apart from the contents of the sacculus, the equally obvious reply is that these organs exist only in the female, and that if they were coxal glands they would exist in both sexes, as is the case with the supereoxal glands of the Oribatidæ, and the coxal glands of such other Acarina as are known to possess those organs, including, according to Winkler, the Gamasinæ, where they are very small and totally unlike the organs I have been describing. Winkler figures them in the male.

The presence of the organs in the female only seems to confine our suggestions as to their function to the generative system; and all the other evidence which I have obtained confirms this view. Omitting for the moment the very specialized species *Holotaspis marginatus* and *H. monticagus* and their one or two allies, all the other species investigated which possess the sacculus and its appendages usually have contents therein. Taking again *Hemogamasus horridus* and *H. hirsutus* as convenient

types, it will be seen by Pl. XXXIV. figs. 48, 49, 53, &c. that the sacculus and cornu usually contain a number of loose bodies, varying in quantity and mixed up with a thickish fluid and granular or minutely filamentous matter. If the testes of the males of these respective species be examined, and the most mature spermatocysts be compared with the bodies contained in the sacculus of the female and its cornu and diverticula, it is impossible to avoid noticing the extreme similarity of the two: those in the sacculus &c. are usually a little smaller than those in the testis, and show signs of having been subjected to rather more pressure; often they have burst and are mere empty shells, but the perfect ones retain the shape and appearance of the male spermatocysts. If a male *H. hirsutus* be killed at that stage of the coitus when the spermatie capsule has been filled but not discharged, and if the capsule be allowed to discharge upon a glass slip and its contents be compared with those of the sacculus of a female freshly killed, immediately after the completion of the coitus, the identity of the two cannot be doubted (Pl. XXXII. figs. 24, 25).

In *Laelaps vacua* the commonest form of the ripe spermatocysts in the testis of the male is rather special; it is what I believe is known as the "curved dumb-bell" shape in sponge-spicules (Pl. XXXIII. figs. 27, 28). This is also the commonest form amongst the bodies found in the sacculus fœmineus, and the two agree in other respects besides form. It is indeed a fact that in all species examined the spermatocyst in the male testis has an appearance more or less peculiar to the species; and that, in spite of slight variation, the bodies in the sacculus usually fairly correspond to the ripe spermatocysts; also that if the latter can be obtained from the spermatie capsule of the male and from the sacculus of the female immediately after coition that resemblance amounts to identity as far as I have been able to investigate the matter. There are, however, some species, such as *Laelaps cuneifer*, *Holotaspis montiragus*, *Holotaspis marginatus*, &c., where the sacculus never contains spermatocysts, but only fine granular matter if anything, which may or may not be spermatozoa; but in these species there generally is not any connection between the cornu and the camera spermatis.

It may, I think, therefore safely be said that the contents of the sacculus are the products of the male genital organs.

In cases where the sacculus has contents but they are small in amount, which most usually occurs where the creature is oldish and the ova very fully developed, or the ovary nearly or partly exhausted, the whole contents will generally be found collected in the cornu. If the organs be fuller, then the sacculus itself and, in *H. hirsutus*, the great globular diverticula are amply supplied, occasionally almost full. If the last-named species be killed immediately after coitus, then the rami will be found to be full also; but the contents, in the cases I have seen, very soon slip out of the rami into the sacculus. I have not been able to obtain *H. horridus* in coitû.

The question arises, how do the spermatocysts get into the sacculus? There appear to be only two possible methods—the one that they are ejected from the spermatie capsule into the vagina, pass thence all along the oviduct, through the camera spermatis and perhaps part of the ovary, thence into the cornu, and then into the sacculus and its diverticula, and even into the rami, whence they finally return, as required, by the same road to the camera spermatis. This seems an extremely elaborate and not very probable

mode, but it has in its favour the fact that the vagina is a large opening, and that such species as *Gamasus crassus* and *G. crassipes*, which have not any sacculus or correlated organs, but which have a spermatheca in the vagina itself, are, as shown at page 296, fecundated by that opening.

The other possible method is that the products of the male organs are ejected from the narrow mouth of the capsule into the more or less trumpet-shaped mouth of the ringed tubes in the cuticle joining the coxa of the third leg to the more chitinized part of its acetabulum, and pass directly up the ringed tubes into the sacculus; this is a sufficiently simple method, and is rendered more probable by the similarity of the situation of the opening to that by which *Astacus* and many other Crustacea and Myriapoda are fecundated, although in these cases it is also the aperture for the deposition of ova. The only objection which I see to this is the fact that the spermatozoa found in the sacculus undoubtedly appear considerably too large to have passed through the ringed tubes; this is a serious difficulty, but it is possible, and even probable, that the ringed tubes may be capable of distension, and that the spermatozoa, which are soft bodies, are capable of compression, and can be forced through very small apertures, just as the eggs are forced through even hard, not distensible, openings which seem quite incapable of allowing them to pass. The weight of the objection is also considerably modified by the circumstance that it practically has to be faced in either explanation, for the large spermatozoa are found both in the cornu and the sacculus; and yet in *Laelaps acuta* the tube leading from the camera spermatis to the cornu and in *L. vacua* the tube leading from the cornu to the sacculus are scarcely larger in diameter than the ringed tubes, and yet if the spermatozoa be introduced into the vagina they must pass through both these tubes before they can get into the sacculus, but in the sacculus they are found abundantly.

I had hoped to settle this question by actual observation, but I have found that it is not possible to see sufficiently clearly to be quite certain whether the small end of the spermatheca is applied to the opening of the vagina or to the mouth of the ringed tube; the whole capsule is certainly not introduced into the vagina as it is in *G. crassus*, but the epigynum, which covers or borders the opening of the vagina, lies just between the third legs, and therefore just between the opening of the ringed tubes, and, being large, almost reaches them. In the position which the male and female occupy during the coitus, it is almost impossible to be absolutely certain whether the narrow end of the capsule, which lies between the mandibles of the male, is applied a little more or a little less to the side; but in the instances of *H. hirsutus* which I have watched it has appeared to me, as far as I could judge, that the mandibles were too far at the side for the vagina, and seemed much more like being at the mouth of the ringed tubes.

I have not even found spermatozoa or spermatozoa in the ringed tubes, but neither have I ever found them in the vagina or oviduct of any species possessing the sacculus or ringed tubes, although I find them abundantly in those situations in species which have not the ringed tubes.

It must be clearly borne in mind that in such species as *G. crassus*, *G. terribilis*, &c.,

where I know that the capsule is discharged into the vagina, there is a distinct spermatheca, usually filled with sperm, leading out of or forming part of the vagina, which does not exist in any of the species that possess the sacculus or ringed tubes. It is also worthy of remark that in the one species investigated which has not possessed either the sacculus or this vaginal spermatheca or recess (*Laelaps ligoniformis*) there is what I should judge to be a spermatheca (Pl. XXXIV. fig. 66) just at the opening of each ringed tube, and this does not exist in any of the other species.

It is also to be remembered that in most spiders, e. g. *Tetragnatha*, *Theridium 4-punctatum*, &c., the spermathecae do not open into the vulva, but have separate external apertures\*. In the spiders, or most of them, the spermatozoa are contained in spermatophores or spermatocysts.

Taking all these matters into consideration, I incline to think, although I should not like to state it as a fixed opinion, that in what I may call the sacculus species the sperm-elements enter the body of the female by the ringed tubes, and not by the vagina.

From the above-described facts, and particularly having regard to the great change which takes place in the sperm-elements of *Hæmogamasus hirsutus* between the time when they are found in the capsula spermatis and that when they enter the camera spermatis, I think that the following is probably the function and action of the female organs above described, viz. :—That the germ-elements are produced in the arms of the lyrate organ, and gradually work their way to the base of that organ, where they break off and pass into or by the base of the camera spermatis; that the sperm or spermatocysts enter the sacculus probably, but not certainly, by way of the ringed tubes and rami; that the spermatozoa are at that time not fully developed, and that they only attain their final development within the body of the female; that the sacculus with its cornu, and diverticula when present, is the organ in which this development takes place, and whose office it is to mature the spermatozoa; that when the spermatozoa are really ripe they pass out of the cornu into the camera spermatis; that there they meet the germs and fertilize them; that the ova then lodge in what is called the ovary and form oöcysts by the outpushing of its walls; that in these oöcysts they attain a considerable amount of development, although probably not as high a state of maturity as they will attain in the oviduct, whence they pass through the vagina to the exterior.

It may be suggested with considerable force that this explanation fails in the case of such species as *Laelaps vacua* and *L. cuneifer*, where there is not any apparent connection between the cornu and the camera spermatis or ovary; I cannot help thinking, however, that, although I have not found it, this connection must exist at some time of year or under some circumstances; I cannot otherwise understand the presence of abundant spermatocysts in the sacculus.

Finally it remains to account for the function of the organs in such a species as *Holotaspis montivagus*, with its three little hollow balls forming a trefoil within the

\* Bertkau, " Ueber den Generationsapparat der Araneiden," Archiv für Naturgesch. 1875, p. 285.

sacculus, and its small third tube entirely coiled away within the sacculus; but this, I confess, I am not able to do at present; it must remain for future investigation. I have little doubt that the third tube is the homologue of the tube which joins the cornu to the camera spermatis in *Laelaps acuta*, and it is possible that, under some circumstances, it may emerge from the sacculus and join the camera as in that species. The three chambers of the trefoil are not usually empty; they more generally contain very fine granular matter, which might possibly be spermatozoa, but certainly not spermatoeysts. It may be possible that in this species, where the male has never yet been found, the sacculus has become modified into an organ with other functions not yet understood; or it may even be possible that an agamous generation exists, and that the sperm-elements may be preserved in this singular receptacle from the mother within whose body the embryo becomes so highly developed; but these are only mere suggestions of possibilities, and I do not in any way put them forward as facts or even probabilities.

Another totally different but very interesting variation of the female genital organs of the Gamasinæ from Winkler's type (*G. crassipes*) is found in *Sejus togatus*, Koch. These parts are delineated in Pl. XXXIII. fig. 43. It will be seen how unlike they are to anything yet spoken of; they are a thorough return to the ring form. There is a single azygous central ovary (*ov*), having the appearance of a bunch of grapes—all the numerous larger eggs being in oöeysts on the exterior, and the germinal part more central. From the ovary proceed two oviducts (*od*), not one, as in all the other species we have been considering; these two oviducts join in an azygous vagina (*va*), out of which leads an immensely large, flask-shaped spermatheca (*spt*), which lies between the oviducts, has a narrow mouth and stalk, and powerful muscles attached evidently for the purpose of ejecting the contents. It is generally full of spermatozoa of the curious form shown by fig. 45. These spermatozoa are also found in the oviducts and ovary of the female.

The principal interest of these organs lies in the fact that, although very unlike what are usually found in the Gamasinæ, they closely resemble those of the other subfamily, the Uropodinæ; although the general appearance of the creature and the anatomy of the alimentary canal, and most other parts, are of the type of the Gamasinæ, not of the Uropodinæ. This relationship of the female is rendered more interesting from the fact that the male also shows certain affinities to the Uropodinæ.

#### THE ALIMENTARY CANAL.

I have not many variations to record in this system; one or two, however, that I have observed may be of some interest.

The ventriculus in most species of Gamasidæ is a smallish viscus, having a moderately large and wide caecal prolongation forward in the central line, and often a corresponding one backward. Two large and long paired sac-like cæca spring from its lateral anterior

part and run forward; and two pairs of similar but larger cæca spring from the lateral posterior part and run backward: these are arranged one above the other; the upper pair are the longer: they usually agree in both sexes.

In *Hæmogamasus horridus* the female agrees with the above description, but the male is entirely without the lower pair of hind cæca (Pl. XXXV. fig. 72).

In *Laelaps cuneifer* the anterior median cæcum is bifid at its anterior extremity, each half curling slightly outward in a rather singular hood-like manner; the anterior lateral cæca also are recurved at their distal ends in a form which I have not seen elsewhere; the hind central cæcum is very wide. I have omitted the drawing which I had made of this canal in order to relieve the already overcrowded Plates.

An interesting feature is found in the pharynx of *Hæmogamasus horridus*. It is well known that in predatory Acarina, and indeed in most that live by suction, the pharynx is the sucking-organ, and that it is provided with a special set of muscles beautifully adapted to dilate and contract it. This, which has been well described by Henking\*, MacLeod†, and others, is not confined to the Acarina, but is found also in many other Arachnida. Winkler also, in the paper so often referred to above, describes it well in *Gamasus crassipes*, and shows there that the lumen of the pharynx is an upright oblong with two branches at its upper end; he also mentions that its walls are somewhat chitinized; he gives excellent delineations of the musculature.

In dissecting *Hæmogamasus horridus* I was surprised to find that the development in the same direction had gone much further, and that there was an actual chitinized skeleton to the pharynx, forming a closed chitinous organ of a very definite shape and highly elastic; this is delineated by fig. 23 (Pl. XXXII.), from which it will be seen that the whole structure is lanceolate and comes almost to a point posteriorly, where the œsophagus arises from it; and is truncate anteriorly, where it joins the mouth. The organ is tricarinate, *i. e.*, if three carinæ of birds' sternæ were hollow and open at their proximal edges, and were placed with these edges together so as to form one common lumen, and to diverge from one another at equal angles, a very fair model of this pharyngeal skeleton would be obtained; but it is all one piece, without any break or space between the carinæ, which are firmly ankylosed to each other. Thus the lumen in a transverse section of the organ looks like a triradiate sponge-spicule (fig. 73, *ph*). It will be seen from the same figure that one carina goes perpendicularly downward, that the two others branch from it like the arms of the letter Y, and that the large distensor muscles are attached to the side-surfaces of all the carinæ; while the much smaller constrictors pass from one edge to the other, and are doubtless aided by the elasticity of the chitin. In spite of the small size it is quite possible to dissect this organ out, and fig. 23 was drawn from such a preparation, which is still in my possession.

It may be mentioned that in *Hæmogamasus horridus* and *H. hirsutus* the two great

\* "Beiträge zur Anatomie, Entwicklungsgeschichte und Biologie von *Trombidium fuliginosum*, Herm.," Zeitschr. f. wiss. Zool. Bd. xxxvii. (1883) pp. 569, 570.

† "La structure de l'intestin antérieur des Arachnides," Bull. Acad. R. d. Belg. 1884.

Malpighian vessels which are usually free are attached to the hind cæca of the ventriculus almost the whole length of the cæca.

#### EXCRETORY ORGANS.

In addition to the great Malpighian vessels there exist in some Gamasids, although apparently not in all, a pair of organs which I believe have not yet been recorded in the family; they lie in the side of the hinder part of the abdomen close under the skin, and are stout sacs discharging to the exterior by a pore in the cuticle. In *Hæmogamasus horridus* there are two such sacs on each side; they are flattened and the two are close together (Pl. XXXII. fig. 22). They have been practically similar in the other cases where I have found them. These organs are well known in other Acarina, *e. g.* in the Tyroglyphidæ, where Claparède noticed them as long ago as 1868\*, in the Oribatidæ, where I described them and called them the expulsores vesicles †, &c. They contain a yellowish oily fluid, and have been generally admitted to be excretory organs; they appear to be sacs closed on the interior side, their only opening being external.

#### MUSCULATION.

I do not find that the extremely pretty levatores ani muscles, and the neighbouring muscles which serve to compress the hind part of the abdomen dorso-ventrally, have been figured or described. Fig. 74 (Pl. XXXV.) is from a transverse section of *H. hirsutus* passing through the anus, and the musculature will be so readily understood from that drawing that I do not think I need describe it. The drawing is made from a preparation of a specimen killed with boiling water, and the anus is consequently rather unnaturally protruded, but I selected it as showing the construction better than other specimens where this had not occurred.

#### SUMMARY.

For the convenience of those who wish to see at a glance whether this paper contains anything likely to interest them I beg to summarize it as follows.

I suggest that it contains:—

1. A series of observations on the coition of the Gamasinae, showing a mode previously quite unknown except from a partial description of a single case formerly recorded by me; and only less curious than that of the spiders, but entirely different therefrom.
2. Some considerable differences in the male sexual organs from any previously

\* "Studien an Acariden," Zeitschr. f. wiss. Zool. xviii. Bd. pp. 445, 546, Taf. xxxv.

† 'British Oribatidæ,' Ray Soc. p. 179.

described in the family, and some singular cases of the formation of spermatozoa and spermatocysts not previously recorded.

3. A description of a set of organs in the female genital system not previously known, and which apparently serve chiefly for the maturation of the sperm-elements within the body of the female, with the varieties of these organs in numerous species, also some other not unimportant variations in the female reproductive organs from any hitherto recorded in the family.

4. A description of the female reproductive system, not before known, of a member of the genus *Sejus* showing its similarity to those of the Uropodinae.

5. A description of a pharyngeal skeleton and some other points of interest relative to the alimentary canal.

6. A few other novelties of less importance in the internal anatomy of the Gamasinæ.

#### DESCRIPTIONS OF NEW SPECIES.

*HÆMOGAMASUS HORRIDUS*, sp. n. (Pl. XXXII. figs. 1-5.)

	♀	♂
Length without rostrum, about.....	1·4 mm.	1·16 mm.
Breadth, about .....	·77 „	·65 „
Length of legs, 1st and 4th pairs, without caruncle or ungues, about	1·3 „	1·1 „
„    „    2nd „ 3rd „    „    „    „    „	·90 „	·70 „

*Colour* darkish umber-brown.

*Texture.* Almost the whole dorsal surface is covered with a chitinous plate, which, however, is rather thin; it is smooth but not polished; there are not any markings on the chitin. The plate covers the fore part of the body but does not extend to the posterior end; a border of softer white cuticle is shown round the posterior and the greater part of the lateral margins, especially in the female.

*Shape* longish; nearly parallel-sided, but somewhat wider behind than in front; posterior end rounded, anterior slightly shouldered and narrowed in. Dorsal surface rather flat.

*Mandibles.* Those of the male are exceedingly curious; they are elaborate and difficult to describe; they will be best understood from fig. 3. The whole mandible is short and thick for the family; the fixed arm of the chela thick, not diminishing in thickness until close to the distal end, when it suddenly curves downwards like a parrot's beak; but the projection of the beak below is very slight. There are two minute teeth close to the beak; the rest of the arm is rather undulated than toothed. The movable arm of the chela is the more singular; it is a broad undulated piece without teeth until nearly opposite the end of the fixed arm, then there is a break or indentation on the under edge; from this point arises a great hook, which first curves forward, then turns strongly backward, almost parallel to its outward

course, and continues in that direction until near its origin, when it turns outward and upward and ends in a sharp point. At the place where the hook arises there are two discoidal or ovoid projections from the upper edge of the movable arm, the proximal smaller than, and somewhat overlying, the distal; these are less highly chitinized than the rest of the chela. The portion of the movable chela which works within the penultimate joint of the mandible forming the articulation is very large, and has a considerable-sized foramen in its upper part; from its lower part there projects a long narrow sac of cuticle, not much chitinized, and which stands free from the rest of the mandible and nearly reaches the indentation before the hook. The mandible of the female (fig. 4) has the distal end of the fixed arm of the chela much more gradually curved and thinner than that of the male; the two teeth behind it are much stronger, and there are two curious transparent blades which descend from its outer edge and appear like guides to the movable arm. Two very much smaller blades of similar material are found on the lower edge of the last-named arm, which otherwise has not anything remarkable about it; it is entirely without the great hook of the male.

*Epistome* (fig. 5) hyaline, campanulate (with the broad straight end attached to the body), lateral edges curved downward; the whole free edge is bordered by a dense fringe of long fine hairs directed forward.

*Legs* near together, long; without apophyses in either sex; all legs terminated by long caruncles and claws, and furnished with numerous strong spines and hairs.

*Dorsal surface* densely clothed with short spine-like hairs, set in transverse wavy rows; the hairs longer than the distance between the rows, and alternate, so that the end of each hair overlaps the row behind and lies between two hairs of that row. These hairs all point backward except those at the edge, which stand slightly outward and form a fringe round the body. The hairs increase a little in length from the anterior to the posterior part of the body; the longest are those on the soft cuticle. Length of the hairs from about .03 millim. at the anterior to about .07 millim. at the posterior end of the body; distance apart laterally about .02 millim. There are two long straight hairs projecting over the rostrum.

*Ventral surface* haired. Anal plate small, inversely pyriform; there are three long hairs behind it. Genital plate of female sac-shaped, widest posteriorly, attached by its whole surface, not hinged; its anterior edge bordered by a fine membrane. Genital aperture of female a curved transverse slit. There are two small curved metapodic plates, one on each side of, but some distance from, the genital plate. Stigmal plates narrow and curved. Sternal plate with distinct scale-like markings.

*Habitat.* Found commonly, but not abundantly, in the nests of the Common Mole (*Talpa europæa*) in England. The young may probably be parasitic on the Mole, as I do not often find them in the nest.

## HÆMOGAMASUS NIDI, sp. n. (Pl. XXXII. figs. 6 and 7.)

	♀	♂
Length without rostrum, about .....	·94 mm.	·72 mm.
Breadth, about .....	·51 "	·40 "
Length of legs, 1st and 4th pairs, without caruncle or unguis, about	·78 "	·60 "
"    "    2nd " 3rd "    "    "    "    "    "    "	·53 "	·15 "

This species is so like *H. horridus* in general appearance that I have not thought it useful to draw a figure of it; there are, however, well-marked anatomical differences; it is also much smaller and lighter in colour. Its movement is different from that of *H. horridus*; *H. nidi* moves in little jerks or springs, *H. horridus* does not.

*Colour* yellow-brown, not very dark.

*Texture.* The whole, or almost the whole, dorsal surface is covered with a chitinous plate; the chitin, however, is very thin, and allows the Malpighian vessels and often the ventriculus to be plainly seen through the dorsum; it is smooth, but not polished; there are not any markings on the chitin. Sometimes a narrow border of soft cuticle is seen round the hinder part of the body, especially in the female, but not nearly so wide or conspicuous as in *H. horridus*.

*Shape.* Long, almost parallel-sided; posterior end rounded, anterior slightly shouldered and narrowed. Dorsal surface rather flat.

*Mandibles* of the male (fig. 6) with the fixed arm of the chela gradually diminishing in thickness and curving downward, forming a slightly recurved pointed claw-like ending; there is one strong tooth far back. The movable arm is a very powerful strongly curved piece which overlaps the fixed arm, when closed, some distance behind the point of the latter. From the outer side of the movable arm springs a large doubly-curved accessory piece, which extends a little beyond the end of the fixed arm, and curves upward; it is truncated at its distal end; but at the inner edge of the truncated surface arises a sharp spine, directed perpendicularly upward close to the end of the fixed arm; there is also a second accessory piece almost hidden by that last described.

*Epistome* (fig. 7) rather irregular, sub-triangular, with rounded apex and concave sides; the greater part of the lateral edges and the distal edge are fringed with processes which can hardly be called hairs, but are rather long ragged projecting pieces of the material of the epistome itself; they are not set close together nor bisymmetrically on the two lateral edges.

*Legs* rather near together, long and thin, without apophyses in either sex. All legs terminated by long-shaped caruncles and claws. Legs furnished with numerous curved hairs and spines.

*Dorsal surface* densely clothed with short spine-like hairs set in transverse wavy rows, the hairs slightly longer than the distance between the rows, and alternate; they all point backward except those at the lateral edge, which stand slightly outward and form a fringe. The hairs increase a little in length from the anterior to the posterior end of the body; the longest are those on the soft cuticle. Length of

hairs from about .02 millim. at the anterior to about .04 millim. at the posterior end of the body; distance apart laterally about .01 millim.

*Ventral surface* haired, all the plates of very thin chitin; anal plate small, inversely pyriform. Genital plate of female larger than in *H. horridus*, widened and rounded posteriorly, attached by its whole surface. Genital aperture of female a transverse slit. There are two little lateral metapodie plates as in *H. horridus*; stigmal plates curved and very thin.

*Habitat.* Found abundantly in the nests of the Common Mole (*Talpa europæa*) in England.

*LLELAPS ORIBATOIDES*, sp. n. (Pl. XXXII, figs. 12-15.)

	♀	♂
Length without rostrum, about	.77 mm.	.47 mm.
Breadth, about	.47 "	.38 "
Length of legs, 1st pair, without caruncle or unguis, about	.60 "	.48 "
"    "    2nd "    "    "    "    "	.46 "	.36 "
"    "    3rd "    "    "    "    "	.42 "	.33 "
"    "    4th "    "    "    "    "	.57 "	.50 "

The female of this species may generally be recognized among its neighbours of the same locality by two large black spots on the dorsum, near the posterior end, which are really produced by the excretory organs showing through the cuticle.

*Colour* yellow-brown, not very dark.

*Texture.* The whole dorsal surface is covered by a single unbroken chitinous plate; the chitin is rather thin, and is entirely divided up, by very fine lines, into little scale-like or angular spaces, measuring rather more in a direction across the body than in the direction from anterior to posterior end; in the former direction averaging about .02 millim. No other markings; the chitin otherwise smooth, but not polished.

*Shape.* Almost elliptical, very slightly shouldered in front, rather rounder posteriorly.

*Mandibles* of male (fig. 13). Fixed chela with a single sharp spine (the poison spine?); no other teeth. Movable chela not much longer than the fixed, broad and divided into three parts, viz.: (1) the principal piece of the arm, which is truncated almost at a right angle to its lower edge, and has its upper distal end a long curved point; there is one strong median tooth; (2) a long narrow slightly undulated accessory piece projecting beyond No. 1; (3) a broad outer lamina about as long as the accessory piece, and having a rounded end with a notch in it.

*Epistome* (fig. 15) rounded, with a few small triangular or tooth-like projections on its distal edge, and a few fine radiating markings on its proximal dorsal surface.

*Legs* not very long, second pair the thickest; without apophyses in either sex. All legs furnished with not very numerous hairs, and with roundish caruncles and very fine claws.

*Dorsal surface* provided with fine hairs, set not very near together in irregular transverse rows, the hairs slightly longer than the space between the rows; they all point



*Dorsal surface* with four longitudinal rows of about ten spines on the dorsum, and two rows, or a double row, all round the periphery except just the anterior edge, on which there are two fine spines, near together, projecting forward. The dorsal spines are sparsely set, increase greatly in size from the anterior to the posterior end of the body, and do not overlap, except at the rear. The anterior spines are sharply pointed; those of the female about .03 millim. long: the hind spines are very thick, blunt, and spatulate; those of the female about .12 millim. long.

*Ventral surface.* Female with anal plate fused with ventral, very large, covering half the abdomen, and divided by fine lines into scale-like spaces. Genital plate almost touching the fused ventral and anal. It is bell-shaped, *i. e.* rounded anteriorly, straight posteriorly; a central triangle with the point forward is the most chitinized part in this plate; the peripheral band is also chitinized, but two lenticular spaces between are slightly chitinized and look almost like foramina. Sternal plate normal; there are two small plates near its anterior edge and two near its posterior corners. Stigmal plate almost straight, but clavate posteriorly. The male, in addition to the usual sexual differences of the plates, has in the middle of the ventro-anal plate, and about midway between the anus and the coxæ of the fourth leg, a large and singular projection standing straight downward and formed like a short length of coneave gutter (half tube), from the lower edge of which project two large chitinous apophyses, much more strongly chitinized than any other part of the body. There are three or four spines round it. I do not know the function of this organ. It has the appearance of a male genital armature, but the ordinary male genital aperture is quite plain and unmistakable in its usual place at the other end of the body, *viz.* just in front of the anterior edge of the sternal plate.

*Habitat.* I found a very small number of specimens near Innsbruck, in Tyrol, on the stumps of dead pine-trees, and while this paper has been passing through the press I have found the species in large numbers in England on the underside of fungi growing on old tree-stumps at Goring in Oxfordshire.

I regret that want of space on the Plates has prevented my figuring the ventral surface of this creature.

#### EXPLANATION OF THE PLATES.

A. Anus.

*ac.* Acetabula for insertion of the coxæ of the legs. The figures 1, 2, 3, 4 refer to the 1st, 2nd, 3rd, or 4th pair of legs.

*ap.* Anal plate.

*bp.* Bipilate appendage (Winkler's labium, Kramer's "Bauchtäster").

*br.* Brain (so-called). The small dark cells are the cortical or corpuscular layer, the rest the inner or fibrous mass.

*cæ.* Front cæcum of the ventriculus.

*cæ<sup>1</sup>.* Upper hind cæcum of the ventriculus.

*cæ<sup>2</sup>.* Lower hind cæcum of the ventriculus.

- cas.* Capsula spermatis (Spermatic capsule). See page 294.
- cc.* Chitinous cuticle.
- cl.* Cloaca.
- cm.* Soft (flexible) cuticle.
- cms.* Camera spermatis (Sperm-chamber). See pages 299, 300.
- cs.* Cornu sacculi (the horn of the sacculus). See page 301.
- ct.* Connective tissue.
- dc.* Ductus ejaculatorius.
- dy.* Cells considered by Winkler to be dermal glands.
- dp.* Dorsal plate.
- ep.* Epistome (dorsal anterior edge of the oral tube, or rostrum).
- epy.* Epigynum (external genital plate of the female).
- eph.* Epipharynx.
- fc.* Fat-cells.
- ga.* Genital aperture of the male.
- gla.* Accessory glands of the male genital system.
- hd.* Hypodermis.
- hg.* Hind gut.
- hs.* Hypostome (ventral anterior portion of the oral tube).
- l.* Leg, the figures 1, 2, 3, 4 indicate the 1st, 2nd, 3rd, or 4th pair.
- la.* Levatores ani muscles.
- m.* Muscles of the legs; the figures show the pair of legs.
- md.* Mandibles.
- mdr.* Retractor muscles of the mandibles.
- mph.* Pharyngeal muscles (page 310).
- mr.* Retractor muscles of the rostrum.
- msp.* Suspensory muscles of the tendinous platform (episternite).
- mv.* Malpighian vessels.
- nn.* Mandibular nerve.
- O.* Ovary (see note on page 297).
- od.* Oviduct (see page 298).
- w.* Œsophagus.
- ol.* Lyrate organ (see page 298).
- ov.* Ova.
- ove.* Ovum with nearly matured embryo.
- ovs.* Ovum with yolk-segmentation.
- P.* Palpus.
- ph.* Pharynx.
- pt.* Peritreme (stigmatic canal).
- R.* Rostrum.
- rs.* Rami sacculi (see page 301).
- S.* Stigma.
- sa.* Sacculus fœmineus (see page 300).
- sd.* Diverticula of the sacculus fœmineus (see page 302).
- sg.* Salivary gland.
- sm.* Sperm-mother-cells.
- sp.* Stigmal plate.
- spt.* Spermatheca.
- st.* Sternal plate.
- sz.* Spermatozoa.
- T.* Testis.
- ta.* Tubuli annulati (ringed tubes). See page 301.
- tp.* Tendinous plate for attachment of muscles (episternite).
- tr.* Tracheæ.
- V.* Ventriculus.
- va.* Vagina.
- vd.* Vasa deferentia.
- vp.* Ventral plate.

In all drawings of whole organs, or of groups of organs, except figures 40, 49, 66, the top of the Plate is the anterior end. This does not apply to sections.

#### PLATE XXXII.

Fig. 1. *Hemogamasus horridus*, ♀, sp. n. (page 312), dorsal aspect; × 35. Both mandibles are extruded.

Fig. 2. The same species, ♀, ventral aspect; × 35. The legs are cut short to save space. The ventral surface of the oral tube is shown anteriorly; its front part is the hypostome (maxillary lip), the central fringed triangle being the lacinia of Mégnin, and the two lateral pieces the

galeæ of the same writer. Behind the oral tube is seen the bipilate organ ("Bauchtäster" of Kramer, "labium" of Winkler, &c.); behind this, in the median line, the almost hexagonal sternal plate; then the genital plate with a membranous anterior edge, and a small crescentic metapodic plate on each side of it posteriorly; finally, the anal plate (inversely pyriform). The stigmal plates are along the edges of the anterior part of the body.

- Fig. 3. The same species: last two joints of one of the mandibles of the male seen from the outer side;  $\times 350$ . The lowest lobe and the two smaller globular lobes of the movable arm of the chela are less chitinized than the other portions. The working or cardinal portion of the movable arm is sunk in the fixed arm, and is only shown, as though the latter were transparent, in order to exhibit its unusual form and elliptical foramen.
- Fig. 4. The same species: chela of one of the mandibles of the female seen from the outer side;  $\times 350$ . The two laminae on the under-edge of each arm of the chela are less chitinized than the rest of the organ. The fixed arm of the chela in all Gamasid-mandibles is the upper arm.
- Fig. 5. (Near right lower corner.) The same species: epistome of the male seen from above;  $\times 350$ . It is very hyaline, but the basal triangle is rather more chitinized than the remainder. The radiating lines springing from this are markings, not hairs.
- Fig. 6. *Hemogamasus nidi*, sp. n. (page 314): chela of one of the mandibles of the male from the outer side;  $\times 380$ .
- Fig. 7. The same species: epistome seen from above;  $\times 350$ . It is very hyaline; the radiating lines near the centre are markings, not hairs.
- Fig. 8. *Hemogamasus hirsulus*, ♀, dorsal aspect;  $\times 15$ . This drawing is to show the course of the alimentary canal and Malpighian vessels; it is taken from a young, but mature, living specimen, the internal organs showing through the dorsal surface in consequence of the transparency of the cuticle. The spines and hairs are omitted for the sake of clearness; the legs also are omitted. The oral tube (rostrum) is in outline; the epistome is seen between and above the extruded mandibles; the irregular-shaped<sup>2</sup> plate of thin chitin on the dorsal surface is semi-transparent, and varies in form in every specimen. The small ventriculus, with its great anterior and upper posterior caeca, is dark (as in nature when the creature is recently fed); the Malpighian vessels are almost white (as in nature when seen by reflected light). The cloaca is shown, looking globular near the centre of the posterior end, between the distal terminations of the caeca. The striated part is the soft cuticle.
- Fig. 9. (Near centre of lower part of Plate.) The same species; chela of one of the mandibles of the male from the outer side;  $\times 650$ . The lobate proximal portion of the fixed arm is flat (a blade) and is very hyaline.
- Fig. 10. The same species: epistome of female seen from above;  $\times 350$ .
- Fig. 11. The same species: epistome of another female seen from the same direction and magnified to the same extent, in order to show the variation in different specimens. Both this and fig. 10 are carefully made from actual examples.
- Fig. 12. *Lalaps oribatoides*, sp. n. (page 315), ♀, dorsal aspect;  $\times 65$ . The two conspicuous black spots arise from the excretory organs showing through the cuticle. The mandibles are retracted.
- Fig. 13. The same species: chela of one of the mandibles of the male seen from the outer side;  $\times 355$ . The sharp spine on the fixed arm of the chela is probably a poison-fang.
- Fig. 14. The same species: chela of one of the mandibles of the female seen from the outer side;  $\times 300$ .
- Fig. 15. The same species: epistome of female seen from above;  $\times 300$ . The organ is very hyaline, but the sub-triangular space at the base is rather more chitinized than the rest. The lines running forward from it are markings, not hairs.

- Fig. 16. (Left lower corner.) *Laelaps* (?) *ligoniformis*, sp. n. (page 316), ♀, dorsal aspect; × 75. Mandibles almost entirely retracted.
- Fig. 17. (Near 16.) The same species; chela of one of the mandibles of the male from the outer side; × 600.
- Fig. 18. *Holotaspis montivagus* (page 287): distal portion of the epistome of the female; × 345. This organ is hyaline; the smaller, central, Y-shaped projection not so much as the rest. The basal part of the organ, which is not drawn, is simply a continuation of what is drawn, forming a sub-triangular lamina with slightly rough edges. The wavy lines shown on the figure are markings, not hairs.
- Fig. 19. (Middle of right edge.) *Gamasus crassus*, Kramer (page 296): chela of one of the mandibles of the male seen from the outer side; × 190. The obovate foramen is seen in the movable arm, and the extremely minute poison-fang and duct (?) in the fixed arm.
- Fig. 20. The same species: epistome of male, three-quarter view from above; × 190. It is placed in this position in order to show how the distal end curves downward. The large central triangle is hollow and contains fine cellular matter; the peripheral part is dense chitin.
- Fig. 21. The same species: epistome of female seen from above; × 190. Wholly chitinized.
- Fig. 22. Expulsory vesicle from one side of *Hæmogamasus horridus* (page 311); × 65.
- Fig. 23. Pharyngeal chitinous skeleton of *Hæmogamasus horridus* (page 310), three-quarter view from below; × 170. The truncated (upper) end is the oral end; the small piece of tube springing from the lower (pointed) end is the commencement of the œsophagus.
- Fig. 24. Four ripe spermatozooids taken from the proximal end of the testis of a male *Hæmogamasus hirsutus* immediately after dissection in water containing a small quantity of potassium acetate; × 400.
- Fig. 25. Five spermatozooids taken from the sacculus femineus of the female of the same species immediately after dissection in similar liquid; same amplification.

## PLATE XXXIII.

- Fig. 26. Four spermatozooids taken from the ripest found in the testis of an adult male *Laelaps acuta* immediately after dissection; × 150.
- Fig. 27. Group of spermatozooids taken from the testis of an adult male *Laelaps vacua* immediately after dissection; × 300. The lowest are the ripest.
- Fig. 28. Three spermatozooids taken from the cornu sacculi of a female of the same species immediately after dissection; × 300.
- Fig. 29. The whole genital system of an adult male *Gamasus terribilis* (page 290), × 55, showing the two testes joined by a thin central band, the azygous ductus ejaculatorius, and the great accessory gland.
- Fig. 30. (Right middle.) The whole genital system of an adult male *Laelaps cuneifer* (page 292); × 70. The organs are in the natural position, as seen from above; the testis transversely across the body. The testis and vasa deferentia nearly hide the great accessory gland.
- Fig. 31. (Left top corner.) The same system from the same species; × 150. The testis is turned over backward, and the vasa deferentia extended, so as to show the bifid distal end of the accessory gland.
- Fig. 32. (Below fig. 30.) Terminal portion of the testis of the same species, × 300, showing the early condition of the sperm-mother-cells and their development into riper spermatozooids. The mature spermatozooid is very large in this species.

- Fig. 33. The anterior portion of the genital system, but without the testis, of an adult male *Laelaps lœvis*; to show the two elliptical accessory glands (page 292) with the constriction at their points of discharge. A single spermatoeyst is travelling down one vas deferens. This was so in the actual specimen.
- Fig. 34. (Left middle.) Sagittal median section through the testis of *Laelaps lœvis*,  $\times 150$  (page 292), showing the developmental history of the sperm-mother-cell and spermatozoa, so far as it takes place in the testis.
- Fig. 35. (The lowest line.) This is a series of drawings, numbered consecutively in small figures 1 to 11. It illustrates the history of the development of the sperm-mother-cells and spermatozoa in *Gamasus crassus* (page 293); all drawn,  $\times 170$ . These are all taken from the testis of the male; the latest stage is to the right, but those found in the female are usually even more filamentous.
- Fig. 36. (Right lower corner.) Outline of the rostrum (oral tube) and sternum, &c., seen from below, of a male *Hæmogamasus hirsutus* killed *in coitu* in an early stage of the coitus; showing the spermatie capsule still in the genital aperture of the male, and not yet full-sized nor containing spermatoeysts;  $\times 70$  (page 295).
- Fig. 37. Spermatie capsule of the same species at its largest size,  $\times 70$ ; taken from a male killed *in coitu* at the moment when the spermatie capsule is about to be removed from the genital opening of the male by the mandibles of the male; it is now full of spermatoeysts, &c.
- Fig. 38. Rostrum, mandibles, &c., seen from the side, of a male of the same species killed *in coitu*, at the end of the coitus, after the contents of the spermatie capsule had been discharged and after it had contracted by its elasticity;  $\times 145$ . The rostrum has been dissected out; the empty capsule is seen with its small end held between, and attached to, the two mandibles. The lower part of the rostrum is shown in optical section, in order to exhibit the pharynx and its musculation.
- Fig. 39. Rostrum, mandibles, &c., seen from the side, of a male *Laelaps cuneifer*, killed *in coitu*, at the same stage of the coitus as the last figure;  $\times 150$  (page 295). The spermatie capsule is in a similar condition.
- Fig. 40. One mandible, seen from the side, of a male *Gamasus crassus* killed *in coitu*;  $\times 110$  (page 296). The greater part of the mandible and the whole spermatie capsule were inside the vagina of female, and were dissected out after death. The spermatie capsule is seen passing through the foramen in the movable arm of the chela of the male mandible. The anterior end of the capsule has been fractured and destroyed; its contents have been discharged.
- Fig. 41. Genital aperture of a male of the same species killed *in coitu* at the moment when the spermatie capsule is about to leave the aperture,  $\times 110$ , showing the mode in which the end of the spermatie capsule, which emerges last, is folded over.
- Fig. 42. Spermatheca of the female of the same species;  $\times 100$ . It arises as a stalked diverticulum from the anterior end of the vagina, above and between the inner chitinized labia.
- Fig. 43. (Left lower corner.) The whole genital system of an adult female *Sejus togatus* seen from above;  $\times 300$ . It shows the racemose form of the ovary, the paired oviducts, and azygous vagina, all resembling *Uropoda* (page 309). The large central sac is the spermatheca, from which proceed muscles which are omitted in this figure.
- Fig. 44. (A little to the right.) The spermatheca of the same creature seen from the side;  $\times 100$ . This is to show the muscles attached to its hind and ventral surfaces.
- Fig. 45. (Left top corner.) A group of ripe spermatozoa taken from the testis of an adult male *Sejus togatus*;  $\times 300$ . Those taken from spermatheca of the female are precisely similar. Compare these with the penultimate form in *Gamasus crassus*, fig. 35, 10.
- Fig. 16. (Right lower corner.) General view of the alimentary and genital systems of an adult female

*Laelaps laevis*;  $\times 75$ . The figure is to give an idea of the arrangement of the parts relatively to one another; it is taken looking down from above, after the dorsal plate, the fatty matter underlying it, and such muscles as interfered with the view had been removed. The whole of the ventriculus and its anterior and its upper posterior caeca are seen (light); the lower posterior caeca just show (dark). The hind gut is hidden by the sacculus fœmineus and its cornu, which are in the centre, and by the ova. The most mature ovum, *ovs*<sup>2</sup>, must in one respect be considered diagrammatic, because it should have been drawn very much larger; but to have made it the full size would have greatly increased the size of the figure without corresponding advantage, and would have obscured parts of the caeca which I wished to show. The distal ends of the lyrate organ are seen (dark) projecting from below the anterior lateral caeca of the ventriculus. The œsophagus and pharynx are not drawn, as they are not in the part of the body where the genital and alimentary systems interlock.

Fig. 47. Terminal portion of one of the arms of the lyrate organ of an adult female *Hæmogamasus hirsutus*;  $\times 275$ . To show the cellulation, &c.

#### PLATE XXXIV.

Fig. 48. The sacculus fœmineus, with its upper appendages, &c., and the lyrate organ and ovary of an adult female *Hæmogamasus horridus* (page 297), *in situ*, seen from above;  $\times 60$ . The central part of the lyrate organ and of the ovary, and the camera spermatis and oviduct, are hidden by the sacculus, which contains numerous spermatoeysts, &c. The cornu sacculi contains similar bodies, and passes underneath to the camera spermatis. The rami and ringed tubes are extended.

Fig. 49. The same organs and the oviduct of an adult female of the same species seen from the side;  $\times 85$ . This is taken from a specimen which, although adult, was young, *i. e.* comparatively recently mature. The sacculus fœmineus is fuller of spermatoeysts than in the last figure, but the ova are very little developed. The arms of the lyrate organ would not descend so much *in situ*—they would be almost horizontal; they have been turned slightly downward to show the whole of the sacculus.

Fig. 50. (Right lower corner.) The same species. One of the tubuli annulati (ringed tubes) seen from the side,  $\times 175$ , to show the form of the mouth of the tube in the acetabulum of the third leg. The acetabulum is not shown, only the tube.

Fig. 51. The sacculus fœmineus, with its appendages and the lyrate organ, of an adult female *Laelaps stabularis*, seen from above;  $\times 100$ . These organs are not quite *in situ*: the cornu is straightened out to show its whole form; it would really curl more round the base of the lyrate organ. A few spermatoeysts are seen in the rami (as after recent coition).

Fig. 52. (Right margin.) The lyrate organ and ovary of an adult female *Hæmogamasus hirsutus* (page 302) seen from above;  $\times 85$ . The camera spermatis is seen in the centre.

Fig. 53. The sacculus fœmineus, with its two great globular diverticula and other appendages, of an adult female of the same species, seen from above;  $\times 75$ . Drawn from a specimen dissected in very dilute glycerine. The sacculus, cornu, and both diverticula contain numerous spermatoeysts; there are not any in the rami.

Fig. 54. (Left, near top.) Proximal termination of one of the tubuli annulati of an adult female of the same species in the corresponding ramus, seen from the side;  $\times 400$ . The globular termination within the ramus is extremely delicate and hyaline.

Fig. 55. (Lower left corner.) Distal termination, or mouth, of the same tube of the same creature, in the acetabulum of the leg, seen from the side, to show its form;  $\times 250$ .

- Fig. 56. (Centre of Plate.) The sacculus fœmineus, with its appendages and the lyrate organ, and ovary of an adult female *Laelaps oribatoides* (page 303), *in situ*, seen from above;  $\times 175$ . The two globular diverticula of the sacculus are seen, close together, above the lyrate organ. The long winding cornu sacculi contains all the spermatocysts, as is usual in oldish specimens; the eggs are attaining a considerable degree of development, but the most mature egg is not shown in the drawing. The ringed tubes are not shown quite to their distal extremities.
- Fig. 57. (Left margin.) Sacculus fœmineus and cornu and part of the ringed tubes of an adult female *Laelaps vacua* (page 303);  $\times 300$ . The cornu contains numerous spermatocysts, and some remains are seen in the sacculus; compare the former with figs. 27, 28. The tube between the sacculus and cornu is extended; *in situ* it is wound round the organ.
- Fig. 58. (Right lower margin.) Sacculus fœmineus, cornu sacculi, &c. of an adult female of a small *Laelaps*, sp. ? (page 303);  $\times 150$ . The spermatocysts are here seen both in the sacculus and cornu.
- Fig. 59. (Centre of upper margin.) Sacculus fœmineus, cornu, ringed tubes, lyrate organ, and camera spermatis of an old adult female *Laelaps acuta* (page 303), seen from above;  $\times 100$ . The tube from the cornu to the camera is extended by the sacculus and lyrate organ being moved further from each other than in nature. *In situ* the sacculus lies between and above the arms of the lyrate organ, and the tube winds round the former. The ringed tubes are cut short. The sacculus is turned a little on its side; *in situ*, its cornu is downward.
- Fig. 60. Sacculus fœmineus, cornu sacculi, ringed tubes, lyrate organ, and a few ova of an adult female *Holotaspis marginatus* (page 304), seen from above;  $\times 160$ . The short and singular cornu is between the sacculus and the lyrate organ.
- Fig. 61. (Centre of lower margin.) Sacculus and ringed tubes of an adult female of a small *Holotaspis*, sp. ? (page 304), seen from above;  $\times 150$ . There is not any cornu sacculi.
- Fig. 62. (Left margin.) Sacculus fœmineus, ringed tubes, and lyrate organ of an adult female *Laelaps cuneifer*, seen from above;  $\times 150$ .
- Fig. 63. (Right lower corner.) Sacculus fœmineus, ringed tubes, and lyrate organ of an adult female *Holotaspis montivagus* (page 304), seen from above. Organs *in situ*;  $\times 150$ .
- Fig. 64. The trefoil of three small sacs, &c., dissected out of the sacculus fœmineus of an adult female of the same species;  $\times 300$ .
- Fig. 65. (Near middle of left margin.) The lyrate organ, camera spermatis, ringed tubes, &c. of an adult female *Laelaps* (?) *ligoniformis* (page 305), seen from above;  $\times 150$ . There are not any sacculus fœmineus, cornu, &c.
- Fig. 66. Stalked receptacle (spermatheca?) found close to the mouth of the ringed tube on each side of the body of the adult female of the same species, seen from the side;  $\times 310$  (page 305). A small piece of the cuticle of the acetabulum of the third leg is seen on edge at the left of the drawing.

## PLATE XXXV.

- Fig. 67. Horizontal, rather thick, section of an adult female *Hæmogamasus horridus*, almost at the level of the dorsal surface of the brain, where that organ comes nearest to the dorsum;  $\times 75$ . The sacculus fœmineus, with part of its cornu, and a portion of each ramus are seen in the centre of the figure; the rami are practically shortened (*i. e.* the whole length is not seen), because from their bending downward the section cuts the dorsal wall of each ramus at its bend; thus the apparent cæcal anterior ending of each ramus is not the termination of that organ, but the place where the section strikes the curve. The ringed tubes would lie below the section. The distal portion of one arm of the lyrate organ is seen on each side, crossed by the rami. The

most mature egg is seen in a form which it often assumes, sometimes to a much greater degree, when about being forced through a narrow passage—*e. g.* the entrance of the oviduct. A small part of the upper portion of the brain is seen with the dark cells of the cortical layer at the edge; behind it is the œsophagus, cut through and looking like a ring, surrounded by numerous portions of the tendinous platform (episternite) and the muscles proceeding from it. The cloaca is cut about where the two Malpighian vessels enter, and shows a septum between. The greater part of the portion of these vessels which lies in the hinder half of the body is shown, but not the bend by which they reach the cloaca. Almost the whole of the upper hind cæca of the ventriculus is shown, and nearly the whole of the right anterior cæcum; the left is cut across.

- Fig. 68. Sagittal section of the posterior portion of an adult female *Hæmogamasus horridus*, cut a little to one side of the median line;  $\times 75$ . It shows the sacculus fœmineus, with a portion of its cornu and the commencement of one ramus lying above the ventriculus. Nearly the whole length of the oviduct and vagina is shown.
- Fig. 69. Transverse section of an adult female of the same species, cut through the insertion of the fourth pair of legs;  $\times 85$ . It cuts the sacculus fœmineus just at the point where the rami are starting from it. The arms of the lyrate organ are cut across.
- Fig. 70. Sagittal section of an adult female *Hæmogamasus hirsutus*, cut a trifle to the side of the median line;  $\times 70$ . It shows one of the great diverticula of the sacculus fœmineus cut through and also a part of the sacculus itself. The camera spermatis is full of filamentous spermatozoa, and the point where the arms of the lyrate organ join it is seen. Almost the whole length of the oviduct and vagina are exhibited.
- Fig. 71. Sagittal section of an adult female *Holotaspis montivagus*(?), cut precisely in the median line;  $\times 125$ . The sacculus is shown with the central and a portion of one lateral chamber of the trefoil (pages 304–305); also the tube proceeding from the central chamber and wholly contained within the sacculus. The lyrate organ, cut through, is just behind the sacculus. An egg has the embryo highly developed; a portion of the Malpighian vessels of the embryo is already functional and is filled with the usual contents; it is near the dorsum of the embryo. This large egg has, as generally happens, flattened the cloaca and pushed some of the surrounding organs somewhat out of position. The whole length of the œsophagus is seen passing right through the brain and entering the ventriculus; one mandibular nerve is also indicated. A salivary, or poison, gland lies below the mandibular muscles. The tendinous platform (episternite) is seen almost surrounded by the ventriculus. The tendency to the dome-like recess in the vagina is seen.
- Fig. 72. Transverse section of an adult male *Hæmogamasus horridus*, cut between the third and fourth legs;  $\times 120$ . The two great accessory glands are cut just where the large columnar cells of the hinder parts of the organs are fading into the more reticulated anterior portion; the testis is seen above in several blocks, showing sperm-mother-cells in various stages.
- Fig. 73. Transverse section through the rostrum of an adult female *Hæmogamasus horridus*, cut near the anterior end of the pharynx;  $\times 280$ . It shows the tricarinata (in section triadate) form of the pharyngeal skeleton (page 310) and the distensor and constrictor muscles.
- Fig. 74. Transverse section of an adult female *Hæmogamasus hirsutus*, cut through the anus;  $\times 200$ . It shows the levatores and constrictor ani muscles, &c. The creature was killed with boiling water, and consequently the anus is protruded rather more than would be natural.

X. *A Contribution to Indian Carcinology.* By J. R. HENDERSON, M.B., F.L.S.,  
Fellow of the University of Madras, Professor of Biology in the Madras Christian  
College.

(Plates XXXVI.—XL.)

Read 16th June, 1892.

#### INTRODUCTION.

THE Decapod and Stomatopod Crustacea referred to in this paper, though furnished by several distinct collections, are all from Indian localities, and it has therefore been found most convenient to incorporate the results of their examination in a single report. A large proportion of the species are contained in two collections, both of considerable size, the first formed by my friend Mr. Edgar Thurston, Superintendent of the Madras Government Museum, chiefly from stations in the Gulf of Manaar, the second by myself, from various localities in the Madras Presidency. Both collections were to some extent examined and the species identified in India, prior to my return to England on leave in 1891, and I fully anticipated that a short period of work at the British Museum would have enabled me to complete the identifications. But the time thus occupied proved much longer than I had calculated, a large portion of it being taken up with the examination of some of the commonest and longest known forms, which are certainly not so well known as they ought to be; and I may add that my later studies have convinced me that the working out of a large collection of shallow-water species cannot be satisfactorily accomplished in India.

While engaged in this work, Dr. Günther and Mr. Pocock, of the British Museum, kindly placed in my hands for examination a series of Indian Crustacea deposited in the National Collection, including a large number of specimens presented by the late Surgeon-General F. Day, C.L.E., and Mr. E. W. Oates, F.Z.S., which have enabled me considerably to enlarge the scope of this paper. Dr. Day's collection consists chiefly of the larger and better known Indian marine Decapods, from various localities, as well as a number of land and freshwater Crabs (Telphusidæ), and a large series of freshwater and marine Prawns, belonging to the genera *Palæmon* and *Penæus*, which have induced me to revise, to some extent, the characters of the Indian species belonging to the latter genus. Mr. Oates's collection, though not of large extent, includes a number of most interesting forms—principally *Macrura*—taken by dredging at depths of from ten to twenty fathoms, in the Gulf of Martaban, Burmah; and, as might be expected, it contains some of the species lately described by Dr. De Man, from the neighbouring Mergui Archipelago. In addition to these I have examined two small collections from Ceylon, the first consisting of between fifty and sixty species, which were sent me for identification

before I left India, by Mr. Haly, of the Colombo Museum, the second a small series of littoral forms, presented to the British Museum by Mr. H. Nevill.

From all these sources I have been able to identify two hundred and eighty-nine species, of which thirty-three are described as new to science, including two which are regarded as the types of new genera. The number of new species is perhaps smaller than might be expected in a collection the size of that reported on, but I may state that want of time has compelled me to set aside a considerable number, either not yet identified or believed to be new. In certain of the larger genera, e. g. *Pilumnus*, *Leucosia*, and *Alpheus*, I have attempted to name only the better known forms; for, till someone with access to types provides us with a revision of these groups, the determination of many of the species must remain uncertain, if not impossible. The material at my disposal has enabled me to reduce several previously constituted species to the rank of synonyms, and work of this kind is perhaps quite as important as adding to the list of known forms. Space and other considerations have forced me to make my remarks concerning previously known species as brief as possible, and I have only attempted to record the publications in which these are originally or most fully described, or where their synonymy is discussed; while, in regard to distribution, I have merely indicated the chief localities in which they have been previously found, and in the case of the less perfectly known species have added the authorities for these.

The limited knowledge we possess in regard to most groups of the Invertebrate fauna of India has more than once been commented on, and is noteworthy considering the length of time that the country has been inhabited by Europeans; indeed, as regards Crustacea, up to a comparatively recent date, there was less definite knowledge of the Indian fauna than of the fauna of many other Asiatic and Australasian countries. The older writers are often extremely vague in the localization of their species, but there can be little doubt that a large proportion of the Crustacea recorded under such general terms as "Seas of Asia," "Eastern Seas," or "East Indies," came originally from India. Fabricius and Herbst, towards the end of last century, described a considerable number of Indian species, and at a later period collections, chiefly from Pondicherry, found their way to Paris, and some of the species are recorded by Milne-Edwards, in his well-known 'Histoire Naturelle des Crustacés.' Comparatively few English naturalists in India appear to have paid any attention to this group, but collections, both comparatively small, were made by General Hardwicke and Colonel Sykes, and the first of these collections is frequently referred to by White in his List of the Crustacea in the British Museum. In more recent times the late Sir Walter Elliot, of the Madras Civil Service, formed a collection on the Coromandel coast which passed into the hands of the late Mr. Spence Bate, who refers to a few of the species in his Report on the 'Challenger' Macrura. The work of Professor Wood-Mason, Superintendent of the Indian Museum, Calcutta, is well known; during the last twenty years he has published valuable papers, more especially on the Telpusidæ, and during the past year a Report on the deep-sea Crustacea from the Bay of Bengal, taken by H.M.S. 'Investigator,' in which a number of new forms are described.

In 1857 the Austrian frigate 'Novara,' on a scientific voyage round the world, touched

at Madras, Ceylon, and the Nicobars, and Prof. Camil Heller, in his Report on the Crustacea of the Expedition, enumerates over one hundred species of Decapods and Stomatopods taken in these localities. Recently the Crustacea collected by the brothers Sarasin at Trincomali in Ceylon, and amounting to ninety-two species, have been recorded, and some new species described by Dr. F. Müller\*. But the most valuable contribution to the subject hitherto published is the Report by Dr. De Man, of Middelburg, on the Crustacea collected in the Mergui Archipelago by Dr. Anderson, late Superintendent of the Indian Museum, Calcutta. This Report, which was published in 1887-88, and forms vol. xxii. of the Linnean Society's Journal in Zoology, is valuable, not merely on account of its dealing with the first collection of any extent made in the Bay of Bengal, one which naturally comprised a considerable proportion of new species, but also on account of the careful manner in which the author has redescribed a number of common species, which had been imperfectly characterized by their first describers.

All naturalists who have worked at this group have felt the impossibility, in many cases, of determining the actual species which furnished the crude figures, or brief diagnoses, by means of which most of the commoner and more widely distributed forms have been handed down to us in the works of Herbst and Fabricius. Milne-Edwards appears to have interpreted the species of last-century writers, without an actual examination of their types, and any errors he may have made in consequence have been followed by most subsequent writers. It is therefore highly desirable, as De Man has suggested and partly done, to re-examine the earlier types, which were described in a manner that ampler material and increased knowledge have shown to be quite inadequate. In most cases where the original specimens are sufficiently well preserved to render their identity certain, and where there can be no doubt as to correctness of labelling, it is probably advisable to adopt the original designation, though whether a long-established and universally-adopted name should be displaced by the discovery of some forgotten specimen seems to me very questionable.

The greater part of my own collecting has been done at three differently-situated localities, some account of which, along with the chief features in their Crustacean fauna, I have ventured to draw up, such information being usually scanty in systematic works, where very often the writer has not been at the same time the collector of the specimens on which he reports.

The harbour of Madras, which may be taken as typical of the entire Coromandel coast, does not at first sight appear to offer much promise to the carcinologist, but more extended observation will show that it is far richer in species than could have been expected from the nature of the locality. On this coast the sea breaks at some distance from the shore in an almost constant surf, and the waves finally roll in on a low sandy beach, where the average range of the tide is not more than two or three feet. On the sandy shore species of *Ocypoda* (*O. platytarsis*, *O. macrocera*) are met with, running about towards the water's edge in countless numbers, chiefly in the

\* "Zur Crustaceenfauna von Trincomali." Verhandl. d. naturf. Gesellsch. Basel. Theil viii. 1887.

morning and evening, when the sun's rays are less powerful, and on the slightest sign of alarm they at once seek their burrows. One species of this genus (*O. cordimana*) is, however, a strictly terrestrial crab, and occurs at some distance from the sea, often living among the matted branches of a trailing convolvulus, which is frequently also the shelter of a sand-lizard (*Mabuia Bibronii*, Gray), and it may be seen even further inland, inhabiting the sandy soil of casuarina plantations. Hiding in the sand at low water, the curious anomurous forms *Hippa asiatica* and *Albunea symnista* are found, the former in particular being very abundant. On the stonework of the harbour, and in those few localities where rocks appear, species of *Grapsus* and *Plagusia* are seen clinging tenaciously to the surface by means of their sharp dactyli, which enable them effectually to withstand the force of the breakers among which they live. Outside the surf-zone is a belt of shallow water, with the bottom composed chiefly of broken shells and sand, in which the Crustacean fauna is undoubtedly rich. I have obtained considerably over one hundred species from it, and there are certainly many more yet to be discovered. All my gleanings from this belt come from the heaps of material thrown up on the beach by fishermen, who practise fishing by means of very long nets, taken out through the surf in catamarans, and afterwards drawn in on the shore. Here are found species of *Doclea*, *Egeria*, *Neptunus*, *Goniosoma*, *Malula*, *Calappa*, *Philyra*, *Dorippe*, *Diogenes*, *Thenus*, and *Squilla*, along with representatives of other genera in smaller numbers. Indeed, it is scarcely possible to examine the shore-heaps without finding the following species:—*Doclea hybrida*, *Goniosoma variegatum*, *Malula victrix*, *Philyra scabriuscula*, *Dorippe facchino*, *Diogenes custos*, and *Squilla nepa*, which are certainly those found in greatest abundance. Grey and sombre hues prevail among these species, which, doubtless, effectually protect them on a more or less sand-tinted bottom, while the comparative absence of fragile forms—the fossorial ones excepted—and the relative abundance of swimming species, *e. g.* Portunids, *Malula*, and the curious hermit-crab, *Spiropagurus spiriger*, indicate an exposed and turbulent habitat. In the Madras fish bazaars numerous species of *Penæus*, *Palæmon*, *Panulirus*, *Neptunus*, &c. are exposed for sale, for among the lower orders of the community size is apparently the sole criterion of edibility as regards Crustacea. The two edible species *par excellence* among Europeans are the large swimming crab (*Scylla serrata*) and the prawn (*Penæus monodon*), although some of the specimens sold under the latter designation belong to the genus *Palæmon*, and come from fresh water. The so-called “river” Cooum, the water of which is brackish only towards its temporary outlet, and everywhere much contaminated by town sewage, affords shelter to species of *Palæmon*, *Penæus*, and other *Macrura*. On its banks are seen the burrows of a large species of *Sesarma* (*S. tetragona*), and the crab itself may frequently be observed near the openings of drains, while the sand and mud-flats are honeycombed by species of *Gelasimus*. The tanks or freshwater ponds, and even the wells, are inhabited by species of *Palæmon*, *Telphusa*, and *Caridina*, the most conspicuous being the freshwater prawn *Palæmon carcinus*, which attains a considerable size, and the freshwater crab, *Telphusa Leschenaulti*. The burrows of *Telphusæ* may be seen almost everywhere, except in the most arid situations. Though the Madras coast is, by its physical conditions, peculiarly unsuited for dredging,

I have taken by this method, in the sheltered water of Madras harbour, several species which I have not met with elsewhere.

Stretching along the Coromandel coast, for a very considerable distance both north and south of Madras, is a system of shallow backwaters or lagoons running parallel to the sea-line, though often separated from the sea itself by an interval of a mile or more, and joined by means of canals into a continuous waterway. In certain places the backwater widens out to form large lake-like expanses, one of which, the so-called Pulicat Lake, is thirty-seven miles in length. For the greater part of the year this system is practically shut off from the sea, but during the rainy season the intervening sandy bar, at intervals, is either artificially cut, or forced by the surplus accumulation of water, the result being that the sea is allowed to enter and a certain admixture takes place. Porpoises and sharks find their way in at this time, while sea-snakes (*Hydrophiidae*) are often extremely plentiful, and indeed may be found throughout the year. The fauna is extremely rich, more especially in free-swimming organisms, and is decidedly marine in character, though the water, as already stated, is more or less fresh. I have taken with the tow-net large numbers of Schizopods, *Lucifer*, and other marine forms, in places where the water was freely used for drinking purposes by my boatmen. At night the surface often teems with brilliantly phosphorescent organisms, which on examination prove to be mainly the smaller Crustacea. One of the best hunting-grounds on the backwater is the village of Emore, about nine miles to the north of Madras, which formerly, before the hill ranges became so readily accessible by rail, was a favourite resort. Here is a considerable expanse of water, bounded on the landward side by low, flat, grass-grown plains, intersected by canals and creeks. In the lake, as it may be termed, *Scylla serrata* is very abundant, and large numbers are sent to the Madras market, while species of *Penaeus*, and the swimming Grapsoid crab, *Varuna litterata*, are no less characteristic. The sandy or muddy shores, close to the water's edge, are everywhere pierced by the narrow cylindrical holes of two species of *Gelasimus* (*G. annulipes* and *G. triangularis*). The curious habit peculiar to the males, of waving the larger claw as if beckoning, which has earned for them the title of "calling crabs," is by no means general in the two above-mentioned species; at least I have observed it on comparatively few occasions. What the object of this movement is I am unable to say, but when I noticed it a large number of individuals were simultaneously engaged in the act: the claw which is so enormously developed on one side of the body in the male sex is, in all probability, used as a hole-boring organ. Locally the Gelasimi are known as "dhobi crabs," doubtless from the resemblance of their beckoning movement to the manner in which the native washerman swings the clothes over his head in the act of pounding them against a flat stone. One of the commonest backwater Decapods is the hermit-crab, *Clibanarius padarensis*, lately described from the Mergui Archipelago, the young of which are found in great numbers near the water's edge, and almost invariably inhabiting the shells of Cerithiids. Two other hermits, both species of *Canobita* (*C. rugosa* and *C. compressa*), also frequently occur, but they freely leave the water, and are often to be met with wandering some distance inland. In certain localities *Alpheus malabaricus* is found in muddy creeks

where it probably burrows in the soft bottom, and thus differs strikingly in habit from its marine congeners. Four terrestrial species are characteristic of the marshy grass-grown flats which skirt the backwater, all of them belonging to the group *Catometopa* of the *Brachyura*. The most abundant of these are *Sesarma quadrata*, seen running in and out of its burrows at all times, and the larger *Cardisoma carnifex*, which lives in colonies, and is apparently very common, though the animal itself is rarely seen, as it emerges from its hiding-places only by night. The latter species is occasionally met with at some distance from the water, and its underground dwellings, unlike those of most land-crabs, do not pass vertically downwards for the first part of their course; they also lack the neat and finished appearance of the external opening, seen in the burrows of most *Telphusæ*. The two remaining species, *Metasesarma Rousseauxii* and *Metaplax distinctus*, are less frequent; the former is by no means uncommon at Ennore, while the latter is more sparingly met with, and I am unable to state whether it, like the others, seeks protection from its enemies by hiding underground. The backwater fauna is one that will amply repay investigation, and in *Crustacea* much has still to be done before the commoner species are even approximately known.

No collecting-ground in the Indian Seas can show a greater profusion of animal life than the Gulf of Manaar, between India and Ceylon, famous for its pearl fisheries. At various times many interesting zoological discoveries have been recorded from this area, and within recent years valuable collections in most of the *Invertebrate* groups have been formed by Mr. Thurston, of the Madras Museum. The *Crustacea* which he has entrusted to me for examination were collected chiefly at Rameswaram Island, Tuticorin, and the Pearl Banks on the Ceylon side of the Gulf (*Muttuwartu Par*, *Silavaturai Par*, and *Cheval Par*), including many of the most interesting species referred to in this paper. In the summer of 1889 I spent about three weeks in the first of these localities, and for the opportunity which I thus enjoyed of collecting there I am largely indebted to my friend the Setupathi, the Rajah of Ramnad, who not only placed at my disposal his bungalow at the village of Pamban, but also provided me with boats and efficient native divers. The island of Rameswaram, famed for its venerable temple—the resort of large numbers of Hindu pilgrims—forms the first link in the chain of islands and sandbanks which, known as Adam's Bridge, stretches from the mainland to Ceylon. To the naturalist it presents special interest from the fact that a fringing coral reef appears at intervals along the coast, and the marine fauna is consequently both rich and varied, while a few miles to the south there is a series of smaller but more completely reef-bound islands. As a rule, even outside the reef, there is complete absence of the swell or surf so characteristic of the Coromandel coast, and during either monsoon one side of the island at least is sheltered and the sea smooth. Remarkably shallow water is met with on all sides, and within a mile or so of the shore the depth probably nowhere exceeds five or six fathoms; on the outer portion of the reef, where the living coral is most abundant, there is usually not more than from ten to fifteen feet of water. The tidal zone varies considerably, both in character and extent. Within the reef it forms a belt, perhaps averaging fifty yards or so in width, exposed at low water, and then bounded by the still submerged growing coral, while elsewhere it consists of a

flat expanse of sand or mud, which frequently extends seawards for some considerable distance. In the tidal belt blocks of dead and water-worn coral are strewed about, and in places these enclose artificial rock pools, in which Crustacea, Molluses, Sponges, Holothurians, &c. are very abundant. The Crustacea most commonly met with at low water are:—*Atergatis floridus*, *Leptodius exaralus*, *Pilumnus cespertilio*, *Eriphia lævimana*, *Thalamita pygmaea*, *Metopograpsus messor*, *Iciolophus planissimus*, *Petrolisthes dentatus*, and *Gonodactylus glaber*. Of these it may be mentioned that the *Pilumnus* is remarkably sluggish and apathetic; the *Thalamita* is extremely active, while the *Petrolisthes* conceals itself under stones or pieces of coral, and when captured usually throws off its claws. On walking over the coral blocks a peculiar clicking noise is heard on all sides, which is found to proceed from species of *Alpheus*, very common in the tidal pools. This noise is produced by the crustacean rapidly flexing the dactylus of its larger chela against the corresponding immobile finger, probably under the stimulus of fear, for the movement is very freely indulged in when the animal is handled. Near high-water mark, in places where slight pools are left by the tide, a minute hermit-crab (*Diogenes*, sp.), scarcely a quarter of an inch in length, is very common, and here and there on the sandy shore colonies of *Cenobita rugosa* have established themselves, in company with the ubiquitous Oecypods. In a tidal backwater, which forms shallow lagoons at intervals round the island, the burrowing *Gelasimus annulipes* is seen in great numbers, and, on sand- or mud-banks, *Scopinera myctiroides*, a species of similar habits.

The great wealth of animal life on the reef is very apparent, for on a calm day, with no breeze to ruffle the surface, and with merely a few feet of clear water intervening, the growing coral can be readily examined from a boat, when it is seen to be arranged in irregular patches of varying size, often brightly coloured, and separated by spots of coral sand. Under favourable conditions objects even of moderate size can be readily discerned, the most conspicuous being Actiniæ, Asterids, Echini, large Molluses, such as *Pterocera*, *Cypræa*, &c., and gaudily-hued fishes. The most satisfactory mode of collecting is by means of diving; practised divers have no difficulty in loosening large blocks of coral, and in bringing these to the surface, whence they are drawn into the boat. In this way large numbers of crustaceans are taken, either hiding in the crevices or clinging to the coral branches. The genera most numerously represented are:—*Chlorodius*, *Leptodius*, *Elisus*, *Pilumnus*, *Trapezia*, *Polyonyx*, *Alpheus*, and *Gonodactylus*, but a list of even the commoner species would occupy more space than can be allotted to it here. Very interesting and varied are the modes by which most of these are protected in this densely populated area, where the struggle for existence must necessarily be severe. The slow inactive Maioid forms are frequently rendered inconspicuous by heterogeneous collections of foreign objects, such as sponges, corallines, hydroids, &c. attached to the carapace or legs, the retention of which is, in some cases, facilitated by the presence of short hooked hairs. Some specimens of *Micippa* appear, however, to content themselves with a simple coating of sand-grains which are entangled in or held by the short hairs on the upper surface. The well-known habit possessed by many Dromiids, of seeking protection under an enveloping sponge or ascidian, which is

deeply hollowed out by the body of the crab, is exemplified in most of the reef-dwelling species, and the canals of larger fixed Sponges afford a shelter to species of *Polyonyx*, *Alpheus*, and *Gebiopsis*. The larger species of *Alpheus*, and *Gonodactylus glaber*, are often found ensconced in short tunnels, bored through the coral probably by *Lithodomi* or other molluscs, and when captured the Stomatopod has the habit of alternately flexing and extending its tail with considerable rapidity and force. Certain representatives of widely separate families, e. g. *Æthra scruposa* and *Ebalia fallax*, have the carapace very irregularly elevated or even pitted, so that they bear an undoubted resemblance to pieces of eroded coral, and, as they move but slowly, this adaptation to their environment must often aid in their protection. But specially interesting in many of the species are the colour-markings, which probably, in most cases, are protective in their nature; and it may be added that an examination of dry or spirit specimens gives one but a meagre idea of the vivid tints which characterize many of the reef-dwellers during life. The colours which occur most frequently are purple, brown, and red, either uniformly diffused over the surface of the crab, or restricted so as to form spots or bands. A modification of the latter type is seen in such diverse forms as *Zebrida Adamsii*, *Cycloxanthus lineatus*, *Eupagurus zebra*, and *Galathea elegans*, in which there is an arrangement of dark, radiating, or subparallel lines, on the carapace and legs. A hint as to the possible use of these bands was afforded by a small semitransparent Lamellibranch (*Avicula zebra*, Reeve), with black radiating lines on its shell, which is met with adhering by its byssus to a hydroid (*Aglaophenia urens*, Kirchenpauer)\*; in this case the lines so exactly simulate the short lateral ramuli of the hydroid that the shell is with difficulty recognized, even by a practised eye. In all probability the above-mentioned crustaceans live on the stems of Gorgoniæ, Hydroids, or similar organisms. The Cancroid genera are more often brightly coloured than are those of other groups, and they include the species which are found in greatest numbers on the reef. It may be stated generally that the inactive forms are those most commonly disguised, either by the presence of foreign objects or by colour adaptations, while their more active neighbours, such as the Portunidæ and many Macrura, are, as a rule, of more sombre hue, but are more frequently armed with sharp spines, probably for defensive purposes, while those which seek safety in tunnels or burrows are often pale in colour, with their outer shell of thin texture. Before leaving this subject I may refer to a structural feature which is very noticeable in many species, more especially among the Cyclometopa, viz. the strong spoon-like excavation of the claws, which possibly enables these crabs to obtain a firmer hold of, and break off, the smaller coral branches when in search of food.

On the subject of geographical distribution there is little to be said, apart from the notes which appear in the body of this paper. The Indian Crustacean fauna is apparently very similar to that of a great portion of the Indo-Pacific area, and it is doubtful whether there is a single genus confined to or specially characteristic of India. The distribution

\* I am indebted to Mr. Edgar Smith and Mr. Kirkpatrick, of the British Museum, for the identification of the mollusc and hydroid respectively.

of a large number of the marine species—which from time to time are discovered in widely separate localities—is apparently to a great extent determined by the distribution of coral reefs, and as regards the higher Crustacea, at least, any attempt to subdivide the large central or coral-reef region of the Indo-Pacific area seems of doubtful value, and we can scarcely seek for natural subdivisions till we pass into the temperate and colder waters, north and south of the coral region. Nearly two thirds of the total number of species recorded in this paper are known to occur in the seas of the Malay Archipelago; about one third occur at Mauritius or the neighbouring islands; the same proportion in the seas of North Australia, and a slightly greater number in the islands of the Pacific (New Caledonia, Fijis, Samoa, Sandwich Is., &c.). Nearly one fourth of the number occur at Japan; while one fifth are found in the Red Sea, the same proportion on the east coast of Africa, and about the same in Australian localities excluding those on the north coast. Not less than twenty-seven of our species occur on the coast of Natal, and at least thirteen in the seas of New Zealand; while eight extend their range into the Atlantic area. The same amount of attention has not been paid by collectors to each of these regions, some having been more specially favoured; but, in spite of this, there can be no doubt of the great affinity between the Indian and Malayan Crustacean faunas.

The distribution of the freshwater species offers certain points of interest. The genus *Telphusa* has representatives in South-Eastern Asia (Malay Archipelago, Malay Peninsula, and China) of what may be termed a granulated group of species; in Burmah and Upper India similar forms are met with, e. g. *T. Atkinsoniana*, Wood-Mason, and *T. Pealiana*, Wood-Mason, which so far as is known do not extend their range into the Indian Peninsula\*; while further west, in Beloochistan and Persia, the allied *T. fluvialilis* makes its appearance, and finally spreads along both sides of the Mediterranean. The genus *Paratelphusa* has a somewhat similar range, extending from the Malay Archipelago along the Malay Peninsula into Burmah and Northern India, but no species have yet been recorded from South India or Ceylon. Very little is as yet known of the Indian species of *Palaemon*, but there can be no doubt that they are very numerous. *P. scabriculus*, a very well-marked species, described originally from Ceylon, occurs in Upper India and in the Malay Archipelago; it, however, remains to be seen whether it does not also occur in Burmah and the Malay Peninsula. The marked prevalence of freshwater prawns in the streams of South-eastern Asia and the Malay Archipelago, with the apparently complete absence of crayfish from the same region, seems to strengthen Professor Huxley's suggestion that the latter have been displaced by better fitted competitors. The genus *Caridina* is represented at Madras, and probably elsewhere in India, by a species which I am unable to separate from *C. Wyckii*, described by Hickson from Celebes, and which itself is perhaps not distinct from a longer-known species, found in North and East Africa, a remarkably extended range for a fresh-water species.

\* In the British Museum there is a specimen of *T. Atkinsoniana* from Ceylon.

In conclusion I would express my indebtedness to those gentlemen who have assisted me during the preparation of this paper. To Dr. Günther and Mr. Pocock, of the British Museum, my thanks are specially due for their having granted me ready access to the collections under their charge and facilitating my work in various ways, to the latter especially for having spent much time on my behalf and for kindly undertaking to supervise the figuring of the new species during my absence in India. I am indebted to Professor Alphonse Milne-Edwards, of Paris, for kindly examining and naming some specimens I sent him, which were referable either to species described by himself or to species of which the types are preserved in the Paris Natural History Museum. To Mr. E. Thurston my thanks are also due for assistance rendered in many ways.

*List of Species, with the localities at which they were taken.*

DECAPODA.

BRACHYURA.

- Acheus lacertosus*, Stm.—Gulf of Martaban.  
 — *affinis*, Miers.—Gulf of Martaban.  
*Oncinopus aranea*, De Haan.—Muttuwartu Par ; Gulf of Martaban.  
*Huenia Proteus*, De Haan.—Tuticorin ; Rameswaram.  
*Simocarcinus simplex* (Dana).—Tuticorin.  
*Menathius monoceros* (Latr.).—Tuticorin ; Silavaturai Par ; Muttuwartu Par ; Rameswaram ; Gulf of Martaban.  
*Doclea hybrida* (Fabr.).—Ceylon ; Madras.  
 — *muricata* (Fabr.).—Madras ; Gulf of Martaban.  
*Stenocionops cervicornis* (Herbst).—Tuticorin.  
*Egeria arachnoides* (Rumph.).—Madras ; Gulf of Martaban.  
*Hygastenus Pleione* (Herbst).—Silavaturai Par.  
 — *convexus*, Miers.—Gulf of Martaban.  
 — *Hilyendorfi*, De Man.—Tuticorin ; Cheval Par ; Rameswaram.  
 — *Brockii*, De Man.—Gulf of Martaban.  
*Chlorinoides aculeatus* (Milne-Edw.).—Gulf of Martaban.  
 — *Coppingeri*, Haswell.—Muttuwartu Par ; Gulf of Martaban.  
*Naxia hirta* (A. Milne-Edw.).—Tuticorin.  
 — *taurus*, Pocock.—Gulf of Martaban.  
*Schizophrys aspera* (Milne-Edw.).—Ceylon ; Tuticorin ; Rameswaram ; Madras.  
*Hoplophrys Oatesii*, gen. et sp. n.—Gulf of Martaban.  
*Micippa Philyra* (Herbst).—Tuticorin ; Rameswaram.  
 — *Thalia* (Herbst).—Tuticorin ; Muttuwartu Par ; Rameswaram.  
 — *mascarenica*, Kossmann.—Gulf of Martaban.  
 — *margaritifera*, n. sp.—Gulf of Martaban.  
*Pilocarcinus Styx* (Herbst).—Tuticorin ; Muttuwartu Par ; Rameswaram.  
*Laubrus longimanus* (Linn.).—Ceylon ; Madras ; Gulf of Martaban.  
 — *contrarius* (Herbst).—Tuticorin.

- Lambrus affinis*, A. Milne-Edw.—Tuticorin; Ceylon; Rameswaram; Gulf of Martaban  
 — *longispinus*, Miers.—Tuticorin.  
 — *Holdsworthi*, Miers.—Tuticorin.  
 — *sculptus*, A. Milne-Edw.—Gulf of Martaban.  
 — *hoplonotus*, Ad. & White.—Muttuwartu Par.  
*Cryptopodia fornicata* (Fabr.).—Gulf of Martaban.  
*Æthra scruposa* (Linn.).—Ceylon.  
*Zebrida Adamsii*, White.—Tuticorin.  
*Paratymolus sexspinosus*, Miers.—Tuticorin.
- Atergatis integerrimas* (Lam.).—Tuticorin; Ceylon; Rameswaram.  
 — *floridus* (Rumph.).—Tuticorin; Ceylon; Rameswaram.  
 — *lævigatus*, A. Milne-Edw.—Tuticorin.  
 — *dilatatus*, De Haan.—Ceylon.  
*Carpilius maculatus* (Linn.).—Ceylon.  
*Carpilodes tristis*, Dana.—Muttuwartu Par.  
 — *margaritatus*, A. Milne-Edw.—Tuticorin; Rameswaram.  
 — *venosus* (Milne-Edw.).—Ceylon.  
 — *cinctimanus* (White).—Ceylon.  
*Liomera punctata* (Milne-Edw.).—Tuticorin; Muttuwartu Par; Ceylon.  
 — *Rodgersii* (Stm.).—Ceylon.  
*Lophactea granulosa* (Rüpp.).—Tuticorin; Rameswaram.  
 — *senigranosa* (Heller).—Muttuwartu Par; Rameswaram.  
 — *fissa*, n. sp.—Tuticorin.  
*Actæa granulata* (Aud.).—Tuticorin; Cheval Par; Rameswaram.  
 — *calculosa* (Milne-Edw.).—Tuticorin; Muttuwartu Par.  
 — *nodulosa* (White).—Tuticorin.  
 — *Peronii* (Milne-Edw.), var. *symanosa*, n.—Muttuwartu Par.  
 — *rufopunctata* (Milne-Edw.).—Tuticorin; Cheval Par.  
 — *Ruppellii* (Krauss.).—Tuticorin; Rameswaram.  
*Hypocælus rayosus*, n. sp.—Tuticorin.  
*Xantho impressus* (Lam.).—Ceylon.  
*Medæus distinguendus* (De Haan).—Gulf of Martaban.  
*Euxanthus Melissa* (Herbst).—Tuticorin; Ceylon.  
*Zozymus Æneus* (Linn.).—Ceylon.  
*Polycremonus ochtades* (Herbst).—Muttuwartu Par; Madras.  
*Halimede Thurstoni*, n. sp.—Tuticorin.  
*Cycloxanthus lineatus*, A. Milne-Edw.—Tuticorin.  
*Lophozozymus Dodone* (Herbst).—Tuticorin; Muttuwartu Par; Rameswaram.  
 — *cristatus*, A. Milne-Edw.—Muttuwartu Par.  
*Chlorodius niger* (Forsk.).—Tuticorin; Muttuwartu Par; Rameswaram.  
*Chlorodopsis spinipes* (Heller).—Muttuwartu Par; Ceylon.  
*Leptodius exaratus* (Milne-Edw.).—Sind; Tuticorin; Silavaturai Par; Ceylon; Rameswaram.  
*Etisus lærimanus*, Randall.—Tuticorin; Ceylon; Rameswaram.  
*Etisodes Electra* (Herbst.).—Tuticorin; Rameswaram.  
*Phymodius unguatus* (Milne-Edw.).—Ceylon.  
 — *monticulosus* (Dana).—Tuticorin.  
*Cymo Andreossi* (Aud.).—Tuticorin; Muttuwartu Par; Rameswaram.

- Menippe Rumphii* (Fabr.).—Tuticorin ; Ceylon ; Rameswaram ; Madras.  
*Ozius tuberculatus*, Milne-Edw.—Ceylon.  
*Epixanthus frontalis* (Milne-Edw.).—Ceylon ; Nicobars.  
 — *dentatus* (White).—Nicobars.  
*Actumnus setifer* (De Haan).—Muttuwartu Par ; Gulf of Martaban.  
 — *verrucosus*, n. sp.—Tuticorin ; Muttuwartu Par.  
*Pilumnus respertilio* (Fabr.).—Tuticorin ; Ceylon ; Rameswaram.  
 — *labyrinthicus*, Miers.—Rameswaram.  
*Trapezia Cymodoce* (Herbst).—Tuticorin ; Muttuwartu Par ; Rameswaram.  
 — *rufopunctata* (Herbst).—Tuticorin ; Ceylon.  
 — *murulata* (Macleay).—Ceylon.  
 — *areolata*, Dana.—Ceylon.  
*Tetralia ylaberrima* (Herbst).—Tuticorin ; Muttuwartu Par ; Rameswaram.  
*Eriphia levimana*, Latr.—Tuticorin ; Ceylon ; Rameswaram.  
*Neptunus pelagicus* (Linn.).—Sind ; Bombay ; Malabar ; Tuticorin ; Ceylon ; Madras &c. ; Akyab.  
 — *gladiator* (Fabr.).—Ceylon ; Rameswaram ; Madras ; Gulf of Martaban.  
 — *sanguinolentus* (Herbst).—Sind ; Bombay ; Ceylon ; Rameswaram ; Madras.  
 — *argentatus*, White.—Gulf of Martaban.  
 — *hastatoides* (Fabr.).—Madras ; Gulf of Martaban.  
 — *Andersoni*, De Man.—Gulf of Martaban.  
 — *tuberculatus*, A. Milne-Edw.—Gulf of Martaban.  
 — *armatus*, A. Milne-Edw.—Rameswaram.  
 — *Sieboldi*, A. Milne-Edw.—Muttuwartu Par.  
*Xiphonectes longispinosus* (Dana).—Gulf of Martaban.  
*Achelous granulatus* (Milne-Edw.).—Gulf of Martaban.  
 — *Whitei*, A. Milne-Edw.—Madras ; Gulf of Martaban.  
 — *orbicularis*, Richters.—Gulf of Martaban.  
*Scylla serrata* (Forsk.).—Ceylon ; Madras, &c. ; Calcutta.  
*Thalamita prymna* (Herbst).—Tuticorin ; Rameswaram ; Madras.  
 — *Admete* (Herbst).—Rameswaram ; Gulf of Martaban.  
 — *Sarigynji*, A. Milne-Edw.—Tuticorin ; Rameswaram.  
 — *sima*, Milne-Edw.—Tuticorin.  
 — *integra*, Dana.—Tuticorin ; Rameswaram ; Gulf of Martaban.  
 — *serlobata*, Miers.—Tuticorin.  
*Goniosoma cruciferum* (Fabr.).—Tuticorin ; Ceylon ; Madras ; Akyab.  
 — *affine* (Dana).—Madras.  
 — *nator* (Herbst).—Ceylon ; Rameswaram ; Madras.  
 — *luciferum* (Fabr.).—Ceylon.  
 — *annulatum* (Fabr.).—Tuticorin ; Rameswaram ; Madras.  
 — *Hellerii*, A. Milne-Edw.—Tuticorin ; Ceylon ; Rameswaram.  
 — *erythrodactylum* (Lam.).—Ceylon.  
 — *orientale* (Dana).—Tuticorin ; Ceylon.  
 — *ornatum*, A. Milne-Edw.—Madras.  
 — *variegatum* (Fabr.).—Kurachi ; Bombay ; Madras.  
 — *rostratum*, A. Milne-Edw.—Calcutta ; Sunderbunds ; Gulf of Martaban.  
*Lupocyclus inequalis* (Walker).—Gulf of Martaban.  
*Lissocarcinus polybioides*, Ad. & White.—Gulf of Martaban.

- Lissocarcinus levis*, Miers.—Tuticorin ; Gulf of Martaban.  
*Kraussia nitida*, Stm.—Tuticorin ; Madras.
- Heteroplae nitidus*, Miers.—Madras ; Gulf of Martaban.  
*Scalopidia spinosipes*, Stm.—Gulf of Martaban.  
*Cardisoma carnifex* (Herbst).—Tuticorin ; Ceylon ; Madras, &c.  
*Telphusa indicu*, Latr.—Nilgiri hills.  
 — *lugubris*, Wood-Mason.—Nepal.  
 — *Masoniana*, n. sp.—North-West Provinces ; River Jumna.  
 — *Leschenaulti*, Milne-Edw.—Ceylon ; Madras ; Ganjam.  
 — *rugosa*, Kingsley.—Ceylon.  
 — *enodis*, Kingsley.—Ceylon ; Madras.  
 — *Pocockiana*, n. sp.—Jubbulpore.  
 — *fluriatilis*, Latr.—Quetta.  
 — *Atkinsoniana*, Wood-Mason.—Kangra ; Simla ; Burmah.  
*Paratelphusa sinensis*, Milne-Edw.—Burmah.  
 — *spinigera*, Wood-Mason.—Sind ; North-West Provinces ; Roorkee ; Calcutta ; Ganjam.  
 — *Dayanu*, Wood-Mason.—Burmah.  
 — *Martensi*, Wood-Mason.—North-West Provinces ; Roorkee.  
*Ocypoda ceratophthalma* (Pallas).—Tuticorin ; Rameswaram ; Madras, &c.  
 — *macrocera*, Milne-Edw.—Tuticorin ; Rameswaram ; Madras.  
 — *platytarsis*, Milne-Edw.—Ceylon ; Rameswaram ; Madras.  
 — *cordimana*, Latr.—Tuticorin ; Madras.  
*Gelasimus annulipes*, Latr.—Tuticorin ; Rameswaram ; Madras, &c.  
 — *triangularis*, A. Milne-Edw.—Madras ; Ennore.  
*Macrophthalms depressus*, Rüpp.—Rameswaram.  
 — *pectinipes*, Guérin.—Sind.  
 — *Lutvilliei* (Desm.).—Ceylon (fossil).  
*Scopinera myctiroides* (Milne-Edw.).—Tuticorin ; Rameswaram ; Ennore.  
*Myctiris longicarpus*, Latr.—Akyab.  
*Metopograpsus messor* (Forsk.).—Tuticorin ; Rameswaram ; Madras.  
*Grapsus strigosus* (Herbst).—Tuticorin ; Rameswaram ; Madras, &c.  
 — *maculatus* (Catesby).—Tuticorin.  
*Plagusia immaculata*, Lam.—Madras.  
*Leiolophus planissimus* (Herbst).—Rameswaram ; Madras.  
*Varuna litterata* (Fabr.).—Ceylon ; Ennore ; Ganjam ; Calcutta ; Burmah.  
*Metaplax distinctus*, Milne-Edw.—Ennore.  
*Sesarma tetragonu* (Fabr.).—Madras ; Ennore.  
 — *quadrata* (Fabr.).—Tuticorin ; Madras ; Ennore.  
*Sarmatium indicum* (A. Milne-Edw.), var. *malabaricum*, n.—Cochin.  
*Metasesurma Rousseauvii*, Milne-Edw.—Ennore.  
*Xenophthalmus pinnotheroides*, White.—Rameswaram.  
 — *obscurus*, n. sp.—Gulf of Martaban.  
*Elamene unguiformis*, De Haan.—Gulf of Martaban.  
 — *truncata*, A. Milne-Edw.—Silavaturai Par.
- Calappa hepatica* (Linn.).—Tuticorin ; Ceylon ; Rameswaram ; Gulf of Martaban.  
 — *gallus* (Herbst).—Tuticorin ; Ceylon ; Rameswaram ; Gulf of Martaban.

- Calappa lophos* (Herbst).—Ceylon; Madras; Gulf of Martaban.  
 — *philargius* (Linn.).—Ceylon; Gulf of Martaban.  
*Matula victrix*, Fabr.—Sind; Tuticorin; Ceylon; Madras; Ganjam; Akyab.  
 — *lunaris* (Herbst).—Madras; Ganjam.  
 — *Miersii*, Henderson.—Tuticorin; Ceylon; Madras.  
*Leucosia craniolaris* (Linn.).—Ceylon; Muttuwartu Par; Rameswaram; Madras; Gulf of Martaban.  
 — *Whitmeei*, Miers.—Gulf of Martaban.  
*Pseudophilyra Melita*, De Man.—Muttuwartu Par; Gulf of Martaban.  
 — *pusilla*, n. sp.—Gulf of Martaban.  
*Philyra scabriuscula* (Fabr.).—Tuticorin; Rameswaram; Madras, &c.  
 — *verrucosa*, n. sp.—Madras.  
 — *Adamsii*, Bell.—Silavaturai Par; Rameswaram; Gulf of Martaban.  
 — *platycheiru*, De Haan.—Silavaturai Par.  
 — *globosa* (Fabr.).—Tuticorin; Rameswaram; Madras, &c.  
 — *polita*, n. sp.—Madras.  
*Myra fuyax* (Fabr.).—Ceylon; Rameswaram; Gulf of Martaban.  
 — *australis*, Haswell.—Gulf of Martaban.  
*Ebalia Pfefferi*, De Man.—Muttuwartu Par.  
 — *fallax*, n. sp.—Muttuwartu Par; Gulf of Martaban.  
*Arcania septemspinosa* (Fabr.).—Madras; Gulf of Martaban.  
 — *undecimspinosa*, De Haan.—Gulf of Martaban.  
*Narsia plicata* (Herbst).—Rameswaram; Gulf of Martaban.  
 — *abbreviata*, Bell.—Silavaturai Par; Rameswaram; Gulf of Martaban.  
*Dorippe dorsipes* (Linn.).—Ceylon; Silavaturai Par; Rameswaram; Madras  
 — *facchino* (Herbst).—Tuticorin; Rameswaram; Madras, &c.  
 — *astuta*, Fabr.—Madras.  
*Cymopolia Jukesii*, White.—Gulf of Martaban.

## ANOMURA.

- Dromidia unidentata* (Rüpp.).—Tuticorin; Ceylon.  
 — *australensis*, Haswell.—Silavaturai Par.  
*Cryptodromia pentagonalis*, Hilg.—Muttuwartu Par; Silavaturai Par.  
*Dromia Ramplii*, Fabr.—Ceylon.  
*Pseudodromia integrifrons*, Henderson.—Tuticorin.  
*Conchæetes artificiosus* (Fabr.).—Madras.
- Raninoides serratifrons*, n. sp.—Cheval Par.
- Hippa asiatica*, Milnc-Edw.—Rameswaram; Madras, &c.  
*Albunea symista* (Linn.).—Rameswaram; Madras, &c.  
 — *Thurstoni*, n. sp.—Cheval Par.
- Cænobita rugosa*, Milnc-Edw.—Tuticorin; Silavaturai Par; Rameswaram, &c.  
 — *compressa*, Milnc-Edw.—Madras, &c.  
*Diogenes Diogenes* (Herbst).—Tuticorin; Rameswaram; Madras, &c.  
 — *merquensis*, De Man.—Muttuwartu Par; Madras.  
 — *miles* (Herbst).—Silavaturai Par; Rameswaram; Madras.

- Diogenes custos* (Fabr.).—Rameswaram ; Madras, &c.  
 — *affinis*, n. sp.—Madras.  
 — *violaceus*, n. sp.—Madras.  
 — *planimanus*, n. sp.—Rameswaram ; Madras.  
 — *arurus*, Heller.—Tuticorin ; Rameswaram ; Madras ; Eumore.  
 — *costatus*, n. sp.—Tuticorin ; Rameswaram ; Madras.  
 — *rectimanus*, Miers.—Madras.  
*Pagurus punctulatus*, Oliv.—Tuticorin ; Rameswaram.  
 — *Hessii*, Miers.—Madras ; Gulf of Martaban.  
 — *deformis*, Milne-Edw.—Tuticorin ; Rameswaram.  
 — *ruripes*, Heller.—Tuticorin ; Muttuwartu Par.  
 — *setifer*, Milne-Edw.—Tuticorin ; Madras ; Gulf of Martaban.  
*Troglopagurus manuarensis*, gen. et sp. n.—Tuticorin ; Muttuwartu Par.  
*Aniculus aniculus* (Fabr.).—Tuticorin ; Muttuwartu Par.  
 — *strigatus* (Herbst).—Tuticorin.  
*Clibanarius clibanarius* (Herbst).—Madras.  
 — *infraspinatus*, Hilg.—Madras.  
 — *padarensis*, De Man.—Tuticorin ; Rameswaram ; Madras, &c.  
 — *Arethusa*, De Man.—Muttuwartu Par ; Rameswaram ; Madras.  
*Catapagurus ensifer*, n. sp.—Gulf of Martaban.  
*Spiropagurus spiriger* (De Haan).—Madras ; Gulf of Martaban.  
*Eupagurus zebra*, n. sp.—Muttuwartu Par.
- Petrolisthes dentatus* (Milne-Edw.).—Tuticorin ; Muttuwartu Par ; Rameswaram.  
 — *Boscii* (Aud.).—Muttuwartu Par ; Rameswaram.  
 — *militaris* (Heller).—Muttuwartu Par ; Cheval Par ; Rameswaram.  
*Raphidopus indicus*, n. sp.—Madras.  
*Pachycheles tomentosus*, n. sp.—Kurachi.  
*Porcellanella triloba*, White.—Rameswaram.  
*Polyonyx obesulus*, Miers.—Tuticorin ; Rameswaram.  
 — *tuberculosis*, De Man.—Cheval Par ; Rameswaram.  
*Galathea elegans*, White.—Tuticorin ; Gulf of Martaban.  
 — *spinosirostris*, Dana.—Muttuwartu Par ; Gulf of Martaban.  
*Munida spinulifera*, Miers.—Muttuwartu Par ; Gulf of Martaban.

## MACRURA.

- Gebiopsis Darwinii*, Miers.—Tuticorin ; Cheval Par ; Rameswaram.
- Thenus orientalis* (Fabr.).—Madras, &c.  
*Panulirus ornatus* (Fabr.).—Ceylon.  
 — *penicillatus* (Oliv.).—Ceylon.  
 — *dasyppus* (Latr.).—Silavaturai Par ; Madras.
- Caridina Wyckii* (Hickson).—Madras.  
*Alpheus malabaricus*, Fabr.—Pulicat.  
 — *Edwardsii* (Aud.).—Kurachi ; Tuticorin ; Muttuwartu Par ; Rameswaram ; Gulf of Martaban.

- Alpheus Hippothoë*, De Man.—Rameswaram.  
 — *frontalis*, Say.—Tuticorin.  
 — *lævis*, Randall.—Tuticorin ; Rameswaram.  
 — *Neptunus*, Dana.—Kurachi ; Rameswaram.  
*Dorodotes lexicarina*, Bate.—Gulf of Martaban.  
*Angasia Stimpsonii*, n. sp.—Gulf of Martaban.  
*Rhynchocinetes rugulosus*, Stm.—Tuticorin.  
*Pontonia tridacnæ*, Dana.—Tuticorin ; Rameswaram.  
*Leander longirostris* (Say).—Kurachi ; Sunderbunds ; Gulf of Martaban ; Mergui.  
 — *tenipes*, n. sp.—Bombay ; Madras ; Gulf of Martaban.  
 — *modestus*, Heller.—Madras.  
*Palæmon carcinus* (Fabr.).—Bombay ; Ganjam ; Calcutta ; Sunderbunds ; Tavoy ; Burmah.  
 — *dispar*, v. Mart.—Calcutta.  
 — *scabriculus*, Heller.—River Indus.  
 — *Dayanus*, n. sp.—Orissa ; Jubbulpore ; Calcutta ; Beerbhoom ; Delhi ; Roorkee ; Loodiana ; Hurdwar ;  
 Debroo ; River Jumna ; Lahore.  
 — *altifrons*, n. sp.—Delhi ; River Jumna ; Lahore.  
*Nika processa*, Bate.—Gulf of Martaban.  
*Ægeon orientalis*, n. sp.—Gulf of Martaban.  
  
*Penæus monodon*, Fabr.—Bombay ; Madras, &c. ; Ganjam.  
 — *indicus*, Milne-Edw.—Kurachi ; Madras ; Ganjam ; Calcutta ; Akyah.  
 — *affinis*, Milne-Edw.—Kurachi ; Bombay ; Canara ; Madras.  
 — *sculptilis*, Heller.—Kurachi ; Malabar ; Madras ; Sunderbunds ; Gulf of Martaban.  
 — *Dobsoni*, Miers.—Madras.  
 — *velutinus*, Dana.—Gulf of Martaban.  
 — *brevicornis*, Milne-Edw.—Kurachi ; Calcutta.  
 — *caudiculatus*, Oliv.—Gulf of Martaban.  
 — *compressipes*, n. sp.—Gulf of Martaban.  
*Solenocera crassicornis* (Milne-Edw.).—Madras ; Gulf of Martaban.  
*Acetes indicus*, Milne-Edw.—Gulf of Martaban.

## STOMATOPODA.

- Lysiosquilla maculata* (Fabr.).—Tuticorin ; Madras.  
*Squilla nepa*, Latr.—Tuticorin ; Ceylon ; Madras.  
 — *affinis*, Berthold.—Rameswaram ; Madras ; Sunderbunds.  
 — *scorpio*, Latr.—Madras.  
 — *raphidea*, Fabr.—Madras ; Sunderbunds.  
*Pseudosquilla ciliata* (Fabr.).—Madras.  
*Gonodactylus chiragra* (Fabr.).—Ceylon ; Andamans.  
 — *glaber*, Brooks.—Tuticorin ; Ceylon ; Silavaturai Par ; Rameswaram.  
 — *Demanii*, n. sp.—Rameswaram.  
*Protosquilla trispinosa* (Dana).—Ceylon ; Rameswaram ; Gulf of Martaban.

## Order DECAPODA.

## Suborder BRACHYURA.

## Group OXYRHYNCHA.

## Genus ACLEUS, Leach.

## 1. ACLEUS LACERTOSUS, Stimpson.

*A. lacertosus*. Stimpson, Proc. Acad. Nat. Sci. Philad. p. 218 (1857); Miers, 'Alert' Crust. p. 188 (1884).

(= *A. breviceps*, Haswell).

Gulf of Martaban, two females with ova, and a male (*Oates*).

These specimens are not in a very good state of preservation, but there can be little doubt that they belong to this species.

*Distribution*. E. & N. Australia.

## 2. ACLEUS AFFINIS, Miers.

*A. affinis*, Miers, 'Alert' Crust. p. 188 (1884); De Man, Brock's Crust. p. 218 (1888).

Gulf of Martaban, a female (*Oates*).

This species is distinguished from the last chiefly by the presence of a prominent bilobed tubercle on the cardiac area, and by its tuberculated ocular peduncles.

*Distribution*. E., N., and W. Australia, Malay Archipelago.

## Genus ONCINOPUS, De Haan.

## 3. ONCINOPUS ARANEA, De Haan.

*O. aranea*, De Haan, Crust. Japon. p. 100, pl. xxix. fig. 2 (1850).

(= *O. Neptunus*, Adams & White, *O. subpellucidus*, Stm., *O. angulatus*, Hasw.).

Muttuwartu Par. a female with ova, and a male carrying a *Sacculina* (*Thurston*).  
Gulf of Martaban, several specimens (*Oates*).

All the described species of this genus are referred by Miers to *O. aranea*, and he has shown that there is considerable variation in the length and robustness of the legs, characters on which the so-called species had been founded. The carapace and legs are much more attenuated in the male than in the female.

*Distribution*. Japan, Mindoro Sea, Singapore, N. & N.E. Australia, New Hebrides.

## Genus HUENIA, De Haan.

## 4. HUENIA PROTEUS, De Haan.

*H. Proteus*, De Haan, Crust. Japon. p. 95, pl. xxiii. figs. 4, 5 ♂, fig. 6 ♀ (1850).

(= *H. Dehaani*, White; *H. Proteus*, vars. *tenuipes*, *elongata*, and *heraldica*, Adams & White).

Tuticorin. several specimens, overgrown with sponges and polyzoa (*Thurston*). Common on the reef at Rameswaram (*J. R. II.*).

*Distribution.* Japan, China, Malay Archipelago, N. & N.E. Australia.

#### Genus SIMOCARCINUS, Miers.

##### 5. SIMOCARCINUS SIMPLEX (Dana).

*Huenia simplex*, Dana, Crust. U.S. Explor. Exped. vol. i. p. 133, pl. vi. fig. 3, ♂ (1852).

*H. brevisrostrata*, Dana, l. c. p. 134, pl. vi. fig. 4, ♀ (1852).

Tuticorin, a male and a female (*Thurston*).

The male is of small size and has the rostrum much more elongated than is represented in Dana's figure, with the apex somewhat trigonal. In the female the rostrum has been broken off, and, as noted by Miers, the anterior pair of lateral lobes on the carapace are larger than figured by Dana, and their apices are subtruncated. In this species, as in the last, there is great sexual dimorphism.

*Distribution.* Sandwich Is. (*Dana, Miers*).

#### Genus MENÆTHIUS, Milne-Edwards.

##### 6. MENÆTHIUS MONOCEROS (Latreille).

*M. monoceros* (Latr.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. viii. p. 252 (1872), *ubi synonym.*

Rameswaram, Tuticorin, Muttuwartu Par, Silavaturai Par (*Thurston*); Gulf of Martaban (*Oates*). Very common on the reef at Rameswaram, and usually overgrown with sponges and hydroids (*J. R. II.*).

No less than eleven so-called species have been referred by A. Milne-Edwards to this very variable and widely distributed form.

*Distribution.* From the Red Sea and East Coast of Africa to Japan, New Caledonia, and the Fiji Is.

#### Genus DOCLEA, Leach.

##### 7. DOCLEA HYBRIDA (Fabr.).

*D. hybrida* (Fabr.), De Man. Mergui Crust. p. 9 (1887).

(=? *D. hybridoida*, Bleeker).

Ceylon (*Italy*). Very common at Madras, and elsewhere on the Coromandel coast (*J. R. II.*).

*Distribution.* Malay Archipelago, Mergui.

##### 8. DOCLEA MURICATA (Fabr.).

*D. muricata* (Fabr.), Milne-Edwards, Hist. Nat. Crust. t. i. p. 295 (1834).

Gulf of Martaban (*Oates*). Madras, not uncommon (*J. R. II.*).

The spines on the carapace of this species are strongly developed, more especially in

young individuals; the fourth lateral spine is nearly twice the length of the third. The carapace and legs are densely pubescent.

A male of average size (from Madras) gives the following measurements:—carapace (omitting spines) 31 mm. long, 27 mm. broad, third lateral spine 3 mm., fourth spine 5.5 mm., posterior median spine 4.5 mm., first ambulatory leg 60 mm. long.

*Distribution.* South India, Singapore.

#### Genus STENOCIONOPS, Latreille.

##### 9. STENOCIONOPS CERVICORNIS (Herbst).

*S. cervicornis* (Herbst), Milne-Edwards, Hist. Nat. Crust. t. i. p. 338 (1834).

Tuticorin, four females (one with ova), three males (*Thurston*).

The carapace, rostral spines, ambulatory legs, and in males also the abdominal segments carry numerous tufts of strong curved hairs (each hair is about 3 mm. long) which help to form an attachment for the numerous sponges, hydroids, ascidians, &c., with which the specimens are beset. In the male the rostral spines are scarcely more marked than in the female, but the posterior prolongation of the carapace is narrower and more upturned, and the chelipedes are stronger, with a wider hiatus between the fingers.

The largest male has the carapace (not including rostral spines) 42 mm. long and 29 mm. broad, the rostral spines 25 mm. long. The largest female is somewhat larger.

*Distribution.* Mauritius (*Milne-Edwards*).

#### Genus EGERIA, Latreille.

##### 10. EGERIA ARACHNOIDES (Rumph.).

*E. arachnoides* (Rumph.), Miers, 'Alert' Crust. p. 191 (1884).

(= *E. indica*, Leach, *E. Herbstii*, Milne-Edwards).

Madras, common (*J. R. II.*); Gulf of Martaban (*Oates*).

There is great variation in the relative size and acuteness of the spines or tubercles on the carapace of this species. In all the specimens a small spine is present at the distal end of the meropodites of the chelipedes and ambulatory legs. In a single large specimen (a female with the carapace 30 mm. long and 23 mm. broad) the two most posterior tubercles on the middle line of the carapace are prolonged into rather prominent spines, as well as the last branchial tubercle.

The carapace of an average specimen (female) is 19 mm. long and 16 mm. broad, the second ambulatory leg 95 mm. long.

*Distribution.* N. & N.E. Australia, Malay Archipelago, China.

#### Genus HYASTENUS, White.

##### 11. HYASTENUS PLEIONE (Herbst).

*H. Pleione* (Herbst), De Man, Brock's Crust. p. 225, taf. vii. fig. 3 (1888).

Silavaturai Par, a female with ova (*Thurston*).

In this specimen the carapace is yellowish in colour, mottled with red on the gastric area and at the sides of the cardiac area. The carapace, which is overgrown with sponges and ascidians, measures 35 mm. in length and 20 mm. in breadth; the rostral spines are 11 mm. long, and measured between their apices 5.5 mm.

*Distribution.* Mergui, Malay Archipelago.

## 12. HYASTENUS CONVEXUS, Miers.

*H. convexus*, Miers, 'Alert' Crust. p. 196, pl. xviii. fig. B (1884).

Gulf of Martaban, a female with ova (*Oates*).

I refer this with some doubt to the present species. It agrees in having the gastric area of the carapace smooth and very convex, the cardiac area also smooth and but slightly less convex. But the rostral spines are somewhat less divergent, and a small epibranchial spine is present, while according to Miers there is none. In other respects it agrees with the description, and it is apparently identical with dried specimens from Penang, in the British Museum, labelled by Miers "*Hyastenus convexus*, Miers, var." The carapace measures 13 mm. long (not including the rostral spines), and the rostral spines 6 mm. long.

*Distribution.* N.E. Australia (*Miers*); Penang (*Brit. Mus.*).

## 13. HYASTENUS HILGENDORFI, De Man.

*H. hilgendorfi*, De Man, Mergui Crust. p. 14, pl. i. figs. 3, 4 (1887).

Rameswaram, Tuticorin, Cheval Par (*Thurston*). Not uncommon on the reef at Rameswaram (*J. R. II.*).

Allied to *H. Pleione* (Herbst), from which it may be distinguished by the absence of median spines from the dorsal surface of the carapace, and the presence of only two tubercles on the anterior gastric region. The rostral spines are much longer in adult males than in females and young males. Most of the specimens are overgrown with hydroids and sponges.

The largest specimen (an adult male) has the carapace 34 mm. in total length (including rostral spines), and the rostral spines measured from the level of the anterior orbital margin 15 mm. long.

*Distribution.* Mergui (*De Man*).

## 14. HYASTENUS BROCKII, De Man.

*H. Brockii*, De Man, Brock's Crust. p. 221, taf. vii. fig. 1 (1888).

Gulf of Martaban (*Oates*).

In a single male specimen which I refer to this species (carapace 8.5 mm. long, 6 mm. broad, length of rostrum 10 mm.) the cardiac area of the carapace is more elevated than is represented in De Man's figure. It is chiefly characterized by its very long and slender rostral spines, which are longer even than the carapace.

*Distribution.* Amboina.

## GENUS CHLORINOIDES, Haswell.

## 15. CHLORINOIDES ACULEATUS (Milne-Edwards).

*Chorinus aculeatus*, Milne-Edwards, Hist. Nat. Crust. t. i. p. 316 (1834).

*Paramithrax (Chlorinoides) aculeatus*, var. *armatus*, Miers, 'Alert' Crust. p. 193, pl. xviii. fig. A (1884).

Gulf of Martaban, two males (*Oates*).

The var. *armatus* is distinguished, according to Miers, only by the form of the postocular spine; but he has apparently overlooked De Haan's figure of *Maja (Chorinus) aculeata*, M.-Edw. (Crust. Japon. tab. xxiii. fig. 2), in which the postocular spine is represented of the same form as in this variety. Miers mentions the existence of spines at the distal end of the meropodites of the ambulatory legs, which are also represented in De Haan's figure, so perhaps the so-called var. *armatus* is really the typical form.

The carapace of the larger specimen is 20 mm. long and 14 mm. broad, the rostral spines 14 mm. long.

*Distribution.* Japan, N. Australia.

## 16. CHLORINOIDES COPPINGERI, Haswell.

*Paramithrax Coppingeri*, Haswell, Catal. Austral. Crust. p. 15 (1882).

*Chlorinoides coppingeri* (Hasw.), Miers, 'Challenger' Brachyura, p. 53, pl. vii. fig. 3 (1886).

Muttuwartu Par (*Thurston*); Gulf of Martaban, two young specimens (*Oates*).

These agree completely with dried specimens in the British Museum named by Miers, except that the cardiac spines are scarcely united basally. They are probably not full-grown, as the carapace of the largest measures only 12 mm. long. According to Miers it is perhaps a variety of *C. longispinus*, De Haan.

*Distribution.* N.E., N., and W. Australia (*Haswell, Miers*); Bass Strait (*Miers*).

## GENUS NAXIA, Milne-Edwards.

## 17. NAXIA HIRTA (A. Milne-Edwards).

*Naxioides hirta*, A. Milne-Edwards, Ann. Soc. Entom. France, ser. 4, t. v. p. 143, pl. iv. fig. 1 (1865).

*Podopisa Petersii*, Hilgendorf, Monatsb. Acad. Wissensch. Berlin, Nov. 1878, p. 785, taf. 1. fig. 1-5.

*Naxia (Naxioides) Petersii* (Hilg.), Miers, 'Alert' Crust. p. 523 (1884); De Man, Mergui Crust. p. 19 (1887).

Tuticorin, a female with ova (*Thurston*).

This specimen has more numerous tubercles on the carapace than are represented in Hilgendorf's figure (a male), and the spine on the posterior margin of the carapace is less acute; the last feature is also noticed by De Man, owing probably to the fact that his specimen, like the one which I have examined, was a female. The rostral spines are entire in the Tuticorin specimen and measure only about 6 mm. in length, while the carapace (including rostral spines) measures 31 mm. in length.

*Distribution.* East Africa, Amirante Is., Andaman Is., Philippines.

18. *NAXIA TAURUS*, Pocock.

*N. taurus*, Pocock, Ann. Mag. Nat. Hist. ser. 6, vol. v. p. 77 (1890).

Gulf of Martaban, two males (*Oates*).

I have compared these with the type-specimen and can find no difference except that in the latter the rostral spines are much longer, being more than half the length of the carapace, whereas in the only Martaban specimen which is perfect as regard the spines they are less than half the length of the carapace. This difference cannot be regarded as one of any importance. The accessory rostral spinules are placed nearer the apices of the rostral spines than in the type, but this is perhaps only what might be expected in a variety with the rostrum shortened.

In the larger specimen the carapace (omitting rostral spines) is 15 mm. long; the type is similarly 20 mm. long.

*Distribution.* China Sea (*Pocock*).

Genus *SCHIZOPHRYS*, White.19. *SCHIZOPHRYS ASPERA* (Milne-Edw.).

*S. aspera* (M.-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. viii. p. 231, pl. x. fig. 1 (1872), *ubi synonym.*

Tuticorin (*Thurston*); Ceylon (*Italy, Nevill*); Rameswaram and Madras (*J. R. H.*).

Strongly marked sexual differences are noticeable in this very common and variable species. In the female the carapace is more uniformly granulated, the lateral spines of the carapace are shorter, and the accessory rostral spinules are rudimentary.

*Distribution.* From the Red Sea and East Africa, to Japan, New Caledonia, and the Navigator Is.

Genus *HOPLOPHRYS*, n.

Carapace subovate, with the regions moderately defined, the surface spinose. Rostrum composed of two short, flattened, acute, and slightly divergent spines. A well-developed preocular or supraocular spine, and a closed fissure on the upper orbital margin. Orbit moderately circumscribed, only deficient below near the postorbital angle. Basal antennal joint rather narrow, its distal external angle prolonged into a flattened acute spine, which is distinctly seen when the carapace is viewed from above; the two succeeding joints of the peduncle slender. External maxillipedes with the ischium longitudinally sulcate in the middle line externally; the outer distal angle of the merus produced into a rounded projecting lobe, and the inner angle slightly emarginate for the carpus; the exognath tapers rather abruptly from about its middle to the narrow distal end. Chelipedes and ambulatory legs rather short, and spinose; the chelipedes not enlarged in the male, with the fingers excavate at the tips and a slight basal hiatus between the two. All the segments of the male abdomen distinct.

Possibly some of the above characters, *e. g.* the spiny nature of the carapace and limbs,

may be specific and not generic. In some respects this genus is intermediate between the Subfamilies Schizophrysinæ and Pericerinæ of Miers; it at least illustrates the difficulty of assigning a place in either of these groups to some forms. The genera to which it appears most closely related are *Schizophrys*, White, and *Microphrys*, Milne-Edw. In the first of these the rostral spines carry secondary lateral spinules, there is no distinct supraorbital spine, the upper orbital margin shows two fissures, and the merus of the external maxillipedes is not produced externally and distally. In the second, to which it is perhaps more nearly related, the basal antennal joint is considerably broader, with a longer terminal spine, the rostral spines are longer, the orbits more complete below, and the chelipedes are enlarged in the male, with acute fingers. It also bears considerable resemblance to the American genus *Nemausa*, A. Milne-Edw., belonging to the Mithracinæ, but in this the orbits are well-defined, the basal antennal joint broad and with two external spines, and the merus of the external maxillipedes is not specially produced at its distal external angle.

20. HOPLOPHRYS OATESII, n. sp. (Pl. XXXVI. figs. 1-4.)

Gulf of Martaban, a male (*Oates*).

The gastric region of the carapace is prominent, with two rows of spines arranged in curved lines, the anterior row (convex anteriorly) consisting of seven spines—three small spines on each side of a central slightly larger one, the posterior row (convex posteriorly) of three spines, the middle one of which is larger than any other on the gastric area and is somewhat broadly compressed laterally. The cardiac area with two spines, slightly less prominent than the posterior gastric one, arranged in transverse line, and two still smaller and obtuse spines on the genital area. The branchial area with three spines—an anterior one near the branchiogastric groove, which is the largest of all the spines on the carapace, a small posterior one placed in a line which passes between the cardiac and genital spines, and a large lateral one which is distinctly bifurcate, on the side margin of the carapace. There is a single short spine on the hepatic area a slight distance behind the external orbital angle, and a spine on the carapace internal to and smaller than the supraocular spine. Groups of short curved hairs occur on the frontal, gastric, and branchial regions, but otherwise the surface is perfectly smooth between the spines.

The chelipedes present a few spines on the upper surface of the merus, especially towards its distal end; the carpus has about half a dozen short obtuse spines on its upper surface; the hand has well-developed superior and inferior basal articular tubercles at the carpal articulation, and a single tubercle about the middle of the upper surface, while elsewhere it is smooth and glabrous; the fingers are finely toothed, with a more prominent tooth near the base of the dactylus, and the distal halves of the fingers are in contact. The ambulatory legs are spinose superiorly, the spines being most prominent at the distal ends of the meri and on the carpi; the dactyli with a few minute teeth on the proximal half of the posterior margin. The male abdomen is furnished with a single rounded elevation on each segment except the third, which has three. All the spines on this species are stout in proportion to their length, but with their apices more or less acute.

Very fine red lines are visible on the carapace, usually arranged in pairs, running up some of the spines and on the supraocular spine and rostrum; they are also seen crossing transversely the upper surface of the chelipedes and ambulatory legs.

The carapace is 9.3 mm. long, 7.3 mm. broad, chelipede 10 mm. long, first ambulatory leg 12 mm., second ambulatory leg 11 mm.

I have named the species after Mr. E. W. Oates, who discovered it and a number of other interesting forms referred to in this paper.

#### Genus MICIPPA, Leach.

##### 21. MICIPPA PHILYRA (Herbst).

*M. Philyra* (Herbst), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. xv. p. 6 (1885).  
(= *M. platipes*, Rüpp., *M. bicarinata*, Ad. & Wh., *M. hirtipes*, Dana, *M. spatulifrons*, A. Milne-Edw.).

Rameswaram and Tuticorin (*Thurston*). Not uncommon on the reef at Rameswaram (*J. R. H.*).

*Distribution*. Red Sea, Cape of Good Hope, and Mauritius, to New Caledonia and Fiji.

##### 22. MICIPPA THALIA (Herbst).

*M. Thalia* (Herbst), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. xv. p. 10 (1885).  
(= *M. inermis*, Hasw., *M. pusilla*, Bianconi).

Tuticorin and Muttuwartu Par (*Thurston*); Rameswaram (*J. R. H.*).

Like the other species of the genus, nearly always overgrown with sponges.

*Distribution*. Red Sea and Natal coast to New Caledonia.

##### 23. MICIPPA MASCARENICA, KOSSMANN.

*M. Philyra*, var. *mascarenica*, Kossmann, Malaeostraca in Zool. Ergebn. Reise Rothen Meeres, p. 7, pl. iii. fig. 2 (1877).

*M. mascarenica*, Miers, Ann. Mag. Nat. Hist. ser. 5, vol. xv. p. 7 (1885).  
(= *M. superciliosa*, Hasw., *Paramicippa asperimanus*, Miers).

Gulf of Martaban, three females, one with ova and one bearing a *Sacculina* (*Oates*).

*Distribution*. Red Sea, Mauritius, Singapore, N. Australia.

##### 24. MICIPPA MARGARITIFERA, n. sp. (Pl. XXXVI. figs. 5-7.)

Gulf of Martaban, a male and two females with ova (*Oates*).

The carapace is but little convex, with the hepatic regions deeply excavate, and the surface everywhere strongly granulated, though fewer granules are present in the hollows. Two short blunt spines occur on the margin of the posterior branchial area, and a third less marked is placed internal to these and on the surface of this region. The cardiac area is somewhat circumscribed, and behind it, nearly at the posterior margin of the carapace, there is a small strongly granulated elevation, with a similar but slighter elevation on each side. The anterior half of the lateral margin has a few irregular spines, the largest placed opposite the posterior part of the hepatic depression. The front is vertically deflexed, with the surface granulated and the apex retroflexed, terminating in two obtusely rounded equal lobes separated by a median notch, and on the outer margin of

each lobe is a short curved spine directed forwards (an imaginary line joining these two spines marks the junction of the vertical rostrum with the horizontal apex). The anterior orbital fissure is linear and twice as deep as the wider posterior fissure. On the posterior margin of the carapace are three perfectly hemispherical smooth tubercles exactly resembling pearls set in the margin, and slightly smaller than the ocular cornesæ; a finely crenulated line separates the median from the lateral pearl on each side. The basal antennal joint has two or three short spines in front of the orbit, and the second peduncular joint is not specially dilated; the flagellum carries a few short hairs.

The chelipedes in the male are finely granulated on the upper and lower surfaces of the merus, the whole of the carpus, and the inner surface of the hand and fingers; on the inner surface of the hand the granules become subspinulose, while the outer surface of the hand and fingers is smooth. The opposing edges of the fingers are finely crenulated, and there is a slight basal hiatus between them; the finger-tips are dark in colour. The ambulatory legs are very hairy, with the meral joints enlarged and flattened distally, and a slight lobe occurs on the posterior distal margin of these joints.

The male carapace is 15 mm. long and 12 mm. broad, the chelipedes 20 mm. long, and the second ambulatory leg 17 mm. long; the carapace of the larger female is only 9 mm. long.

This small species is distinguished by its three pearl-like tubercles, the form of the front and of the ambulatory legs, &c. *M. curtispina*, Haswell, has a similarly deflexed rostrum, but it terminates in four rounded lobes, and there are other points of difference.

#### Genus TYLOCARCINUS, Miers.

##### 25. TYLOCARCINUS STYX (Herbst).

*Microphrys Styx* (Herbst), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. viii. p. 247, pl. xi fig. 4 (1872), *ubi synonym.*

Rameswaram, Tuticorin, and Muttuwartu Par (*Thurston*). Common on the reef at Rameswaram (*J. R. II.*).

The general colour of this species is yellowish, with red mottlings on the gastric and branchial regions of the carapace, and along the upper surface of the legs; smaller red spots and lines are found on the chelipedes.

*Distribution.* From the Red Sea to the Pacific.

#### Genus LAMBRUS, Leach.

##### 26. LAMBRUS LONGIMANUS (Linn.).

*L. longimanus* (Linn.), Milne-Edwards, Hist. Nat. Crust. t. i. p. 354 (1831); Miers, Ann. Mag. Nat. Hist. ser. 5, vol. iv. p. 20 (1879).

Ceylon (*Italy*); Gulf of Martaban (*Oates*); Madras (*J. R. II.*).

A male from Madras has the carapace 25.5 mm. long and 27.5 mm. broad, the right chelipede 102 mm. long.

*Distribution.* Mauritius, Mergui, Malay Archipelago, N. and N.E. Australia.

## 27. LAMBRUS CONTRARIUS (Herbst).

*L. contrarius* (Herbst), Milne-Edwards, Hist. Nat. Crust. t. i. p. 354 (1834); Miers, 'Challenger' Brachyura, p. 94 (1886).

(= *L. spinimanus*, Desmarest).

Tuticorin, an adult male (*Thurston*).

The carapace of this specimen is 38 mm. long, 36 mm. broad, and the chelipedes 93 mm. long.

*Distribution.* Mauritius, Malay Archipelago.

## 28. LAMBRUS AFFINIS, A. Milne-Edw.

*L. affinis*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. viii. p. 261, pl. xiv. fig. 4 (1872).

Tuticorin (*Thurston*); Rameswaram (*J. R. II.*); Gulf of Martaban (*Oates*); Ceylon (*Nevill*).

The chelipedes are stouter and proportionately shorter in the female than in the male, and in the latter the ambulatory legs are also more slender. The carapace of a male is 18 mm. long and 18.5 mm. broad. It is a common and widely-distributed species, and, as suggested by Miers, may perhaps prove identical with the longer known *L. pelagicus*, Rüppell.

*Distribution.* Zanzibar, Seychelles, Singapore, Cochin China, Philippines, N. Australia, New Caledonia.

## 29. LAMBRUS LONGISPINUS, Miers.

*L. longispinus*, Miers, Ann. Mag. Nat. Hist. ser. 5, vol. iv. p. 18 (1879).

(= *L. spinifer*, Haswell).

Tuticorin, an adult male (*Thurston*).

This species may be recognized by the median row of large spines on its carapace, and by the presence of large rounded granulated tubercles on the under surface of the chelipedes. The ambulatory legs are strongly compressed.

*Distribution.* Shanghai, Malay Archipelago, N. and N.E. Australia.

## 30. LAMBRUS HOLDSWORTHI, Miers.

*L. Holdsworthi*, Miers, Ann. Mag. Nat. Hist. ser. 5, vol. iv. p. 19, pl. v. fig. 3 (1879).

Tuticorin, a male (*Thurston*).

The specimens described by Miers were all females. The male has more slender chelipedes and the inequalities of the carapace are more marked; there is also a row of minute tubercles passing forwards on each side from the gastric spine towards the orbital margin, which is not represented in Miers's figure. The carapace is 13 mm. long and 14.5 mm. broad, the chelipedes 36 mm. long.

*Distribution.* Ceylon (*Miers*).

## 31. LAMBRUS SCULPTUS, A. Milne-Edw.

*L. (Aulacolambus) sculptus*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. viii. p. 258, pl. xiv. fig. 3 (1872).

Gulf of Martaban, four specimens (*Oates*).

The largest specimen (a female) has the carapace 8 mm. long and 7.5 mm. broad. In this small species there is a well-marked channel on each pterygostomial area leading to the branchial opening. The *L. pisoides*, Adams & White, is a closely allied species, and the two are perhaps not distinct.

*Distribution.* New Caledonia (*A. Milne-Edwards*); "Eastern Seas," and Fiji (*Brit. Mus.*).

### 32. LAMBRUS HOPLONOTUS, Adams & White.

*L. hoplonotus*, Adams & White, 'Samarang' Crust., p. 35, pl. vii. fig. 3 (1848).

Muttuwartu Par, a male (*Thurston*).

The single specimen belongs to the var. *planifrons* of Miers (Ann. Mag. Nat. Hist. ser. 5, vol. iv. p. 24, pl. v. fig. 7) founded on specimens collected by Holdsworth in Ceylon. The carapace is 12 mm. long, and 17.5 mm. in breadth including the lateral epibranchial spines.

*Distribution.* Ceylon, Malay Archipelago, N.E. Australia, New Caledonia.

### Genus CRYPTOPODIA, Milne-Edwards.

### 33. CRYPTOPODIA FORNICATA (Fabr.).

*C. fornicata* (Fabr.), Adams & White, 'Samarang' Crust., p. 32, pl. vi. fig. 4 (1848).

Gulf of Martaban (*Oates*). A single very young specimen apparently referable to this species.

*Distribution.* N., N.E., and E. Australia, Malay Archipelago, Singapore, China, Japan.

### Genus ÆTHRA, Leach.

### 34. ÆTHRA SCRUPOSA (Linn.).

*Æthra scruposa* (Linn.), Milne-Edwards, Hist. Nat. Crust. t. i. p. 371 (1834).

Ceylon (*Haly*).

*Distribution.* Mauritius, Malay Archipelago, Strait of Gaspar.

### Genus ZEBRIDA, White.

### 35. ZEBRIDA ADAMSI, White.

*Zebrida Adamsii*, White, Proc. Zool. Soc. 1847, p. 121; Adams & White, 'Samarang' Crust., p. 24, pl. vii. fig. 1 (1848).

Tuticorin, two females (one with ova) and a male (*Thurston*).

These specimens completely agree as regards colour-markings with the original description and figure of this very beautiful species; the markings are doubtless protective. The single male has the carapace flatter and slightly narrower than in the females, and in the former the propodus of the right chelipede is more strongly developed than that of the other side. The largest specimen (a female with ova) has the carapace 11 mm. long, and 10.5 mm. broad between the apices of the lateral spines; the male is 9 mm. long and 8 mm. broad. *Z. longispina*, Haswell, from Torres Strait, is distinguished only by its longer and more acute spines, and is perhaps merely a local variety.

*Distribution.* Sooloo Sea and coast of Borneo. 6-12 fathoms (*Adams & White*).

## Genus PARATYMOLUS, Miers.

## 36. PARATYMOLUS SEXSPINOSUS, Miers.

*P. sexspinus*, Miers, 'Alert' Crust. p. 261, pl. xxvii. fig. B (1884).

Tuticorin, a male specimen (*Thurston*).

Three spines are present on each antero-lateral margin of the carapace, the first (preocular) and second obtuse, the third at the antero-lateral angle subacute and directed forwards. The terminal joint of the antennal peduncle is greatly flattened and its margin ciliated. The carapace is finely pubescent. Length of carapace 8 mm., breadth 7 mm.

*Distribution.* Torres Strait (*Miers*).

## Group CYCLOMETOPA.

## Genus ATERGATIS, De Haan.

## 37. ATERGATIS INTEGERRIMUS (Lamarek).

*A. integerrimus* (Lam.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. i. p. 235 (1865).

(= *A. subdivisus*, Adams & White).

Tuticorin, a series (*Thurston*); Ceylon (*Haly, Nevill*); Rameswaram, not uncommon at low water under blocks of dead coral (*J. R. II.*).

The carapace of a Tuticorin specimen measures 68 mm. in length and 104 mm. in breadth.

*Distribution.* From E. Africa to China and Japan.

## 38. ATERGATIS FLORIDUS (Rumph.).

*A. floridus* (Rumph.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. i. p. 243 (1865).

Rameswaram and Tuticorin (*Thurston*); Ceylon (*Haly, Nevill*); Rameswaram, common on the reef and at low water (*J. R. II.*).

The carapace of a specimen from Rameswaram measures 41 mm. in length and 58 mm. in breadth.

*Distribution.* From the Red Sea and E. Africa to Japan, N. Australia, New Caledonia, and Tahiti.

## 39. ATERGATIS LÆVIGATUS, A. Milne-Edw.

*A. laevigatus*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. i. p. 24, pl. xv. fig. 4 (1865).

Tuticorin, an adult female (*Thurston*).

In this species the carapace is very convex both from side to side and from before backwards. The antero-lateral margin terminates simply at its posterior end and is not continued into a transverse ridge; four closed and indistinct marginal fissures can be made out, three of them situated rather close together on the posterior half of the margin. The hand is not carinated superiorly and the finger-tips are excavated; the ambulatory legs are strongly carinated. It is regarded by Kossmann as a variety of *A. roseus* (Rüppell), but in the latter species, as described by A. Milne-Edwards, and in specimens

from the Red Sea, in the British Museum, which I have examined, the carapace and chelipedes are covered with numerous small depressions or pits, giving them a rugose appearance, and this character is wanting in the present species; otherwise the two are nearly related.

*Distribution.* Malabar (*A. Milne-Edwards*).

40. *ATERGATIS DILATATUS*, De Haan.

*A. dilatatus*, De Haan, Crust. Japon. p. 46, tab. xiv. fig. 2 (1850).

Ceylon (*Italy*).

I refer some young specimens doubtfully to this species. Müller has had similar doubt in regard to specimens from Trincomali.

*Distribution.* China (*De Haan*); New Caledonia (*A. Milne-Edwards*).

Genus *CARPILIUS*, Leach.

41. *CARPILIUS MACULATUS* (Linn.).

*C. maculatus* (Linn.), *A. Milne-Edwards*, Nouv. Arch. Mus. Hist. Nat. t. i. p. 214 (1865).

Ceylon (*Italy, Nevill*).

*Distribution.* From Mauritius to the Malay Archipelago, New Caledonia, and the Pacific.

Genus *CARPILODES*, Dana.

42. *CARPILODES TRISTRIS*, Dana.

*C. tristris*, Dana, Crust. U.S. Explor. Exped. vol. i. p. 193, pl. ix. fig. 7 (1852).

Muttuwartu Par, a male (*Thurston*).

*Distribution.* Paumotu Archipelago (*Dana*); N. and N.E. Australia (*Miers*); "Eastern Seas" (*Brit. Mus.*).

43. *CARPILODES MARGARITATUS*, *A. Milne-Edw.*

*C. margaritatus*, *A. Milne-Edwards*, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 182, pl. v. fig. 2 (1873).

Rameswaram, two males; Tuticorin, two young males (*Thurston*).

These agree with *A. Milne-Edwards*'s figure and brief description, though they have lost the vivid colour shown in the former. The pearly granulations show a tendency to linear arrangement on the hands. A wide hiatus exists between the fingers, and their margins are toothed. The inner border of the carpus carries two strong granulated and blunt teeth. The largest specimen has the carapace 17 mm. long and 27.5 mm. broad.

*Distribution.* New Caledonia (*A. Milne-Edwards*).

44. *CARPILODES VENOSUS* (*Milne-Edw.*).

*Carpilius venosus*, *Milne-Edwards*, Hist. Nat. Crust. t. i. p. 383 (1834).

*Xantho obtusus*, De Haan, Crust. Japon. p. 47, pl. xiii. fig. 5 (1850).

*Lionera obtusa*, Stimpson, Proc. Acad. Nat. Sci. Philad. March 1858, p. 32.

*Carpilodes venosus*, *A. Milne-Edwards*, Nouv. Arch. Mus. Hist. Nat. t. i. p. 227, pl. vii. fig. 2 (1865).

Ceylon (*Italy*).

*Distribution.* From Mauritius to Japan, New Caledonia, and N. Australia.

45. *CARPILODES CINCTIMANUS* (White).

*Carpilius cinctimanus*, White, Append. Jukes's Voy. 'Fly,' p. 336, pl. ii. fig. 3 (1847).

*Liomera cinctimana*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 176, pl. v. fig. 4 (1873).

*Carpilodes cinctimanus*, Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 234 (1880).

(= ? *Liomera lata*, Dana).

Ceylon (*Italy*, Nevill).

The general ground-colour of this species is bright red. The fingers are black, and a black band encircles the hand, though in young individuals it is sometimes absent. The dactyli of the ambulatory legs have a white band encircling their middle portion, while the narrow apical part is black.

*Distribution.* From Mauritius and the Seychelles, to the Pacific and west coast of North America.

Genus *LIOMERA*, Dana.46. *LIOMERA PUNCTATA* (Milne-Edw.).

*Xantho punctatus*, Milne-Edwards, Hist. Nat. Crust. t. i. p. 396 (1834); A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 199, pl. vii. fig. 6 (1873).

*Liomera punctata*, Miers, 'Alert' Crust. p. 528 (1884).

(= *L. maculata*, Haswell).

Tuticorin, an adult male; Muttuwartu Par, a young male (*Thurston*); Ceylon (*Nevill*).

The carapace of the larger specimen is 18 mm. long and 30 mm. broad. The red spots on the carapace soon fade in spirit. There is a characteristic light-coloured band at the base of the mobile finger of each chelipede.

*Distribution.* Madagasear, Seychelles, Amirante Is., Red Sea, Malay Archipelago, N. Australia, New Caledonia.

47. *LIOMERA RODGERSII* (Stimpson).

*Lachnopus Rodgersii*, Stimpson, Proc. Acad. Nat. Sci. Philad. March 1858, p. 32.

*Liomera Rodgersii*, Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 231, pl. xiii. fig. 3 (1880); De Man, Brock's Crust. p. 237 (1888).

Ceylon (*Italy*).

*Distribution.* Malay Archipelago.

Genus *LOPHACTEA*, A. Milne-Edwards.48. *LOPHACTEA GRANULOSA* (Rüppell).

*L. granulosa* (Rüpp.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. i. p. 247 (1865).

(= *Cancer limbatus*, Milne-Edw.).

Rameswaram, a male; Tuticorin, three males and three females (*Thurston*). Not uncommon on the reef at Rameswaram (*J. R. H.*).

In most of these there is an ill-defined granular ridge on the upper surface of the hand, and in one female it is sharp and prominent; this ridge is one of the chief distinguishing features of the closely-allied *L. cristata*, A. Milne-Edw. In the same female the granu-

lations are more pronounced on the carapace, and they occur even on the mesogastric lobe and towards the lateral and posterior margins of the carapace, whereas in the other specimens they are deficient in these localities. In a third species, *L. Eydouxii*, A. Milne-Edw., the only difference of importance is that the gastric region is less distinctly lobulated, and the lobes separated merely by shallow grooves. It is perhaps possible that all three are varieties of a single variable species. The largest specimen, a male, has the carapace 35 mm. long and 49 mm. broad.

*Distribution.* From the Red Sea and E. Africa to the Pacific.

#### 49. LOPHACTEA SEMIGRANOSA (Heller).

*Atergatis semigranosus*, Heller, Sitzungsber. kais. Akad. Wiss. Wien, p. 313 (1861).

*Lophactea semigranosa*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. i. p. 248 (1865); De Man, Brock's Crust. p. 246, taf. viii. fig. 4 (1888).

Muttuwartu Par, two males and a female with ova (*Thurston*); Rameswaram (*J. R. II.*).

These agree well with a specimen in the British Museum from Suakim, though in the Indian specimens the crest on the upper margin of the head is more strongly marked. The antero-lateral margin of the carapace somewhat resembles that of a *Lophozozymus*. The carapace is granulated anteriorly and towards the sides, smooth posteriorly; but De Man has recently pointed out that the entire surface may be granulated. The carpus and propodus of the chela are granular externally, with the granules arranged in lines, and a large tooth is present on the inner surface of the immobile finger. The ambulatory legs are carinated, but not granulated, and have ciliated margins. The largest specimen, a female with ova, is 9 mm. long and 13 mm. broad.

*Distribution.* Red Sea, Amirante Is., Malay Archipelago.

#### 50. LOPHACTEA FISSA, n. sp. (Plate XXXVI. figs. 8, 8 a).

Tuticorin, a male (*Thurston*).

The areolation and armature of the carapace are similar to those of *L. granulosa*, except that the granules are somewhat fewer in number, and towards the sides of the carapace they tend to become spinulose; a smooth transverse area also exists near the posterior margin. The lateral margins are scarcely so produced as is usual in the genus, and the spiniform granules extend on to them; three wide open fissures are met with, two close together anteriorly, and the posterior one near the hinder termination of the antero-lateral margin. The portion of the antero-lateral margin contiguous to the orbit, *i. e.* between the latter and the first fissure, is straight, thickened, and separated from both the upper and the lower orbital margin by a very narrow fissure: a second narrow fissure is present as usual in the upper orbital margin. The frontal lobes are regularly rounded. The antennal peduncles and external maxillipedes are similar to those of *L. granulosa*.

The chelipedes are like those of *L. granulosa*, *i. e.* strongly tuberculated externally; the fingers are black, compressed, and ridged externally, with a well-marked internal lobe on the immobile finger. The ambulatory legs have the carpal and propodal joints rather less carinated than usual, and their posterior surfaces (especially of the propodi) strongly granulated; well-marked articular facets are present between these joints on each leg.

The male abdomen has merely a few granules on the first two segments; but the sternal region of the thorax is granulated.

The whole upper surface of the carapace, and outer surface of the chelipedes and legs, carry long yellowish green hairs, which are specially elongated on the margins of the legs.

The carapace is 17.5 mm. long and 25.5 mm. broad; the distance between the outer orbital angles 14 mm., lower margin of hand and immobile finger 11.5 mm., height of hand 7.7 mm., length of dactylus 8 mm.

This species is distinguished by the form of the lateral margin of its carapace, and especially by the wide fissures, but also by the peculiar hairs with which it is clothed.

#### Genus ACTÆA, De Haan.

##### 51. ACTÆA GRANULATA (Aud.).

*A. granulata* (Aud.), A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. i. p. 275 (1865).  
(= *A. pura*, Stimpson).

Tuticorin, three specimens, one carrying a *Sacculina*; Cheval Par (*Thurston*); reef at Rameswaram (*J. R. H.*).

I have examined the type of *A. carcharias*, White, in the British Museum, and agree with Miers that it is probably only a variety of *A. granulata*.

*Distribution.* From the Red Sea and East Africa to China and Australia.

##### 52. ACTÆA CALCULOSA (Milne-Edw.).

*A. calculosa* (Milne-Edw.), A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. i. p. 276, pl. xviii fig. 3 (1865).

Tuticorin, thirteen specimens, including four females with ova; Muttuwartu Par (*Thurston*).

This species is allied to *A. granulata*, but is smaller; the carapace is flatter and less contracted posteriorly, with the granules on its surface smoother; the posterior margin is granulated and there is a smooth transverse groove immediately in front of it, which is not seen in *A. granulata*. In the present species also, the tubercles on the hand are more rounded, the abdominal and sternal regions are smooth or only faintly granulated, and the whole aspect is more glabrous.

The largest specimen (a male) has the carapace 11.3 mm. long and 15.5 mm. broad, while the smallest female with ova is only 8.5 mm. long and 12 mm. broad.

*Distribution.* Australia (*A. Milne-Edwards*).

##### 53. ACTÆA NODULOSA (White).

*A. nodulosa* (White), Adams & White, 'Samarang' *Crust.* p. 39, tab. viii. fig. 4 (1848); Miers, 'Challenger' *Brachyura*, p. 120 (1886).

Tuticorin, three females (one with ova) and two males (*Thurston*).

The types in the British Museum are obviously young and only about half the size of the largest Tuticorin examples, but there can be no doubt, I think, as to the identity of the latter. The carapace is only moderately convex, with the anterior regions well-

defined, and separated by somewhat deep smooth grooves; smooth rounded tubercles are everywhere present, as well as a few scattered tufts of hair, which are not seen in the types. On the antero-lateral margin are four elevations, each composed of a collection of tubercles; on the posterior margin is a continuous row of tubercles, and immediately in front of it a second row, which, however, is interrupted in the middle. The chelipedes and ambulatory legs are tuberculate externally, and the latter are fringed with hairs. The digits are black and both are granulated proximally; the black colour occasionally extends back for some distance on both the inner and outer surface of the hand. The sternal region is granulated.

The largest male is 16 mm. long and 23.5 mm. broad; a female with ova is 11.5 mm. long and 17 mm. broad.

A specimen in the British Museum, taken by H.M.S. 'Challenger' at Honolulu, has the carapace slightly broader in proportion to its length, and the tubercles on its surface both smaller and more numerous; the ambulatory legs without hairs. It may perhaps rank as a variety.

*Distribution.* Mauritius (*White*); Honolulu (*Miers*).

54. *ACTEA PERONII* (Milne-Edw.), var. *SQUAMOSA*, n.

*A. peronii* (Milne-Edw.), *Miers*, 'Challenger' Brachyura, p. 122 (1886).  
(= *Xantho spinosus*, *Hess*).

Muttuwartu Par, a female (*Thurston*).

This specimen differs from the typical form in having the tubercles of the carapace replaced by flattened, polished, scale-like elevations; each scale is raised higher from the carapace anteriorly than it is posteriorly, and the whole series presents a filed or ground appearance, as if the filing had been performed from behind forwards. The scales are also present, though of smaller size, on the posterior part of the carapace, whereas in the typical form this part is almost smooth. In the variety the ambulatory legs are hairy and the merus of the last leg is strongly tuberculate (smooth in the typical form); the tubercles of the carpus and propodus of the chelipedes are more conical, and the tubercles present on the eye-stalks and immediately below the suborbital margin are more strongly developed. I cannot regard this specimen as belonging to a distinct species, for I have observed a tendency towards the above characters in undoubted specimens of *A. Peronii*; still it may be useful to distinguish it by a special name.

The carapace measures 9.5 mm. in length and 12 mm. in breadth.

*Distribution.* Australia (*Milne-Edwards, Hess*); Bass Strait (*Miers*).

55. *ACTEA RUFOPUNCTATA* (Milne-Edw.).

*A. rufopunctata* (Milne-Edw.), *A. Milne-Edwards*, *Nouv. Arch. Mus. Hist. Nat.* t. i. p. 268, pl. xviii fig. 1 (1865).  
(= *A. pilosa*, *Stimpson*).

Tuticorin; Cheval Par (*Thurston*).

In this species the fingers are almost excavated at the tips, so it might with equal justice be placed in the genus *Actæodes*.

*Distribution.* From the Red Sea, Seychelles, and Mauritius, to China and the Fijis. It has also been recorded from the Mediterranean, the Canaries, Madeira, and the S. Atlantic.

56. *ACTÆA RUPPELLII* (Krauss).

*A. Ruppellii* (Krauss), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 232 (1880), *ubi synonym.*

Tuticorin, many specimens (*Thurston*). Common on the reef at Rameswaram (*J. R. H.*).

The amount of pubescence varies greatly in different individuals. After examination of the type of *Egle rugata*, Adams & White, I have come to the same conclusion as Hilgendorf and Miers, viz. that it is merely a variety of the present species. *A. hirsutissima*, Rüpp., is also closely allied and perhaps not distinct.

*Distribution.* Natal, Zanzibar, Mauritius, Malay Archipelago, N. and N.E. Australia.

Genus *HYPOCÆLUS*, Heller.

57. *HYPOCÆLUS RUGOSUS*, n. sp. (Pl. XXXVI. figs. 9-11.)

Tuticorin, two females (*Thurston*).

This species is closely allied to *H. granulatus* (De Haan), which has been well described and figured by both De Haan and A. Milne-Edwards, so that only the characters wherein it differs from the latter need be pointed out. The areolation of the carapace is very like that of *H. granulatus*, but the granules are much smaller. The posterior half of the lateral margin of the carapace is irregular and three-toothed, the most anterior tooth being well-defined, and marking the hinder limit of the pterygostomial cavity; whereas in *H. granulatus* this margin is slightly irregular, but not dentate. The pterygostomial cavity has the upper and lower margins straight, and gradually converging to a rather broad truncated hinder end, which is fully half the width of the anterior end; while in *H. granulatus* the lower margin of the cavity is strongly curved and the hinder end narrow and pointed (see Pl. XXXVI. fig. 12); in our new species the cavity also approaches nearer to the orbit.

In both species the chelipedes are somewhat similar in general appearance. In *H. rugosus* the carpus is more strongly tuberculate, and the granules on the outer surface of the hand are arranged in reticulating lines, while the upper surface is convex and covered with prominent granular tubercles; whereas in the longer known form the granules on the outer surface of the hand are arranged in more or less parallel lines along the joint, and the upper surface is flattened or almost concave, with a median and two lateral granulated lines on this area. The ambulatory legs are also more strongly tuberculated in the new species.

The gastric and branchial regions of the carapace are reddish (in spirit specimens), while the carpal joints of the chelipedes, and the legs, show traces of the same colour.

All the comparisons have been made with a single dried specimen of *H. granulatus* (locality unknown) in the collection of the British Museum.

In the larger specimen the carapace is 12.3 mm. long and 17.5 mm. broad; the front is 5.3 mm. broad.

## Genus XANTHO, Leach.

## 58. XANTHO IMPRESSUS (Lamarek).

*X. impressus* (Lam.), A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. ix. p. 198, pl. vi. fig. 2 (1873).

Ceylon, five specimens (*Nevill*).

*Distribution.* Mauritius, Mergui, New Caledonia.

## Genus MEDÆUS, Dana.

## 59. MEDÆUS DISTINGUENDUS (De Haan).

*Cancer (Xantho) distinguendus*, De Haan, *Crust. Japon.* p. 18, tab. xiii. fig. 7 (1850).

*Medæus distinguendus* (De Haan), De Man, *Mergui Crust.* p. 31 (1887).

*Xantho Macgillirayi*, Miers, 'Alert' *Crust.* p. 211, pl. xx. fig. C (1884).

Gulf of Martaban, two young specimens (*Oates*).

I have compared these and found them identical with specimens of similar size from Mergui, in the British Museum, which were referred by De Man—and as I think correctly—to De Haan's species. *Xantho Macgillirayi*, Miers, from Australia, of which both dry and spirit specimens exist in the British Museum collection, is also in my opinion referable to the same species, the differences being unimportant; indeed De Haan's figure is a better representation of *X. Macgillirayi* than is the one given in the Report on the 'Alert' Crustacea. Miers ('Alert' *Crust.* p. 530) appears to have regarded De Haan's species as a variety of *Leptodius exaratus* (Milne-Edw.). In old specimens the granules on the hands appear to be lost, and simply a rugose appearance is left.

*Distribution.* Red Sea, Mergui, China, Japan, N. and N.E. Australia.

## Genus EUXANTHUS, Dana.

## 60. EUXANTHUS MELISSA (Herbst).

*E. Melissa* (Herbst), A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. i. p. 293 (1865).

Tuticorin (*Thurston*); Ceylon (*Italy, Nevill*).

*Distribution.* From India to Australia and the Pacific (Fijis, Tongatabu, &c.).

## Genus ZOZYMUS, Milne-Edwards.

## 61. ZOZYMUS ÆNEUS (Linn.).

*Z. Æneus* (Linn.), Milne-Edwards, *Hist. Nat. Crust.* t. i. p. 385 (1834).

Ceylon (*Italy, Nevill*).

*Distribution.* Red Sea, Mascarenes, Malay Archipelago, Loo Choo Is., Australia, South Pacific.

## Genus POLYCREMNUS, Gerstaecker.

## 62. POLYCREMNUS OCHTODES (Herbst).

*Galene ochtodes* (Herbst), Adams & White, 'Samarang' *Crust.* p. 43, tab. x. fig. 2 (1848).

Muttuwartu Par (*Thurston*); Madras (*J. R. II.*).

The carapace of a specimen from Madras is 23 mm. long and 29 mm. broad.

*Distribution.* Indian Ocean (*Herbst, White*); Malay Archipelago (*Adams & White*).

Genus HALIMEDE, De Haan.

63. HALIMEDE THURSTONI, n. sp. (Pl. XXXVI. figs. 13, 14.)

Tuticorin, a male (*Thurston*).

This species is closely allied to *H. fragifer*, De Haan, from Japan, but is, I think, distinct, though possibly it may afterwards be shown to be a variety of that species, which in general form it much resembles. The carapace is covered with short tufts of hair, which spring from the different elevations, and these last are much less marked than in De Haan's species; they consist simply of minute clustered granules on the gastric, cardiac, and branchial regions. The short antero-lateral margin has two strongly marked teeth, one at the posterior limit of the margin, the other between this and the orbit; opposite the latter tooth there is a strongly-marked flattened tubercle on the hepatic region, and between the tooth and the orbit a third small antero-lateral tooth. External to the postorbital angle is a flattened lobe, and the lower orbital margin is similarly flattened. The frontal lobes are strongly produced, with a deep intervening median fissure; each lobe is regularly convex anteriorly and the margin is finely crenulated. The inferior and internal angle of the orbit is produced, and along with a considerable portion of the lower orbital wall can be distinctly seen from above. The basal antennal joint is joined to the subfrontal process, but does not extend into the inner orbital hiatus as in *Halimede Coppingeri*, Miers (so this latter species is, as surmised by Miers, probably referable to another genus). The merus of the external maxillipedes is faintly emarginate at its distal end, the outer distal angle is slightly produced, and there is a distinct notch for the carpus.

The chelipedes are similar to those of De Haan's species, but the carpus and hand are much less strongly tuberculate, the tubercles being almost obsolete on the outer and lower surface of the hand, while those on the upper surface are regularly flattened. The ambulatory legs and male abdomen resemble those of De Haan's species.

The most important difference between the two species is seen in the frontal lobes, which in that just described have a convex crenulated margin, while in *H. fragifer* they are concave and entire; in the new species also, the carapace and outer surface of the hand are much less tuberculated. The *Medæus nodosus*, A. Milne-Edwards, from New Caledonia, bears a general resemblance to our species, but the antero-lateral margin of the carapace has four teeth, the front is less produced, and the lobes are not rounded; it is perhaps congeneric with the present species.

The carapace is 9 mm. long and 10 mm. broad.

Genus CYCLOXANTHUS, A. Milne-Edwards.

64. CYCLOXANTHUS LINEATUS, A. Milne-Edw.

*C. lineatus*, A. Milne-Edwards, Ann. Soc. Entom. France, t. vii. p. 269 (1867); id. Nouv. Arch. Mus. Hist. Nat. t. ix. p. 209, pl. vi. fig. 5 (1873).

Tuticorin, a male (*Thurston*).

The colour is at first very vivid, but the lines on the carapace soon fade in spirit. The carapace is 11.5 mm. long and 15.5 mm. broad. Milne-Edwards's type-specimen was slightly larger.

*Distribution.* New Caledonia, Lifu, Torres Strait, Arafura Sea.

Genus LOPHOZOZYMUS, A. Milne-Edwards.

65. LOPHOZOZYMUS DODONE (Herbst).

*L. Dodone* (Herbst), De Man, Brock's Crust. p. 270, Taf. x. fig. 2 (1888), *ubi synon.*

(= *Xantho radiatus*, Milne-Edwards, *Atergatis lateralis*, White, *Atergatis elegans*, Heller).

Tuticorin, a series; Muttuwartu Par (*Thurston*); Rameswaram (*J. R. II.*).

I have examined the types of *Atergatis lateralis*, White, from Mauritius, and find that they are identical with this species, as more than one writer had already suspected.

*Distribution.* East Africa, Mauritius, Malay Archipelago, New Caledonia.

66. LOPHOZOZYMUS CRISTATUS, A. Milne-Edw.

*L. cristatus*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 203, pl. vi. fig. 4 (1873).

Muttuwartu Par, three specimens (*Thurston*).

These are probably young, the largest measuring only 13.5 mm. in length and 22 mm. in breadth. Immersion in spirit has completely removed all trace of the vivid colour shown in Milne-Edwards's figure.

*Distribution.* New Caledonia (*A. Milne-Edwards*).

Genus CHLORODIUS, Rüppell.

67. CHLORODIUS NIGER (Forskål).

*C. niger* (Forsk.), De Man, Mergui Crust. p. 32 (1887).

Tuticorin, many specimens; Muttuwartu Par (*Thurston*); Rameswaram, one of the commonest species on the reef (*J. R. II.*).

*Distribution.* From the Red Sea and East Africa to Australia and the Pacific.

Genus CHLORODOPSIS, A. Milne-Edwards.

68. CHLORODOPSIS SPINIPES (Heller).

*C. spinipes* (Heller), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 230, pl. viii. fig. 6 (1873).

Ceylon (*Haly*); Muttuwartu Par, a male (*Thurston*).

The Muttuwartu specimen measures 8 mm. in length and 10.5 mm. in breadth. It is more hirsute than is represented in Milne-Edwards's figure, the carapace, legs, and chelipedes carrying many reddish brown hairs; the under surface is without hairs, and the sternal region is finely granulated. The male abdomen is very narrow, and the penultimate segment is slightly wider at its distal than at its proximal end.

*Distribution.* Red Sea, Malay Archipelago, New Caledonia.

## Genus LEPTODIUS, A. Milne-Edwards.

## 69. LEPTODIUS EXARATUS (Milne-Edw.).

*L. exaratus* (Milne-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 222 (1873); Kossmann, Malacostraca in Zool. Ergebn. Reise Rothen Meeres, p. 32, taf. ii. (1877).

Tuticorin, many specimens; Silavaturai Par (*Thurston*); Ceylon (*Haly, Nevill*); Sind, several specimens (*Day*); very common on the reef at Rameswaram (*J. R. II.*).

A very common and very variable species. A male from Silavaturai has the carapace flatter and less distinctly areolated than usual; the colour in spirit light grey, with a large brownish spot on the gastric area of the carapace, and the distal joints of the ambulatory legs darkly banded. Similar specimens from West Australia are in the British Museum collection, and this variety is figured by Kossmann. An old male from Sind (22.5 mm. long and 35 mm. broad) has the postero-lateral surface of the carapace excavated on each side for the last pair of legs, while its front and chelipedes are twisted and deformed.

*Distribution.* From the Red Sea and E. Africa to Japan and the Pacific.

## Genus ETISUS, Milne-Edwards.

## 70. ETISUS LÆVIMANUS, Randall.

*E. levimanus* (Rand.), Dana, Crust. U.S. Explor. Exped. vol. i. p. 185, pl. x. fig. 1 (1852); A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 234 (1873).

Rameswaram and Tuticorin, many specimens (*Thurston*); Ceylon (*Haly*); common on the reef at Rameswaram (*J. R. II.*).

*Distribution.* From the Red Sea and E. Africa to Japan, the Sandwich Is., and Fijis.

## Genus ETISODES, Dana.

## 71. ETISODES ELECTRA (Herbst).

*E. Electra* (Herbst), Miers, 'Alert' Crust. p. 217 (1884), *ubi synonym.*

(=*E. frontalis*, Dana, *E. rugosa*, Lucas, *E. sculptilis*, Heller, *Chlorodius dentifrons*, Stm., *Chlorodius samoensis*, Miers).

Tuticorin (*Thurston*); Rameswaram, not uncommon (*J. R. II.*).

*Distribution.* Red Sea, Seybelle, Malay Archipelago, N. Australia, Samoa, Sandwich Is.

## Genus PHYMODIUS, A. Milne-Edwards.

## 72. PHYMODIUS UNGULATUS (Milne-Edw.).

*P. ungulatus* (Milne-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 218 (1873).  
(=*Chlorodius arcolatus*, Adams & White).

Ceylon (*Haly*).

*Distribution.* From India to New Caledonia and the Pacific.

## 73. PHYMIDIUS MONTICULOSUS (Dana).

*P. monticulosus* (Dana), Miers, 'Challenger' Brachyura, p. 139 (1886), *ubi synonym.*

Tuticorin, four females and one male (*Thurston*).

The largest specimen—a female—is 16 mm. long and 22 mm. broad.

*Distribution.* From the Indian Ocean to the Pacific.

## Genus CYMO, De Haan.

## 74. CYMO ANDREOSSYI (Aud.).

*C. Andreossyi* (Aud.), Miers, 'Alert' Crust. p. 532 (1884).

(= *C. melanodactylus*, De Haan).

Tuticorin, a female with ova; Muttuwartu Par, a male (*Thurston*); Rameswaram, not uncommon (*J. R. II.*).

The carapace has a few granules arranged transversely on the gastric region and towards the lateral margins, while two conspicuous denticles are present towards the centre of the lateral margin. The front is denticulated, the two submedian denticles being largest. The fingers, with the exception of their tips, are black as in the variety *melanodactylus*, De Haan, but at the same time the lower and outer surface of the larger hand is often granulated, whereas according to Miers it is usually smooth in this variety.

*Distribution.* Red Sea, Rodriguez, Malay Archipelago, Samoa, New Caledonia, Tahiti, Fijis.

## Genus MENIPPE, De Haan.

## 75. MENIPPE RUMPHII (Fabr.).

*M. Rumphii* (Fabr.), De Man, Mergui Crust. p. 36 (1887), *ubi synonym.*

(= *Pseudocarcinus Belangeri*, Milne-Edw.).

Rameswaram, an adult male; Tuticorin, two males (*Thurston*); Ceylon (*Italy*); Madras, an adult male (*Day*). Not uncommon at Madras and elsewhere on the Coromandel coast (*J. R. II.*).

In the Rameswaram specimen the carapace is 51 mm. long and 73 mm. broad, while the larger hand is 66 mm. long, measured along the lower border and including the immobile finger. The Madras specimen collected by Day has the curved line with a forward convexity, which runs across the branchial region of the carapace to the middle of the gastro-branchial groove, bounded in front by a series of six flattened pustular elevations.

*Distribution.* Bay of Bengal (Tranquebar, Nicobars, and Mergui), Malay Archipelago.

## Genus OZIUS, Milne-Edwards.

## 76. OZIUS TUBERCULOSUS, Milne-Edw.

*O. tuberculosus* (Milne-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 238, pl. xi fig. 2 (1873).

Ceylon (*Italy*).

*Distribution.* Mauritius, Nicobars, Mergui, New Caledonia.

Genus EPIXANTHUS, Heller.

77. EPIXANTHUS FRONTALIS (Milne-Edw.).

*E. frontalis* (Milne-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 241 (1873).

Ceylon, an adult male (*Nevill*); Nicobars, three specimens (*Day*).

The Ceylon male is 22.5 mm. long and 38 mm. broad; a female with ova from the Nicobars is 13 mm. long and 21 mm. broad. The right chelipede is greatly enlarged in the male, and a wide hiatus appears between the fingers; the fingers of the left chelipede are slender, incurved, and in contact throughout their length.

*Distribution.* From the Red Sea and E. Africa to Japan and New Caledonia.

78. EPIXANTHUS DENTATUS (White).

*Panopæus dentatus* (White), Adams & White, 'Samarang' Crust. p. 41, pl. xi. fig. 1 (1848).

*Epixanthus dentatus* (White), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 233 (1880).

(= *E. dilatatus*, De Man, *Panopæus acutidens*, Hasw.).

Nicobars, an adult female (*Day*).

The carapace is 27 mm. long and 17 mm. broad, slightly broader proportionately than in either of White's types, but this is perhaps a sexual characteristic. The chelipedes, legs, and marginal parts of the carapace are slightly hirsute, while the hairs appear to have been rubbed off in the types. Purplish reticulating lines are present on the surface of the carapace.

*Distribution.* Mergui, Philippines, Java, N. Australia.

Genus ACTUMNUS, Dana.

79. ACTUMNUS SETIFER (De Haan).

*A. setifer* (De Haan), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. i. p. 287, pl. xviii. fig. 5 (1865); Miers, 'Alert' Crust. p. 225 (1884).

(= *A. tomentosus*, Dana).

Muttuwartu Par, a young male (*Thurston*); Gulf of Martaban, three young specimens (*Oates*).

*Distribution.* Mauritius, Malay Archipelago, Japan, N., N.E., and W. Australia, New Caledonia, New Hebrides, Tahiti, Fijis.

80. ACTUMNUS VERRUCOSUS, n. sp. (Pl. XXXVI. figs. 15, 16.)

Tuticorin, a series of both sexes; Muttuwartu Par (*Thurston*).

The carapace is very convex, covered with a short brown pubescence, and provided with a series of remarkable granulated lobes. The frontal margin is granulated and four-lobed, the rounded prominent submedian lobes separated by a narrow median fissure, the outer lobes of small size. The antero-lateral margin has four prominent, subequal, granulated or subspinose lobes, while the postero-lateral margin is smooth and deeply

excavated; the upper orbital margin is granulated and has two well-marked fissures. The granulated lobes on the carapace are arranged as follows:—on the anterior gastric region, behind the front, two pairs, of which the posterior is much larger; on the posterior gastric region three lobules, one median and anterior, two posterior; on each protogastric or lateral gastric region a peculiar  $\mathcal{W}$ -shaped lobule; on the cardiac region two lobules which are slightly excavated in the centre; on the branchial region three lobules, anterior, postero-external (which is the largest of the three), and a postero-internal one placed external to and between the posterior gastric and cardiac lobules.

The right chelipede is slightly larger than the left in both sexes; both are clothed with a short pubescence on the outer surface of the carpus and hand, except towards the base of the immobile finger. The carpus is sparingly tuberculate externally, with a sulcus running parallel to the articulation with the hand, and separated from the latter by a tuberculated strip; the outer surface of the hand is strongly tuberculate, the tubercles with more or less acute apices, rather closely crowded and without any definite arrangement. The fingers are short, with white and obtuse tips, and the immobile one is placed in a straight line with the lower border of the hand; the dactylus is tuberculate superiorly on its proximal half, and a prominent tooth is present on either finger. The ambulatory legs are simply pubescent. The abdomen is smooth and seven-jointed in both sexes. The external maxillipedes are smooth, with a faint impressed line in the middle of the proximal two-thirds of the ischium. The basal joint of the antennal peduncle is joined to the subfrontal process, and the terminal joints lie in the orbital hiatus.

The largest specimen (a male) has the carapace 18.5 mm. long and 25.3 mm. broad, the lower margin of the hand and immobile finger 18 mm., mobile finger 9.7 mm., height of hand 11.5 mm. There is great disparity shown in the size of adult females (carrying ova) from the same locality—the largest is 18 mm. long and 25 mm. broad, while the smallest is 9 mm. long and 11.5 mm. broad.

This well-marked species in general appearance comes nearest to *A. globulus*, Heller, from the Red Sea and Zanzibar, but the latter has the carapace differently lobulated and the antero-lateral margin with only three projections.

#### Genus PILUMNUS, Leach.

##### 81. PILUMNUS VESPERTILIO (Fabr.).

*P. vespertilio* (Fabr.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v, p. 231 (1880), *ubi synonym.*  
(= *P. ursulus*, Adams & White, *P. mus*, Dana).

Rameswaram and Tuticorin, many specimens (*Thurston*); Ceylon (*Holby*); Rameswaram, very common on the reef and between tide-marks (*J. R. II.*).

*Distribution.* From the Red Sea and E. Africa to Japan, Australia, and the Pacific.

##### 82. PILUMNUS LABYRINTHICUS, Miers.

*P. labyrinthicus*, Miers, 'Alert' Crust. p. 224, pl. xxii. fig. C (1884)

Rameswaram, a single specimen (*J. R. II.*).

This specimen, though probably young (carapace 4 mm. long and 5 mm. broad), shows the very characteristic markings or lines on its dorsal surface, which bear some resemblance to a face.

*Distribution.* N. Australia, Singapore.

#### Genus TRAPEZIA, Latr.

##### 83. TRAPEZIA CYMODOCE (Herbst).

*T. Cymodoce* (Herbst), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. ii. p. 409 (1878), *ubi synonym.*  
(= *T. dentifrons*, Latr., *T. hirtipes*, Jacq. & Lucas, *T. cærulea*, Heller, *T. dentata*, A. Milne-Edw.).

Rameswaram, Tuticorin, and Muttuwartu Par; many specimens (*Thurston*). Very common on the reef at Rameswaram (*J. R. II.*).

*Distribution.* Red Sea, Mascarenes, Malay Archipelago, N. Australia, Pacific.

##### 84. TRAPEZIA RUFOPUNCTATA (Herbst).

*T. rufopunctata* (Herbst), De Man, Brock's Crust. p. 318, Taf. xiii. fig. I (1888).

Tuticorin, a female with ova (*Thurston*); Ceylon (*Italy*).

*Distribution.* Malay Archipelago, Pacific.

##### 85. TRAPEZIA MACULATA (MacLeay).

*T. maculata* (MacLeay), Dana, Crust. U.S. Explor. Exped. vol. i. p. 256, pl. xv. fig. 4 (1852); De Man, Brock's Crust. p. 319, Taf. xiii. fig. 2 (1888).

(=? *T. guttata*, Rüppell).

Ceylon (*Italy*).

This species is closely allied to the last, but their distinctive features have been recently pointed out by Dr. De Man, in his Report on the Crustacea collected by Dr. Brock in the Malay Archipelago. Both species are probably widely distributed, but it is impossible, owing to the confusion that formerly existed, to determine which form is referred to in connexion with many of the recorded localities.

*Distribution.* Red Sea, E. Africa, Amirantes, Mauritius, Rodriguez.

##### 86. TRAPEZIA AREOLATA, Dana.

*T. areolata*, Dana, Crust. U.S. Explor. Exped. vol. i. p. 259, pl. xv. fig. 8 (1852); De Man, Brock's Crust. p. 317 (1888).

Ceylon (*Italy*).

*Distribution.* Malay Archipelago, New Caledonia, Tahiti.

#### Genus TETRALIA, Dana.

##### 87. TETRALIA GLABERRIMA (Herbst).

*T. glaberrima* (Herbst), De Man, Brock's Crust. p. 321 (1888).

(= *T. armata*, Dana, *T. cavimana*, Heller, ? *T. heterodactyla*, Heller, *T. nigrifrons*, Dana).

Tuticorin, a female; Muttuwartu Par, two males (*Thurston*); Rameswaram, several specimens (*J. R. II.*).

It is very doubtful whether all the described species of this genus should not be referred to a single variable species. Most of the specimens I have observed had the front and anterior half of the lateral margin of the carapace edged with brown, as in *T. nigrifrons*, Dana, and in some the merus of the chelipedes carries the same colour anteriorly and distally, while brown spots are apparent at the distal end of the meri and propodi of the ambulatory legs. The pit or hollow, characteristic of *T. carimana*, Heller, and which occurs on the outer proximal surface of the hand, is usually present, but of varying extent. An adult measured 7.5 mm. long and 7 mm. broad.

*Distribution.* Red Sea, Natal, Mascarenes, Malay Archipelago, Australian seas, Pacific.

#### Genus ERIPHIA, Latr.

##### 88. ERIPHIA LÆVIMANA, Latr.

*E. lævimana* (Latr.), De Man, Mergui Crust. p. 68 (1887).

Rameswaram and Tuticorin, many specimens (*Thurston*); Ceylon (*Haly, Nevill*); Rameswaram, common on the reef and among blocks of dead coral between tide-marks (*J. R. H.*).

All the specimens I have examined belong to the typical form, none showing any trace of granulation or tuberculation on the outer surface of the larger chela, as in the variety *Smithii* of MacLeay. A female with ova from Rameswaram is noteworthy on account of its large size, the carapace measuring 58 mm. in length and 72 mm. in breadth; the propodus of the right chela 62 mm., measured along its lower border.

*Distribution.* East Africa and Natal, Mauritius, Malay Archipelago, China, Japan, N. Australia, Pacific.

#### Genus NEPTUNUS, De Haan.

##### 89. NEPTUNUS PELAGICUS (Linn.).

*N. pelagicus* (L.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 320 (1861).

Tuticorin (*Thurston*); Ceylon (*Haly*); Bombay, Sind, Malabar, Akyab (*Day*). Very common on the S. Indian coast (*J. R. H.*).

*Distribution.* From the Red Sea and E. Africa to the Pacific.

##### 90. NEPTUNUS GLADIATOR (Fabr.).

*N. gladiator* (Fabr.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 330 (1861).

Rameswaram (*Thurston*); Gulf of Martaban (*Oates*); Ceylon (*Haly*). Common at Madras (*J. R. II.*).

A male from Rameswaram measures 26 mm. long and 18 mm. broad (including the lateral spines).

*Distribution.* From India to Japan and N. Australia.

## 91. NEPTUNUS SANGUOLENTUS (Herbst).

*N. sanguinolentus* (Herbst), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 319 (1861).

Rameswaram (*Thurston*); Ceylon (*Haly*); Sind, Bombay, Madras (*Day*). Very common on the S. Indian coast (*J. R. II.*).

*Distribution.* Mascarenes, Malay Archipelago, Japan, Australia, Sandwich Islands.

## 92. NEPTUNUS ARGENTATUS, White.

*N. argentatus* (White), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. v. p. 332, pl. xxi, fig. 4 (1861); Miers, 'Challenger' Brachyura, p. 177 (1886).

Gulf of Martaban, four specimens (*Oates*).

The largest specimen (a female with ova) measures 15 mm. long and 27 mm. broad, including the lateral spines. This species is characterized by the presence of a silvery metallic lustre on the ridges of the chelipedes, on the transverse ridges of the abdomen, and elsewhere, still visible both in the above recorded spirit specimens and in White's dried types. It is very closely allied to *N. gladiator*, of which species Miers regarded it as constituting a variety, but I am inclined to consider the two as distinct. It is a smaller species than *N. gladiator*; the ridge on the outer surface of the hand is much more prominent, as also are the ridges on the second and third abdominal segments; while a black spot is present towards the apex of the swimming dactylus as in *N. hastatoides*, but which is not seen in *N. gladiator*. There are also differences in the form of the abdomen—more particularly of the female—in the two species. The median frontal spines are scarcely less developed than in some young specimens of *N. gladiator*, and there is a rudimentary tooth on the supraorbital margin, as in young *N. gladiator*, but in older individuals of the latter this becomes a prominent spine.

*Distribution.* Borneo (*White*); Celebes Sea (*Miers*).

## 93. NEPTUNUS HASTATOIDES (Fabr.).

*N. hastatoides* (Fabr.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 332 (1861).

Gulf of Martaban, a series including two with *Sacculina* (*Oates*). Common at Madras (*J. R. II.*).

A female is 20 mm. long and 31 mm. broad, not including the lateral spines. In this species the posterior angles of the carapace are acute and terminate in spinules—the character on which Prof. A. Milne-Edwards has founded his subgenus *Hellenus*. The lateral spines are longer than in *N. gladiator*; the posterior gastric granulated elevations are more pronounced, so as to become almost tubercular; and the distal half of the swimming dactylus is dark in colour.

*Distribution.* From India to Japan and N. Australia.

## 94. NEPTUNUS ANDERSONI, De Man.

*N. Andersoni*, De Man, Mergui Crust. p. 70, pl. iv. figs. 3, 4 (1887).

Gulf of Martaban, ten specimens (*Oates*).

I refer these with some doubt to *N. Andersoni*, as I have not had an opportunity of

comparing them with De Man's type; but they agree on the whole with his description and figures. In all the specimens the distance between the external orbital angles is about equal to the length of the carapace, the character on which De Man lays most stress in distinguishing the species from *N. hastatoides*. The arms of the chelipedes are variable in length, but scarcely so short, even in females, as represented by De Man. The characters of the front are not stated in the original description, as the single type-specimen was injured in this respect; in the Martaban examples the two median frontal teeth are obtuse and of small size, being less prominent than the lateral teeth, whereas in *N. rugosus*, A. Milne-Edw., with which De Man also compares his species, there is but a single median tooth. The carapace carries seven antero-lateral teeth between the external orbital angle and the long lateral spine, and these teeth, especially the anterior ones, are usually shorter and more obtuse than represented in De Man's figure. The postero-lateral angles of the carapace terminate in a somewhat obtuse tooth, whereas De Man describes it as a spinule. I have some doubt whether the specimens are not referable to a stunted variety of *N. hastatoides*, for, on examining a large series of the latter, I find variation in the direction of the characters assigned to *N. Andersoni*; the characteristic black spot is, however, absent from the swimming dactylus.

The largest specimen—a female with ova—has the carapace only 9 mm. long and 14 mm. broad, not including the lateral spines.

*Distribution.* Mergui (*De Man*).

#### 95. NEPTUNUS TUBERCULOSUS, A. Milne-Edw.

*N. tuberculatus*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 333, pl. xxxi. fig. 5 (1861).

*N. Brockii*, De Man, Brock's Crust. p. 328, Taf. xiii. fig. 1 (1888).

Gulf of Martaban, four specimens (*Oates*).

De Man, when describing *N. Brockii*, stated that it might possibly prove to be identical with *N. tuberculatus*, and the above specimens certainly tend to confirm this opinion. There can be no doubt, I think, that they are identical with the species so well described and figured by De Man. At the same time the median frontal projections are slightly larger than shown in his figure, and they project as far forwards as the contiguous pair, as in *N. tuberculatus*; while, as regards the lateral spines of the carapace, the second, fourth, and sixth are smaller than the others, an arrangement which is indicated in the figures of both writers. In the largest specimen the hand is almost as described by De Man, though a rudimentary spine can be made out over the base of the mobile finger; in a younger specimen, a second small spine is seen near the articulation with the carpus and on the outer surface, as described by A. Milne-Edwards, and his description was evidently taken from a young individual. I thus imagine the two species are identical. In all probability we have to deal with a species in which certain spines, present in the young, diminish in size or altogether disappear in the adult.

The carapace of the largest specimen (a female) is 12.5 mm. long and 22 mm. broad, including the lateral spines; it has a swelling on the left side, evidently due to the presence of a Bopyrid.

*Distribution.* Sandwich Is. (*A. Milne-Edwards*); Aru Is. (*Miers*); Amboina (*De Man*).

96. NEPTUNUS ARMATUS, A. Milne-Edw.

*N. armatus*, A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. x. p. 322, pl. xxxiii. fig. 2 (1861).

Rameswaram, five specimens (*J. R. II.*).

The types of this species are preserved in the British Museum. The surface of the carapace is finely granulated, and the lateral spines are strongly developed, though somewhat shorter in my specimens than in the types. The outer surface of the carpus and propodus of the chelipedes carries a series of finely granulated ridges, with the intervening surface smooth; two fainter ridges are seen on the inner surface of the propodus. The fingers, with the exception of their tips, are dark in colour, and there is a well-defined black spot on the inner surface of the palm near the insertion of the dactylus; the first tooth of the dactylus, as in some other Portunids, is enormously developed.

The carapace of the largest specimen is 17 mm. long and 30.5 mm. broad, not including the lateral spines, which are each about 5 mm. long. A. Milne-Edwards gives the length as 13 mm. and the breadth as 50 mm., but reference to the types and to his figure shows that there is some mistake, probably in the length noted.

*Distribution.* West Australia (*A. Milne-Edwards*).

97. NEPTUNUS SIEBOLDI, A. Milne-Edw.

*N. Sieboldi*, A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. x. p. 323, pl. xxxv. fig. 5 (1861).

Muttuwartu Par, a male (*Thurston*).

This species may be recognized by its four similar, subobtusate frontal projections, the short lateral spines of the carapace, the unarmed hinder margin of the merus of the chelipedes, and the strongly ridged hand, the ridges being seen even on the inner surface. In the Muttuwartu specimen, the median notch or fissure of the front is deeper and narrower than the one on either side, whereas in A. Milne-Edwards's figure they are equally deep and narrow.

The carapace is 12 mm. long and 18 mm. broad.

*Distribution.* Mauritius (*A. Milne-Edwards, Miers*).

Genus XIPHONECTES, A. Milne-Edw.

98. XIPHONECTES LONGISPINOSUS (Dana).

*X. longispinosus* (Dana), Miers, 'Challenger' Brachyura, p. 183 (1886), *ubi synonym.*

(=*X. leptochelus*, A. Milne-Edw.; *Amphitrite vigilans*, Dana).

Gulf of Martaban, a male and a female (*Oates*).

The genus founded for the reception of this variable species comes very near to *Neptunus*, and perhaps the two should be united. The larger specimen (female) is 6.7 mm. long and 9.5 mm. broad.

*Distribution.* From the Seychelles to the Pacific (New Caledonia, Tongatabu, &c.).

## Genus ACHELOUS, De Haan.

## 99. ACHELOUS GRANULATUS (Milne-Edw.).

*A. granulatus* (Milne-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 344 (1861).

Gulf of Martaban, six specimens (*Oates*).

The largest male is 14 mm. long and 19.5 mm. broad, while a female with ova is somewhat smaller. The same silvery sheen is seen as in *Neptunus argentatus*, though much less strongly marked in the present species.

*Distribution.* From the Red Sea and E. Africa to Japan and the Pacific (New Caledonia, Sandwich Is., Fiji Is.).

## 100. ACHELOUS WHITEI, A. Milne-Edw.

*A. Whitei*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 343, pl. xxxi. fig. 6 (1861).

(= ? *Neptunus gracilimanus*, Stm.).

Gulf of Martaban, seven specimens (*Oates*). Common at Madras (*J. R. II.*).

This species may be recognized at once by its remarkable chelipedes, the merus of which is long and very broad, while the more distal joints, and especially the fingers, are extremely slender; the fingers also are acute and slightly upturned. *Neptunus gracilimanus*, Stimpson, is probably identical with *A. Whitei*; the description of the former agrees with that of the present species, and the posterior lateral spine is distinctly longer than those in front of it, especially in young individuals, which gives the species almost the appearance of a *Neptunus*. Indeed, it shows that *Neptunus* and *Achelous* can scarcely be separated, though it is perhaps convenient to retain the latter term for those forms in which the lateral spines are greatly reduced.

The largest specimen (a female) is 19 mm. long and 30 mm. broad, not including the lateral spines; the merus of the left chelipede is 17.5 mm. long and 8 mm. broad; the carpus and propodus 30 mm. long, and the greatest breadth or height of the hand 4 mm.

*Distribution.* Borneo (*A. Milne-Edwards*); south of New Guinea (*Miers*).

## 101. ACHELOUS ORBICULARIS, Richters.

*A. orbicularis*, Richters, Beiträge zur Meeresfauna der Insel Mauritius und der Seychellen, p. 153, Taf. xvi. figs. 14, 15 (1880).

Gulf of Martaban, two males (*Oates*).

The carapace is narrow, smooth, and depressed, with the nine antero-lateral teeth subequal in size, or even diminishing slightly on passing backwards; the postero-lateral margin is almost straight and without any concavity. The front is six-toothed, and the median teeth minute. The merus of the chelipedes is enlarged, angulated externally, and with two spines on the posterior margin.

In the larger specimen the carapace is 8.5 mm. long and 10.5 mm. broad; the distance between the external orbital angles is 7.6 mm.

*Distribution.* Seychelles (*Richters*).

## Genus SCYLLA, De Haan.

## 102. SCYLLA SERRATA (Forskål).

*S. serrata* (Forsk.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 349 (1861).

Calcutta (*Day*); Ceylon (*Haly*). Abundant in the S. Indian backwaters (*J. R. II.*). This is the chief edible crab of India.

*Distribution.* From the Red Sea, E. and S. Africa, to Japan, the Fiji Is., and New Zealand.

## Genus THALAMITA, Latreille.

## 103. THALAMITA PRYMNA (Herbst).

*T. prymna* (Herbst), De Man, Mergui Crust. p. 75, pl. iv. figs. 5, 6 (1887).

Rameswaram and Tuticorin (*Thurston*). Rameswaram, common between tide-marks; Madras (*J. R. II.*).

These belong to the typical form of the species as characterized by De Man. The carapace is smooth, with the exception of the first transverse line, placed behind the orbital margin, which usually carries a fringe of hairs; the natatory legs are also provided with a short marginal fringe. The ridge on the basal joint of the antennal peduncle has two or more spinules, the first of which is well-developed, acute, and usually with traces of a compound origin.

A male from Rameswaram has the carapace 14 mm. long and 62 mm. broad, the right hand 52 mm. long. A female from Tuticorin is 32 mm. long and 45 mm. broad, the right hand 32 mm. long.

*Distribution.* Indian Ocean, Mergui, Malay Archipelago, Japan, Australia, New Caledonia.

## 104. THALAMITA ADMETE (Herbst).

*T. Admete* (Herbst), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 356 (1861).

Rameswaram (*Thurston, J. R. II.*); Gulf of Martaban (*Oates*).

The carapace is only slightly pubescent, and the chelipedes are devoid of granules. The outer surface of the hand is glabrous, and only carries faint raised lines, the usual spines being present on the upper surface.

A female with ova is 10 mm. long and 15 mm. broad.

*Distribution.* From the Red Sea and Natal to Ousima Is., the Fijis, and the Sandwich Islands.

## 105. THALAMITA SAVIGNYI, A. Milne-Edw.

*T. Savignyi*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 357 (1861).

Tuticorin, many specimens (*Thurston*); Rameswaram (*J. R. II.*).

This species only differs from *T. Admete* in having the carapace more strongly granulated, as well as the chelipedes, the hand being provided with several longitudinal granulated lines on its outer surface, and granules are scattered over the intervening

areas, especially on the upper surface. There is a good deal to be said in favour of Miers's view, that it is probably only a variety of *T. Admcke*, to which species it was originally referred by Audouin; the amount of granulation certainly varies considerably in a series of specimens.

The largest male is 12.5 mm. long and 19 mm. broad, and the largest female is nearly the same size; but some females with ova are of much smaller size, a disparity which has been noted by De Man.

*Distribution.* Red Sea (*Savigny, Miers*), Mergui (*De Man*), N.W. Australia (*Miers*), New Caledonia (*A. Milne-Edwards*).

#### 106. THALAMITA SIMA, Milne-Edw.

*T. sima* (Milne-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 359 (1861).  
(=*T. arcuatus*, De Haan).

Tuticorin, two females with ova (*Thurston*).

I refer these specimens with some hesitation to *T. sima*, and possibly they belong to a distinct and undescribed species. The first three antero-lateral teeth are very broad basally, and merely separated by narrow fissures, with their apices subacute, whereas in the typical *T. sima*, as figured by De Haan, these teeth are more prominent and acute, with wider intervening fissures. The carapace is finely granulated and the elevated lines rather poorly marked; the front is regularly arcuate, with the median notch scarcely represented. The outer surface of the hand is almost smooth. In *T. Chaptali*, Aud., which is recorded by Miers from Ceylon ('Alert' Crust. p. 231), and in which the antero-lateral teeth are also obtuse, the last tooth, unlike what is seen in our specimens and in the typical form, is slightly smaller than the preceding tooth.

The larger specimen is 10 mm. long and 14.5 mm. broad.

*Distribution.* Malay Archipelago, China, Japan, New Caledonia, Australia, and New Zealand.

#### 107. THALAMITA INTEGRATA, Dana.

*T. integra*, Dana, Crust. U.S. Explor. Exped. pt. 1, p. 281, pl. xvii. fig. 6 (1852); A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 358 (1861).

Tuticorin (*Thurston*); Rameswaram, not uncommon (*J. R. II.*); Gulf of Martaban (*Oates*).

In this species a characteristic dark band encircles the fingers near their apices, but the apices themselves are white.

*Distribution.* E. Africa, Malay Archipelago, and the Pacific (Fiji, Sandwich Is., &c.). The var. *africana* of Miers occurs in the Atlantic area (Senegambia and Canaries).

#### 108. THALAMITA SEXLOBATA, Miers.

*T. sexlobata*, Miers, 'Challenger' Brachyura, p. 196, pl. xvi. fig. 2 (1886).

Tuticorin, a male (*Thurston*).

This species is distinguished by its six-lobed front and by its very minute fourth antero-lateral spine. The chelipedes are crossed by strigose lines, which are specially noticeable on the upper and distal surface of the merus, the under surface of the propodus, and which are even seen on the inner surface of the latter joint; similar pubescent lines are also met with running longitudinally on the ambulatory legs. The sternal region, anteriorly and at the sides, is seen with a lens to be very finely granulated. In Miers's figure the last antero-lateral spine is more prominent than in my specimen, the fingers are longer in relation to the palm, and of the two spines on the upper margin of the palm the posterior one is much larger than the anterior, while in the Tuticorin example it is only slightly larger. These differences are, however, probably not of much importance.

The carapace is 8 mm. long and 10.5 mm. broad.

*Distribution.* Tongatabu, 18 fathoms (*Miers*).

#### Genus GONIOSOMA, A. Milne-Edwards.

##### 109. GONIOSOMA CRUCIFERUM (Fabr.).

*G. cruciferum* (Fabr.), De Man, Mergui Crust. p. 79, pl. v. fig. 1 (1887).

Tuticorin (*Thurston*); Ceylon (*Italy*); Akyah (*Day*); Madras, not uncommon (*J. R. II.*).

*Distribution.* Indian Ocean, Malay Archipelago, China, Japan, E. Australia.

##### 110. GONIOSOMA AFFINE (Dana).

*G. affine* (Dana), De Man, Mergui Crust. p. 80, pl. v. fig. 2 (1887).

Madras, three adult males and one female (*J. R. II.*).

The carapace of a male is 33 mm. long and 47 mm. broad, not including the lateral spines.

*Distribution.* Singapore (*Dana*); Mergui (*De Man*).

##### 111. GONIOSOMA NATATOR (Herbst).

*G. natator* (Herbst), De Man, Broek's Crust. p. 334, Taf. xiii. fig. 5 (1888).

(= *Charybdis granulatus*, De Haan).

Rameswaram, three males (*Thurston*); Ceylon (*Italy*); Madras (*J. R. II.*).

A Rameswaram specimen is 58 mm. long and 87 mm. broad; the right hand measured along its lower border 76 mm.

*Distribution.* Natal, Mascarenes, Malay Archipelago, China, Japan.

##### 112. GONIOSOMA LUCIFERUM (Fabr.).

*G. luciferum* (Fabr.), De Man, Mergui Crust. p. 83, footnote (1887).

(= *G. quadrimaculatum*, A. Milne-Edw.).

Ceylon (*Italy*).

*Distribution.* Malabar; Java (*A. Milne-Edwards*).

## 113. GONIOSOMA ANNULATUM (Fabr.).

*G. annulatum* (Fabr.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 374 (1861)  
(= *G. orientale*, Heller).

Rameswaram and Tuticorin (*Thurston*); Madras (*J. R. II.*).

In all the specimens violet rings are present on the legs. Miers regarded *G. scardentatum* (Rüpp.) as scarcely distinct from this species, and, according to De Man, *G. annulatum* is itself perhaps merely a younger state of *G. luciferum*; but the size of a Rameswaram specimen scarcely confirms this, for the carapace is 54 mm. long and 77 mm. broad, the left hand 69 mm. along its lower border. There can be little doubt, however, that a revision of the genus *Goniosoma*, founded on the examination of a large series of specimens from different localities, would result in the union of several of the species as at present constituted.

*Distribution.* From Madagascar to the Malay Archipelago.

## 114. GONIOSOMA HELLERII. A. Milne-Edw.

*G. Hellerii*, A. Milne-Edwards, Bull. Soc. Entom. France, t. vii. p. 282 (1867).

*G. merguense*, De Man, Mergui Crust. p. 82, pl. v. figs. 3, 4 (1887).

Tuticorin (*Thurston*); Ceylon (*Italy*); Rameswaram (*J. R. II.*).

These specimens are identical with *G. merguense*, but De Man has recently pointed out, in his Report on the Decapoda collected in the Malay Archipelago by Dr. Brock, that this species is probably identical with *G. Hellerii*, and the descriptions of the two certainly agree. *G. spiniferum*, Miers, from Queensland, is closely allied, but differs in having the posterior margin of the penultimate joint of the swimming-feet not denticulated. *G. Hellerii* is distinguished from *G. luciferum* and *G. annulatum* by the form of the antero-lateral teeth, the last of which is always longer than the others; the carpal joints of the swimming-legs have an acute spine on the under surface, and in adults both the antero-lateral and the frontal teeth are very acute.

An adult male from Tuticorin is 38 mm. long and 52 mm. broad, the right hand 48 mm. long.

*Distribution.* New Caledonia (*A. Milne-Edwards*); Mergui. Amboina (*De Man*).

## 115. GONIOSOMA ERYTHRODACTYLUM (Lam.).

*G. erythroductylum* (Lam.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 369 (1861).

Ceylon (*Italy*).

*Distribution.* Red Sea (*De Man*); Marquesas Islands and Moluccas (*A. Milne-Edwards*).

## 116. GONIOSOMA ORIENTALE (Dana).

*Charybdis orientalis*, Dana, Crust. U.S. Explor. Exped. pt. 1, p. 285, pl. xvii. fig. 10 (1852).

*G. orientale* (Dana), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. x. p. 383 (1861).

(= *G. dubium*, Hoffmann).

Tuticorin, six specimens (*Thurston*); Ceylon (*Italy*).

This species does not appear to be common; in fact Prof. A. Milne-Edwards had not met with specimens when he wrote his Revision of the Portunidae. It is distinguished by the rudimentary state of the second lateral spine of the carapace, which is very minute, and appears as if merely a portion of the first spine; the remaining anterolateral spines are practically subequal. The median and submedian frontal teeth are obtusely rounded and subequal, while the two outermost teeth on each side are more or less triangular. The merus of the chelipedes carries two or three spines on its anterior margin, while the posterior margin is unarmed; the carpus has a large spine on its upper surface, and three spinules on the outer surface; the hand has three finely-granulated ridges on its outer surface, two spines on the upper margin, and two on the outer surface, one of the latter placed at the articulation with the carpus. The fingers are slightly ridged externally. The penultimate joint of the swimming-legs is spinulose along its posterior margin, and a prominent spine is placed on the posterior margin near the distal end of the merus.

The largest specimen, a female without eggs, is 11 mm. long and 17 mm. broad, while a second female, carrying eggs, is considerably smaller.

*Distribution.* Philippines (*Dana*); Timor (*De Man*); Réunion (*Hoffmann*).

#### 117. GONIOSOMA ORNATUM, A. Milne-Edw.

*G. ornatum*, A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. x. p. 376 (1861).  
(= *Thalamita truncata*, De Haan).

Madras, not uncommon (*J. R. II.*).

The carapace of a male is 21 mm. long and 30 mm. broad, the right chelipede 55 mm. long; a female with ova is 15 mm. long and 22 mm. broad. Specimens in the British Museum are considerably larger.

*Distribution.* Malay Archipelago; Japan.

#### 118. GONIOSOMA VARIEGATUM (Fabr.).

*G. variegatum* (Fabr.), Miers, 'Alert' Crust. p. 232 (1884).

Madras, very common (*J. R. II.*); Bombay (*Day*); Karachi (*Brit. Mus.*).

In this species, and in the form which I term var. *callianassa*, the frontal teeth are more or less obtusely rounded in the adult, the last lateral spine of the carapace is about twice the length of the preceding spines, the hands are somewhat swollen, and the carapace is pubescent. De Haan seems to have regarded the two forms as belonging to distinct species; on the other hand, A. Milne-Edwards probably united both in his *G. callianassa*. In what I regard as the typical form, the median frontal projections are very obtusely rounded, the surface of the carapace is finely punctate when the hairs are removed, and the transverse ridges are only moderately developed, there being none on the branchial area, and they are only faintly seen on the cardiac area. The merus of the chelipedes has usually two spines on its anterior margin, and there are also two spines on the upper surface of the hand; the ridges on the outer surface of the hand are smooth, while on the inner surface they are almost obsolete; the under surface of the

hand is perfectly smooth and glabrous. The posterior surface of the three pairs of ambulatory legs is smooth. The penultimate segment of the male abdomen is not specially dilated. A *Sacculina* is frequently attached to the abdomen, and *Portunicepon Hendersonii*, Giard and Bonnier, occurs in the branchial chamber.

G. VARIEGATUM, VAR. CALLIANASSA (Herbst).

In the specimens which I refer to this variety, which also is common at Madras, the median frontal projections are less rounded, and the transverse ridges of the carapace are more strongly developed, especially two on the cardiac area, and there are two parallel lines on the branchial area. The merus of the chelipedes has usually three spines on the anterior margin; there are four spines on the upper surface of the hand, and strongly granulated ridges on both the inner and the outer surfaces of the hand. The whole surface of the chelipedes is more or less strigose, but more particularly the under surface of the hand. Longitudinal pubescent lines are met with on the posterior surface of the ambulatory legs. The penultimate joint of the male abdomen is so dilated as almost to form part of a circle in outline. The specimens are almost certainly identical with that figured by Herbst (*Naturgesch. Krabben u. Krebse*, pl. liv. fig. 7) as *Cancer callianassa*; at the same time they are probably the same as that figured by De Haan as *Portunus (Charybdis) variegatus*, Fabr. (*Crust. Japon*, tab. i. fig. 2).

I have examined a large series of both forms from Madras, and as a rule any specimen can be determined at once by the characters I have enumerated for each variety. I have met with a few specimens, however, in connexion with which some difficulty is experienced, and in which there appears to be an admixture of the two sets of characters.

The var. *bimaculatum*, Miers, taken by the 'Challenger' at Japan, is, I think, perhaps a distinct species; its frontal teeth are quite different in form and very obtuse; if it is really a variety of *G. variegatum*, there is an extraordinary range of variation in this species.

*Distribution.* Malay Archipelago, China, Japan, N. Australia. (It is impossible to say which variety is referred to in regard to the localities assigned to this species.)

119. GONTOSOMA ROSTRATUM, A. Milne-Edw.

*G. rostratum*, A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. x. p. 379, pl. xxxv. fig. 2 (1861).

Sunderbunds and Calcutta, several specimens (*Day*); Gulf of Martaban, eight specimens (*Oates*).

This species is distinguished by the general form of its front, and especially by the great prominence of the median frontal teeth, which are obtusely rounded. In all the above-recorded specimens the last lateral spine of the carapace is considerably larger than those preceding it; but, judging from a larger and apparently full-grown specimen from the Hoogly, in the British Museum, this spine diminishes with age, for in this example it is scarcely larger than those in front of it.

The largest specimen is a female with a Bopyrid in its right branchial chamber; it measures 17 mm. in length and 20 mm. in breadth, including the lateral spines.

*G. rostratum* is also closely allied to *G. variegatum*, of which it may possibly prove to be a variety. The only important difference lies in the character of the front, and I have observed specimens of the latter species in which the median projections were more prominent than the others.

*Distribution.* Mouth of the Ganges (*A. Milne-Edwards*).

#### Genus LUPOCYCLUS, Adams & White.

##### 120. LUPOCYCLUS INÆQUALIS (Walker).

*Goniosoma inaequale*, Walker, Journ. Linn. Soc., Zool. vol. xx. p. 116, pl. viii. fig. 4 (1887).

Gulf of Martaban, a male and a female (*Oates*).

The carapace is armed with nine lateral spines, of which the fourth, sixth, and eighth are rudimentary, especially the eighth, which is very minute, and the second is smaller than the third. *L. rotundatus*, Adams & White, has five lateral teeth, with a single minute one alternating in each interspace, but the carapace is more convex, proportionately narrower, and with a more prominent front. I am unable to say how *L. philippinensis*, Nauck, differs, as this species has only been very shortly and imperfectly characterized.

I think there can be little doubt that the above specimens are referable to Walker's species; at the same time, it ought to be placed in the genus *Lupocyclus*, on account of its general form, its peculiar front, and the basal antennal joint freely movable in the orbital hiatus.

The larger specimen, a female, is 12 mm. long and 15 mm. wide.

*Distribution.* Singapore (*Walker*).

#### Genus LISSOCARCINUS, Adams & White.

##### 121. LISSOCARCINUS POLYBIOIDES, Adams & White.

*L. polybioides*, Adams & White, 'Samarang' Crust. p. 46, pl. xi. fig. 5 (1848).

Gulf of Martaban, a female (*Oates*).

This species is distinguished from *L. laevis*, Miers, by its flatter carapace, more prominent front, the lateral teeth, which gradually diminish in size on passing backwards, and a line runs in from the last lateral tooth on to the surface of the branchial region.

The carapace is 7.2 mm. long and 7 mm. broad.

*Distribution.* Borneo (*Adams & White*); Ceylon (*Miers*); Port Jackson (*Haswell*).

##### 122. LISSOCARCINUS LAEVIS, Miers.

*L. laevis*, Miers, 'Challenger' Brachyura, p. 205, pl. xvii. fig. 3 (1886).

Tuticorin, a female with ova (*Thurston*); Gulf of Martaban, a single young specimen (*Oates*).

In this species the front is broad and not specially prominent. The first and fifth

antero-lateral teeth are small, while the second, third, and fourth are larger and subequal. The hand is without spines.

The carapace of the Tuticorin example is 11 mm. long and 13.5 mm. broad.

*Distribution.* Celebes Sea, 10 fathoms (*Miers*).

#### Genus KRAUSSIA, Dana.

##### 123. KRAUSSIA NITIDA, Stimpson. (Pl. XXXVII, fig. 9.)

*K. nitida*, Stimpson, Proc. Acad. Nat. Sci. Philad. Mar. 1858, p. 40; Miers, 'Alert' Crust. p. 235 (1884).

Tuticorin, a female (*Thurston*); Madras coast (*J. R. II.*).

The front is quadrilobed, with the median slightly smaller than the outer lobes, and the margin of all finely crenulated and fringed with long brown hairs. A median and two lateral fissures on each side of the front are present, which, though obsolete, extend some distance back on the carapace, and the most external arises from the upper orbital margin. The carapace is minutely granulated anteriorly and towards the sides. The lateral margin is crenulated, with a slight tooth about one third of the distance back, and immediately in front of this the margin is slightly indented. The hands are finely granulated externally, and long hairs are present on the legs and on the meral joints of the chelipedes.

The Tuticorin specimen is 13.7 mm. long and 15 mm. broad.

*Distribution.* Chinese and Japanese Seas, on a sandy bottom at a depth of 20-24 fathoms (*Stimpson*); Torres Straits (*Miers*).

#### Group CATOMETOPA.

##### Genus HETEROPLAX, Stimpson.

##### 124. HETEROPLAX NITIDUS, Miers.

*H. nitidus*, Miers, Proc. Zool. Soc. 1879, p. 39, pl. ii, fig. 2.

Gulf of Martaban, a male (*Oates*); Madras coast, several specimens, including females with ova (*J. R. II.*).

I have compared these with the type-specimen in the British Museum, and can find no difference except that the Indian specimens are somewhat smaller.

*Distribution.* Corean Straits, 10 fathoms (*Miers*).

##### Genus SCALOPIDIA, Stimpson.

##### 125. SCALOPIDIA SPINOSIPES, Stimpson.

*S. spinosipes*, Stimpson, Proc. Acad. Nat. Sci. Philad., April 1858, p. 95.

Gulf of Martaban, an adult female (*Oates*).

I have compared this with typical specimens from Hong Kong, named by Stimpson, and presented to the British Museum by the Smithsonian Institution. The carapace is granulated and punctate, with an acute spinule at the posterior limit of the sharply

defined antero-lateral margin. The hands are glabrous externally and sparingly punctate; curved spinules are present on the margins of the ambulatory legs.

The carapace is 11 mm. long and 15 mm. broad; the third ambulatory leg is 33 mm. long.

The genus *Hypophthalmus*, Richters (in Lenz and Richters' 'Beitrag zur Krustaceen-fauna von Madagascar'), is, as pointed out by Miers, synonymous with *Scalopidia*, and the *H. leucochirus*, Richters, apparently differs but little from Stimpson's species.

*Distribution.* Hong Kong, 5 fathoms (*Stimpson*).

#### Genus CARDISOMA, Latr.

##### 126. CARDISOMA CARNIFEX (Herbst).

*C. carnifex* (Herbst), De Man, Max Weber's Crust. p. 285 (1891).

(= *C. Urrillei*, Milne-Edw.).

Tuticorin (*Thurston*); Ceylon (*Haly*). A very common species found burrowing near the margins of the S. Indian backwaters (*J. R. H.*).

*Distribution.* From E. Africa to the Pacific (Samoa, Fijis, Sandwich Is., &c.).

#### Genus TELPHUSA, Latr.

##### 127. TELPHUSA INDICA, Latr.

*T. indica* (Latr.), Milne-Edwards, Crust. in Jacquemont's 'Voyage dans l'Inde,' p. 7, pl. ii. fig. 1 (1844); A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. v. p. 184 (1869).

*T. cunicularis*, Westwood, Trans. Ent. Soc. vol. i. p. 183, pl. xix. fig. 1 (1836).

Very common in hill-streams at Kotagiri and elsewhere on the Nilgiri Hills, at an elevation of about 6000 feet (*J. R. H.*).

I sent a specimen to Prof. A. Milne-Edwards, who kindly informed me that it was referable to *T. indica*, the types of which are preserved in the Paris Natural History Museum; it is also identical with *T. cunicularis*, examples of which from Dukhan, Western Ghats, are in the collection of the British Museum.

The postfrontal ridge is strongly marked and continuous, being well marked even behind the inner canthus of the eye, and only interrupted by the mesogastric furrow; the cervical groove is also well defined. The carpal spine of the chelipedes is acute. The ischial line on the outer surface of the external maxillipedes is absent or faintly defined, and not prolonged to each end of the joint. The penultimate segment of the male abdomen has the lateral margins straight. The colour is a dark, almost black brown, paler in the young.

The carapace of a female is 35 mm. long and 50 mm. broad; of a male, 34 mm. long and 49.5 mm. broad.

*Distribution.* India: Western Ghats (Poona, &c.); South-east Berar; Chota Nagpur; Ranigunj; Parisnath Hill, at an elevation of 3000 feet; Morar (*Wood-Mason*).

## 128. TELPHUSA LUGUBRIS, Wood-Mason.

*T. lugubris*, Wood-Mason, Journ. As. Soc. Bengal, vol. xl. p. 197, pl. xii. figs. 5-7 (1871).

"Environs of Calcutta," Coll. Schlagintweit, two specimens. (They are labelled *T. indica*, and more probably came from the Himalayas.) Nepal, an adult female (*Dr. J. Scully*).

These specimens completely agree with Wood-Mason's excellent description. The species is closely allied to *T. indica*, but may be distinguished as follows:—The post-frontal ridge is not placed so far back on the carapace as in *T. indica*, and is somewhat wrinkled and ill-defined behind the inner canthus of the eye. The carpal spine is blunt. The ischial line on the outer surface of the external maxillipedes is well marked. The penultimate segment of the male abdomen has the lateral margins concave. The ridge connecting the epibranchial tooth with the external orbital angle is nearly straight, whereas in *T. indica* it is curved. The colour, as in the other species, is a very dark brown, and the epidermis readily peels off in *T. lugubris*.

The Nepal specimen has the carapace somewhat more convex than indicated by Wood-Mason, and seen in the other examples, but this is perhaps due to its being an adult female. It carries a large number of newly-hatched young attached to the swimmerets under the abdomen.

*Distribution.* North India: Sikkim, Nepal, and Khasi Hills (*Wood-Mason*).

## 129. TELPHUSA MASONIANA, n. sp. (Pl. XXXVII. figs. 1-4.)

River Jumna, a series; North-West Provinces, four males (*Day*); "India," two dried specimens (*Brit. Mus.*).

The carapace is scarcely depressed. The postfrontal ridge is well defined towards the sides, but the epigastric portions are wrinkled, and almost deficient behind the inner canthus of the eye; the mesogastric furrow is rather deep and slightly bifurcate posteriorly. The cervical groove is broad and well defined, not interrupting the post-frontal ridge; a very distinct anterior and posterior pair of puncta are present on the gastric region adjoining the cervical groove. Both the epibranchial tooth and the external orbital tooth are strongly developed. The branchial region of the carapace is swollen dorsally and laterally in its anterior portion, and numerous faint interrupted crenulated lines run transversely along the whole margin. The frontal margin is somewhat concave, and both it and the orbital margin are finely crenulated; the orbits are remarkably large and shallow.

The chelipedes are unequal, either the right or left being larger, and they are very similar to those of *T. lugubris*, with the exception that the carpal spine is prominent and acute. The external maxillipedes, and also the ambulatory legs, are similar to those of *T. lugubris*, but the ambulatory dactyli are rather more slender than in Wood-Mason's species, and the horny spinules with which they are armed are much less prominent. The penultimate segment of the male abdomen has the lateral margins concave, as in *T. lugubris*, but the concavity is not apparent in very young individuals.

*T. Masoniana* is allied to *T. lugubris*, but on comparing it with that species the

following differences can be made out:—The carapace is less flat, and the frontal margin more concave; the epibranchial and external orbital teeth are much larger and more prominent, with the margin connecting them less oblique; the postfrontal ridge is separated by a wider interval from the orbital margin, the orbits are larger and more open, the carpal spine of the chelipedes is acute and more prominent, and the general colour is apparently not so dark as in *T. lugubris*. The carapace is also proportionately longer when compared with the breadth, as shown by the following table, in which individuals of both species, of the same sex, and as nearly equal in size as the series would permit, are compared:—

	<i>T. lugubris.</i>	<i>T. Masoniana.</i>
1. A young Female.	mm.	mm.
Breadth between epibranchial teeth . . . . .	26	26
Length of carapace . . . . .	22	23·7
2. An adult Male.		
Breadth between epibranchial teeth . . . . .	39	37·7
Length of carapace . . . . .	32·3	31

The largest specimen, a male, is 39·5 mm. long, and the greatest breadth of the carapace 52 mm.; the distance between the epibranchial teeth 45 mm., and between the external orbital angles 29 mm.; breadth of front 12 mm.

*T. Masoniana* is perhaps a representative on the plains of *T. indica*, as *T. lugubris* may be on the hills. I have associated it with the name of Prof. Wood-Mason of Calcutta.

### 130. TELPHUSA LESCHENAULTI (Milne-Edw.).

*T. Leschenaulti* (Milne-Edw.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. v. p. 165, pl. viii. fig. 3 (1869).

Ganjam (*Day*); Madras, common in wells and ponds, also met with burrowing in rice-fields and in all the larger compounds (*J. R. II.*); Ceylon (*Brit. Mus.*).

The carapace and limbs are usually mottled with minute dark brown spots. An adult male from Madras has the carapace 28·5 mm. long, and 37 mm. in greatest breadth.

*Distribution.* Ceylon; Pondicherry; Madras; Malabar; Nicobars; also recorded from Mauritius and Tahiti.

### 131. TELPHUSA RUGOSA, Kingsley.

*T. rugosa*, Kingsley, Proc. Acad. Nat. Sci. Philad. p. 37 (1880).

Pundaloya, Ceylon (*E. E. Green*); Ceylon mountain streams, a series (*Holdsworth*).

As the specimens collected by Holdsworth were referred without hesitation by Miers to this species, I venture to supplement the very brief original description by the following account:—The carapace is subquadrate and depressed. The postfrontal ridge, though interrupted, is well-defined, and the edge crenulated; the median portion bounding the epigastric lobes is placed well in front of, and quite separate from the lateral portions, which are sinuous and curve slightly forwards to pass into the well-marked epibranchial

tooth on each side. The mesogastric furrow is shallow and somewhat broad. The cervical groove is well defined, and passes as far as the postfrontal ridge, slightly internal to the epibranchial tooth, but it does not interrupt the ridge; it is most strongly marked between the anterior branchial and the protogastric lobes. The branchial regions carry many transverse finely crenulated lines, which posteriorly curve round to the under surface of the carapace. The epibranchial tooth is continued into a finely crenulated carina, which extends along the anterior half of the anterior branchial region, and finally curves inwards on the carapace. The border between the epibranchial tooth and the external orbital angle is sinuous and finely crenulated. The frontal margin is slightly concave towards the middle, and both it and the orbital margin are obscurely crenulated.

The chelipedes are unequal in both sexes, either right or left being larger; the merus and carpus have short raised lines externally which almost impart a squamose appearance; the carpal spine is well developed and acute, with a small obtuse tooth in front of its base; the hand is smooth externally, but slightly rugose on the inferior proximal margin; the fingers are strongly toothed, and in adults there is usually a single specially enlarged tooth on the immobile finger of the larger chelipede. The ischial line of the external maxillipedes is placed considerably nearer the inner or median margin of the joint. The ambulatory legs are carinated along the anterior margin, and the carpal joints of the first three pairs have in addition a carina on both the anterior and the posterior surfaces. The male abdomen is slightly constricted towards the middle, becoming wider towards the distal end of the penultimate segment.

The carapace of an adult female is 41 mm. long, and 52 mm. in greatest width.

*Distribution.* Ceylon (*Kingsley*).

### 132. TELPHUSA ENODIS, Kingsley.

*T. enodis*, Kingsley, Proc. Acad. Nat. Sci. Philad. p. 36 (1880).

Pundaloya, Ceylon, a male (*E. E. Green*); "Madras," a single specimen (*Bril. Mus.*). The latter specimen probably came from one of the South Indian hill-ranges, and not from the neighbourhood of Madras.

I refer these with some hesitation to this insufficiently described species. It is, as Kingsley remarks, closely allied to *T. laevis*, Wood-Mason, and the two may afterwards prove to be identical. The carapace is smooth and moderately convex, with no post-frontal ridge, and merely the rudiment of an epibranchial tooth. A faint depression between each anterior branchial and protogastric lobe indicates the cervical groove, and there is a shallow indication of the mesogastric furrow. The median portion of the frontal margin is inflected. The ischial line of the external maxillipedes is placed nearly in the centre of the joint. The ambulatory legs are very slender, and the three terminal joints are provided with many short setose hairs. In the above specimens the chelipedes are similar to those of *T. laevis*, as described and figured by Wood-Mason.

The Ceylon example is 12 mm. long, and 15.5 mm. broad.

In the British Museum there is a series of a closely allied and perhaps identical species from North India, which I refer to *T. laevis*, as the specimens agree well with Wood-

Mason's description and figures. The adult males, however, have a very wide gape between the fingers of the larger chelipede, as in *T. difformis*, Milne-Edw.; and as the latter species appears to be closely allied to *T. lævis* in other respects, perhaps the two are not distinct. The wide gape of the fingers is not specially referred to by Wood-Mason, and it is probably confined to old males; it is not seen in either of the specimens which I refer to *T. enodis*.

*Distribution.* Ceylon (*Kingsley*).

133. TELPHUSA POCOCKIANA, n. sp. (Pl. XXXVII. figs. 5-8.)

Jubbulpore, three males and three females (*Day*).

The carapace is smooth and slightly convex anteriorly, with the branchial regions somewhat expanded laterally. Commencing at the mesogastric furrow, which is fairly well marked, and bifurcated posteriorly, the postfrontal ridge curves outwards and slightly backwards, but stops abruptly a short distance from the side of the carapace: in other words, it does not pass into the epibranchial tooth; throughout its course it is sharply defined and nowhere interrupted, though near the middle line it is slightly wrinkled. It approaches rather nearer than usual to the orbital margin, and the surface of the carapace between the external orbital angle and the outer end of the ridge is considerably excavated. A shallow groove, not always seen in young individuals, passes from this excavation between the end of the ridge and the free margin of the carapace. The cervical groove is well marked at the posterior limit of the gastric area, but shallow and faint elsewhere, and scarcely reaches the postfrontal ridge, which it does not indent; it is better marked in young individuals. The epibranchial tooth is very rudimentary, in fact indicated merely by the posterior limit of a slight notch, and placed a little in advance of the level of the postfrontal ridge, *i. e.* quite close to the external orbital angle, which is itself but little prominent. The antero-lateral margin, behind the epibranchial tooth and bounding the anterior branchial area, is regularly curved and obsolete dentate; behind the posterior limit of this margin are the usual slight transverse ridges extending to the concave postero-lateral margin. A few very slight rugosities or lines are seen on the anterior branchial region, behind the outer limit of the postfrontal ridge. On the gastric region adjoining the cervical groove an anterior and posterior punctum are seen on each side. The frontal margin is almost straight and is scarcely crenulated. The orbits are remarkably large and subtriangulate in outline, the apex of the triangle being placed at the external orbital angle. The epistome is comparatively deep, and the lower margin gives rise to a broad obtuse tooth. The ischial line of the external maxillipedes is faint, and scarcely extends throughout the length of the joint; it is placed nearer the inner margin.

The chelipedes are unequal in size, and very similar to those of *T. indica*; the carpal spine is short but acute, the outer surface of the hand sparingly punctate, and the puncta are arranged in lines on the outer surface of the fingers. The ambulatory legs are also similar to those of *T. indica*. The meropodites have the anterior margin finely crenulated, and a few short horny spinules are met with, on the posterior margin of the propodi. The terminal segments of the male abdomen are wider than those of *T. indica*, and the lateral margins of the penultimate segment are almost straight.

This species bears some general resemblance to *T. indica*, but is distinguished from that species by the peculiar nature of the postfrontal ridge, which, though well marked, does not pass to the lateral margin of the carapace, stopping short abruptly before reaching it; the rudimentary epibranchial tooth is placed near the external orbital angle, and the contiguous part of the carapace is deeply hollowed out. In *T. celebensis*, De Man, a species also with a well-marked postfrontal ridge which does not pass into the epibranchial tooth, there is a second small tooth placed between the epibranchial one and the external orbital angle.

The largest specimen, a male, has the carapace 30.5 mm. long, and the greatest breadth 43.3 mm.; the distance between the external orbital angles is 28.3 mm., and between the epibranchial teeth 34.5 mm.; the front is 12 mm. in breadth.

I have named the species after Mr. R. I. Pocock, of the British Museum Staff.

#### 134. TELPHUSA FLUVIATILIS, Latr.

*T. fluviatilis* (Latr.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. v. p. 164 (1869).

Quetta, a series in the British Museum, collected by W. T. Blanford, and another series from the same locality presented by the Secretary of State for India. "Environns of Calcutta" (*Coll. Schlagintweit*). The latter locality is probably erroneous, and the specimen perhaps came from the Himalayas.

The occurrence of this species so far east is interesting. I have compared the specimens carefully with a large series in the British Museum from various localities on both the European and African sides of the Mediterranean, and can find no differences of any importance. There are specimens in the British Museum from Sistan, Persia.

*Distribution.* Italy, Greece, Turkey, Crimea, Syria, Egypt, Algeria, Cyprus (*A. Milne-Edwards*).

#### 135. TELPHUSA ATKINSONIANA, Wood-Mason.

*T. Atkinsoniana*, Wood-Mason, Journ. As. Soc. Bengal, vol. xl. p. 205, pl. xiv. figs. 12-16 (1871).

Kangra, four females (*Day*); British Burmah, a male (*W. Theobald*); Simla, several young specimens (*Coll. Schlagintweit*).

The Kangra examples are not fully grown (the largest is only 21 mm. long and 27.5 mm. broad) and they have apparently not acquired all the typical characters. The granulations are scarcely represented on the epigastric and protogastric lobes of the carapace, and the outer surface of the hands is only sparingly tuberculate; there can, I think, be no doubt, however, of their identity.

This species is closely allied to *T. fluviatilis*, but the two may be distinguished as follows:—In *T. fluviatilis*, the portion of the postfrontal ridge bounding the epigastric lobes is placed well in advance of, and is practically cut off from, the rest of the ridge, while in *T. Atkinsoniana* it is continuous with the rest. In *T. fluviatilis*, the ridge is somewhat ill defined and more or less interrupted laterally, where it passes into the epibranchial tooth, while in *T. Atkinsoniana* it is strongly defined and prominent at this point.

Specimens of the two allied species *T. denticulata*, Milne-Edw. (China), and *T. Larnaudii*, A. Milne-Edw. (Siam), are in the collection of the British Museum, and they

were regarded by Miers as scarcely distinct from *T. fluviatilis*. In the present limited state of our knowledge as to what constitutes a species in this difficult genus, I think they must be held to be distinct. *T. denticulata* is distinguished, from both *T. fluviatilis* and *T. Atkinsoniana*, by its poorly marked postfrontal ridge, and the small size of the epibranchial tooth. *T. Larnaudii* is even more closely allied, but is distinguished from both by the greater convexity of the branchial regions, which are sparingly granulated; the protogastric and epigastric lobes are not granulated as in *T. Atkinsoniana*; the postfrontal ridge resembles that of *T. Atkinsoniana*, but towards the epibranchial tooth it becomes interrupted as in *T. fluviatilis*.

*Distribution.* North India: Darjeeling; Thaneote Hills, Nepal; Khasi Hills (*Wood-Mason*); Ceylon (*Brit. Mus.*)

#### Genus PARATELPHUSA, Milne-Edwards.

##### 136. PARATELPHUSA SINENSIS, Milne-Edw.

*P. sinensis*, Milne-Edwards, Arch. du Mus. vol. vii. p. 173, pl. xiii. fig. 2 (1854-55).

Burmah, an adult male (*Day*).

*Distribution.* China (*Milne-Edwards*); Siam (*Von Martens*); Moulmein, Burmah (*Wood-Mason*).

##### 137. PARATELPHUSA SPINIGERA, Wood-Mason.

*P. spinigera*, Wood-Mason, Journ. As. Soc. Bengal, vol. xl. p. 194, pl. xii. figs. 1-4 (1871).

Calcutta, Roorkee, North-West Provinces, Sind, Ganjam (*Day*).

According to Wood-Mason this species is very common in the Calcutta tanks. The British Museum has a series from Bengal.

*Distribution.* North India (*Wood-Mason*). It is not known to occur further south than Ganjam.

##### 138. PARATELPHUSA DAYANA, Wood-Mason.

*P. Dayana*, Wood-Mason, Journ. As. Soc. Bengal, vol. xl. p. 192, pl. xi. (1871).

Toung-hoo, Burmah; ten specimens (*Oates*).

This species is characterized by the great convexity of its carapace, and the well-marked postfrontal ridge, with the epigastric portions almost nodose. The four epibranchial teeth (not counting the external orbital angle) very gradually diminish in size on passing backwards, and the greatest diminution is seen in the most posterior one.

The largest specimen, a female, is 30 mm. long, and 41 mm. broad.

*Distribution.* Burmah: Prome and Mandalay (*Wood-Mason*).

##### 139. PARATELPHUSA MARTENSI, Wood-Mason.

*P. Martensi*, Wood-Mason, Ann. Mag. Nat. Hist. ser. 4, vol. xvii. p. 121 (1876).

Roorkee, two males; North-West Provinces, three males, two females (*Day*).

A comparatively small species with three epibranchial teeth as in *P. sinensis*, but the meropodites of the ambulatory legs unarmed. The largest specimen, a female, is 21.5 mm. long and 27 mm. broad.

*Distribution.* North India: Hurdwar, Purneah, Allahabad, Jessore district (*Wood-Mason*).

#### Genus OCYPODA, Fabr.

##### 140. OCYPODA CERATOPHTHALMA (Pallas).

*O. ceratophthalma* (Pallas), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. x. p. 379, pl. xvii. fig. 1 (1882).

Rameswaram and Tuticorin (*Thurston*). Common on the South Indian coast (*J. R. II.*).

The stridulating ridge on the inner surface of the hand is coarsely striated above, and very finely striated below.

*Distribution.* From the Red Sea, E. Africa and Natal, to Japan and the Pacific (Samoa, Fijis, Sandwich Is., &c.), also the coasts of Australia.

##### 141. OCYPODA MACROCERA, Milne-Edw.

*O. macrocera* (Milne-Edw.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. x. p. 381, pl. xvii. fig. 2 (1882).

Rameswaram, many specimens; Tuticorin, two males (*Thurston*); Madras, not uncommon (*J. R. II.*).

This species does not appear to be common. It differs from *O. ceratophthalma* in having the finger-tips of both chelipedes, but especially of the smaller one, dilated and flattened. The outer surface of both hands is also more finely granulated. The colour is a reddish orange, most pronounced on the chelipedes. It occurs at Madras, above high-water mark, but is much less common than the next species.

A Rameswaram specimen (female) has the carapace 30 mm. long and 38 mm. broad.

*Distribution.* India (*Milne-Edwards, Miers*).

##### 142. OCYPODA PLATYTARSIS, Milne-Edw.

*O. platytarsis* (Milne-Edw.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. x. p. 383, pl. xvii. fig. 5 (1882).

Rameswaram (*Thurston*); Ceylon (*Italy*); Madras, very abundant (*J. R. II.*).

The stridulating ridge is narrow and tuberculate in both sexes. The dactyli of the ambulatory legs are broad and flattened in adults. This is the commonest species of *Ocypoda* at Madras, where it occurs in great numbers, burrowing in the sand near high water mark, never at any great distance from the sea. It attains a large size, and a male obtained by Mr. Thurston in Ceylon has the carapace 56 mm. long and 66 mm. broad.

*Distribution.* India and Ceylon (*Milne-Edwards, Miers*).

##### 143. OCYPODA CORDIMANA, Desmarest.

*O. cordimana* (Desm.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. x. p. 387, pl. xvii. fig. 9 (1882).

Tuticorin (*Thurston*). Common at Madras (*J. R. II.*).

This is a smaller species than the foregoing, and distinguished at once by the absence of a stridulating ridge from the chelipedes in both sexes. It is a terrestrial crab and lives in burrows at some distance from the sea.

*Distribution.* From Mauritius and the Seychelles to China, Australia, and the Pacific (New Caledonia, New Hebrides, Fijis, &c.).

#### Genus GELASIMUS, Latreille.

##### 144. GELASIMUS ANNULIPES, Latr.

*G. annulipes* (Latr.), De Man, Mergui Crust., p. 118, pl. viii. figs. 5-7 (1887), *ubi synon.*  
(= *G. perplexus*, Milne-Edw.; *G. pulchellus*, Stm.).

Rameswaram and Tuticorin (*Thurston*). Abundant on the margins of the South Indian backwaters, burrowing in sand or mud (*J. R. II.*).

A curious sexual difference has been pointed out by De Man, viz. the infra-orbital ridge is simple and finely crenulated in the male, whereas in the female the crenulations are larger, and in addition there is an accessory row of acute granules parallel to the ridge, but placed within the orbital cavity.

An adult male from Rameswaram has the carapace 12 mm. long and 21 mm. broad at the level of the external orbital angles; the hand of the larger chela 38 mm. long.

*Distribution.* From E. Africa to the Pacific (Tahiti and the Fijis).

##### 145. GELASIMUS TRIANGULARIS, A. Milne-Edw.

*G. triangularis* (A. Milne-Edw.), De Man, Mergui Crust. p. 119, pl. viii. figs. 8-11 (1887).  
(= *G. perplexus*, Heller).

Madras and Ennore (*J. R. II.*).

This species is found living with *G. annulipes* at the above localities, and the two are almost equally common. *G. triangularis* is, however, a slightly smaller species, and its colour-markings are different, but I omitted to note these in living specimens. The carapace is narrower posteriorly in the present species, and the larger hand has only two granulated ridges on the inner surface, while there are three in *G. annulipes*. The immobile finger of the larger chela is acute at its distal end, whereas in *G. annulipes* it is subtruncated, or almost bidentate, owing to the presence of an accessory tooth near the apex. In the two species there is considerable variation, and varieties of both are common in which the inner margin of both fingers is without any prominent teeth. The females of *G. triangularis* lack the accessory orbital row of granules met with in the females of the other species.

*Distribution.* New Caledonia (*A. Milne-Edwards*); Mergui (*De Man*); Ceylon and Madras (*Heller*).

## Genus MACROPHTHALMUS, Latr.

## 146. MACROPHTHALMUS DEPRESSUS, Rüppell.

*M. depressus*, Rüppell, Beschreib. u. Abbild. Kurzschwänzigen Krabben, p. 19. tab. iv. fig. 6 (1830); De Man, Notes Leyden Mus. vol. iii. p. 255 (1881); id. Brock's Crust. p. 356, taf. xv. fig. 3 (1888).

*M. affinis*, Guérin, Crust. 'Favorite,' p. 172, pl. 1. fig. 2 (1839).

Rameswaram, three specimens (*J. R. II.*).

The carapace is finely granulated, with the exception of the central part of the gastric area, and in young specimens it is only granulated towards the sides. The carpus and hand are smooth and glabrous externally, without spines and with merely a row of granules on the upper margin of the hand internally; the mobile finger has an obtuse crenulated lobe on its inner margin near the base. The ambulatory legs are pubescent, with a single tooth near the anterior distal end of the merus.

I have little doubt that my specimens are referable to Guérin's species, and at the same time they seem to be identical with *M. depressus*, as characterized by De Man, though in the figure of the latter writer the palm is shorter in proportion to the length of the fingers than in the Rameswaram examples. This difference is, however, unimportant. A male specimen is 11 mm. long and 17 mm. wide.

*Distribution.* Red Sea (*Rüppell, De Man*); Bombay, Pondicherry (*Guérin*); North Australia (*Haswell*).

## 147. MACROPHTHALMUS PECTINIPES, Guérin.

*M. pectinipes*, Guérin, Crust. 'Favorite,' p. 167, pl. xlix. (1839); Milne-Edwards, Ann. Sci. Nat. sér. 3, Zool. t. xviii. p. 158 (1852).

Sind, five specimens (*Day*).

This large species is characterized by its spiny-bordered ambulatory legs, and the presence of large scattered tubercular granules on the carapace.

The largest individual is 34 mm. long, and 57 mm. wide at the level of the external orbital angles.

*Distribution.* Bombay (*Guérin, Brit. Mus.*); Penang (*Brit. Mus.*).

## 148. MACROPHTHALMUS LATREILLEI (Desm.).

*M. Latreillei* (Desm.), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 278, pl. xiii. fig. 3 (1873).

Ceylon, in a fossil state; two specimens (*Italy*).

This species has been previously recorded in a fossil state from the recent deposits of Ceylon, the Philippines, Malacca, and New Caledonia, but it has not yet been found living in the Indian seas. One of Mr. Haly's examples was in an excellent state of preservation, and there could be no doubt as to its identity with the species figured by A. Milne-Edwards. According to De Man *M. Polleni*, Hoffmann, from Madagascar, is perhaps synonymous with the present species.

*Distribution.* Living in the seas of New Caledonia (*A. Milne-Edwards*).

## Genus SCOPIMERA, De Haan.

## 149. SCOPIMERA MYCTIROIDES (Milne-Edw.).

*Doto myctiroides*, Milne-Edwards, Ann. Sci. Nat. sér. 3, Zool. t. xviii. p. 152, pl. iv. fig. 24 (1852).

Rameswaram and Tuticorin (*Thurston*). Common at Rameswaram, burrowing in sand and mud; Ennore (*J. R. II.*).

De Man, on what are apparently good grounds, unites *Dotilla*, Stm. (= *Doto*, De Haan, nom. præocc.), and *Scopimera*, De Haan, selecting the former name for the genus; but *Scopimera* is preferable as it is the older name, and *Dotilla* has more recently been used to designate a genus of Mollusca.

In a very large series of this species I have as yet only met with males. There is still much to be learned about the genus, especially as to the nature of the curious 'tympana' on the sterna and on the meral joints of the ambulatory legs.

*Distribution*. Malabar (*Milne-Edwards*); Strait of Gaspar (*Stimpson*); Java (*Brit. Mus.*); Singapore (*Walker*); Seychelles (*Miers*).

## Genus MYCTIRIS, Latr.

## 150. MYCTIRIS LONGICARPUS, Latr.

*M. longicarpus* (Latr.), De Man, Brock's Crust. p. 358 (1888).

(=? *M. brevidactylus*, Stm.).

Akyab, several specimens (*Day*).

*Distribution*. Malay Archipelago, China, Australia and Tasmania, New Caledonia.

## Genus METOPOGRAPSUS, Milne-Edw.

## 151. METOPOGRAPSUS MESSOR (Forsk.).

*M. messor* (Forsk.), De Man, Mergui Crust. p. 144, pl. ix. fig. 11 (1888); id. Brock's Crust. p. 361, taf. xv. fig. 6 (1888).

(= *Pachygrapsus aethiopicus*, Hilg.).

Tuticorin (*Thurston*). Very common at Rameswaram between tide-marks; common at Madras (*J. R. II.*).

*Distribution*. From the Red Sea, E. Africa, and Natal to the Pacific (Samoa, Fijis, Sandwich Is., &c.).

## Genus GRAPSUS, Lam.

## 152. GRAPSUS STRIGOSUS (Herbst).

*G. strigosus* (Herbst), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 286 (1873), *ubi synon.*

Rameswaram and Tuticorin (*Thurston*). Abundant on the harbour walls at Madras, and elsewhere on the Coromandel coast (*J. R. II.*).

*Distribution*. From the Red Sea and E. Africa to the Pacific as far as the coast of Chili.

## 153. GRAPSUS MACULATUS (Catesby).

*G. maculatus* (Catesby), A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 285 (1873).

Tuticorin (*Thurston*).

*Distribution.* Atlantic Region (from Florida to the Cape of Good Hope). Throughout the Indo-Pacific Region.

## Genus PLAGUSIA, Latr.

## 154. PLAGUSIA IMMACULATA, Lam.

*P. immaculata* (Lam.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. i. p. 150 (1878).

(= *P. depressa*, Latr., nec Fabr.).

Madras, common, associated with *Grapsus strigosus* (*J. R. II.*).

*Distribution.* Bay of Bengal, Malay Archipelago, Chinese Seas, N. Australia, and the Pacific as far as the Sandwich Is. and the W. coast of Central America.

## Genus LEIOLOPHUS, Miers.

## 155. LEIOLOPHUS PLANISSIMUS (Herbst).

*L. planissimus* (Herbst), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. i. p. 153 (1878), *ubi synonym.*

Rameswaram, not uncommon between tide-marks (*Thurston, J. R. II.*); Madras (*J. R. II.*).

*Distribution.* Atlantic Region (Florida, West Indies, Madeira, &c.); Indo-Pacific Region, from the Mascarenes to Korea, the coasts of California, Chili, and New Zealand.

## Genus VARUNA, Milne-Edw.

## 156. VARUNA LITTERATA (Fabr.).

*V. litterata* (Fabr.), Milne-Edwards, Ann. Sci. Nat. sér. 3, Zool. t. xviii. p. 176 (1852).

Ceylon (*Italy*); Calcutta, several specimens preserved in the same bottle with *Paratelphusa spinigera*, a fresh-water species; Sittoung; Ganjam (*Day*). Not uncommon in the backwater at Ennore (*J. R. II.*).

If there is no mistake in connection with the locality Sittoung, this species occurs about one hundred miles inland in the Sittoung River, Burmah; it has previously been recorded from fresh water by Miers and others.

*Distribution.* Mauritius, Bay of Bengal, Malay Archipelago, China, Japan, New Caledonia, Australia, New Zealand.

## Genus METAPLAX, Milne-Edw.

## 157. METAPLAX DISTINCTUS, Milne-Edw.

*M. distinctus*, Milne-Edwards, Ann. Sci. Nat. sér. 3, Zool. t. xviii. p. 162, pl. iv. fig. 27 (1852); De Man, Mergui Crust. p. 158, pl. x. figs. 7-9 (1888).

Ennore (*J. R. II.*).

This species is not uncommon in the above locality, found running about in grass, and living in company with *Metasesarma Rousseauxii*. The spinules on the meropodites of the ambulatory legs vary in number in different specimens, and sometimes even on the two sides of the same specimen. In the Ennore examples the ambulatory legs are without hairs, whereas in those from Mergui examined by De Man they were hairy on the terminal joints.

The largest specimen has the carapace 11 mm. long and 15 mm. wide.

*Distribution.* Bombay (*Milne-Edwards*); Mergui (*De Man*).

#### Genus SESARMA, Say.

##### 158. SESARMA TETRAGONA (Fabr.).

*S. tetragonum* (Fabr.), A. Milne-Edwards, *Nouv. Arch. Mus. Hist. Nat.* t. ix. p. 304, pl. xvi. fig. 4 (1873).

Madras, very common on the banks of the Cooum; Ennore (*J. R. II.*).

The carapace is densely pubescent, especially in front, and the hairs are arranged in tufts; a single tooth is placed behind the antero-lateral angle. The upper margin of the hand carries a narrow longitudinal ridge which is finely striated transversely, and the outer surface of the same joint is finely granulated, with a short ill-defined line of granules about the middle of the surface; the dactylus is armed above with ten or eleven horny-tipped tubercles.

An adult male has the carapace 36 mm. long and 40 mm. wide, the right hand and immobile finger 40 mm. long and 24 mm. in height.

*Distribution.* From the Red Sea, E. Africa, and Natal to China and the Pacific (New Caledonia, Fijis, &c.).

##### 159. SESARMA QUADRATA (Fabr.).

*S. quadratum* (Fabr.), Miers, *Phil. Trans. Roy. Soc.* vol. clxviii. p. 490 (1879).

(= *S. affinis*, De Haan; *S. unguolata*, Milne-Edw.; *S. aspera*, Heller).

Tuticorin (*Thurston*). Very common at Madras and Ennore (*J. R. II.*).

The Tuticorin examples belong to the typical form; the carapace of a male is 17.5 mm. long and 21 mm. wide, and there are eleven tubercles on the upper margin of the immobile finger. The Madras and Ennore examples belong to the variety *aspera* of Heller, and the largest male that I have met with is only 15.8 mm. long and 19.5 mm. wide. On examining a large series of adult males I find from thirteen to eighteen tubercles on the immobile finger; as a rule each tubercle is oval and symmetrical, but in one or two specimens they are each slightly curved. *S. Melissa*, De Man, founded on a single specimen from Mergui, with the tubercles horse-shoe shaped, may therefore be only a variety of *S. quadrata*. Tufts of hair are sometimes present on the postfrontal lobes.

*Distribution.* From E. Africa and Natal to Japan and the Pacific (New Caledonia, Fijis).

## Genus SARMATIUM, Dana.

## 160. SARMATIUM INDICUM (A. Milne-Edw.), var. MALABARICUM, n. (Pl. XXXVI. fig. 17.)

*Metagrapsus indicus*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. iv. p. 174, pl. xxvi. figs. 1-5 (1868).

*Sarmatium indicum*, Kingsley, Proc. Acad. Nat. Sci. Philad. p. 213 (1880).

Cochin, several specimens, collected by my former pupil A. G. Paul.

I at first felt disposed to refer these specimens to *S. punctatum* (A. Milne-Edw.), but Prof. A. Milne-Edwards, to whom I sent an example, informed me that it did not belong to that species, but was rather referable to *S. indicum* (A. Milne-Edw.). They differ from the description and figures of the latter species in having the carapace strongly punctate and the inner surface of the hand with a well-marked tubercular ridge (characters which A. Milne-Edwards assigned to *S. punctatum*); the fingers in the male have a much wider gape, and the male abdomen has the terminal segment narrower, and the basal segments relatively broader, than represented in Milne-Edwards's figure. On the other hand, I have compared them with specimens in the British Museum from the Indo-Malayan seas, referred by Miers to *S. punctatum*, and I find the following differences:—In Miers's specimens the fingers in the male have a much narrower gape, and there is a distinct ridge or carina on the outer surface of the immobile finger, running parallel to and near the toothed edge, which is entirely absent from the Cochin specimens. In our specimens the immobile finger is more compressed, and there is a very prominent tooth on its inner margin near the base, while there are also prominent teeth near the apices of both fingers at the posterior limit of the horny plate which is seen on each digit.

Neither *S. punctatum* nor the typical form of *S. indicum* are yet known to occur in India.

The carapace of a male is 21·3 mm. long and 26 mm. broad, the front is 14·3 mm. broad, the right hand (including the immobile finger) is 22 mm. long and 13·5 mm. in height; the dactylus 14·5 mm. long.

*Distribution.* The typical form occurs in Celebes (*A. Milne-Edwards, De Man*).

## Genus METASESARMA, Milne-Edwards.

## 161. METASESARMA ROUSSEAUXXII, Milne-Edw.

*M. Rousseauxii*, Milne-Edwards, Ann. Sci. Nat. sér. 3, t. xx. p. 188 (1853); id. Arch. du Mus. t. vii. p. 158, pl. x. fig. 1 (1854).

*Sesarma Aubryi*, De Man, Mergui Crust. p. 168 (1888), nec *S. Aubryi*, A. Milne-Edw.

Enmore, not uncommon (*J. R. H.*).

I sent a specimen to Prof. A. Milne-Edwards, who referred it to the present species, which also includes examples from Mergui in the British Museum relegated to *Sesarma Aubryi* by De Man. The colour markings are very characteristic. The deflexed portion of the front is dark purplish brown, and immediately behind, a grey or yellow band crosses the carapace transversely and is continued on to each eye-stalk; the remainder of the carapace shows purplish-brown mottlings. The chelipedes and legs are yellow.

A male is 16 mm. long and 19·5 mm. broad, the front 11·3 mm. broad.

*Distribution.* Zanzibar (*Milne-Edwards*); Mergui and Malay Archipelago (*De Man*).

## Genus XENOPHTHALMUS, White.

## 162. XENOPHTHALMUS PINNOTHEROIDES, White.

*X. pinnotheroides*, White, Ann. Mag. Nat. Hist. vol. xviii. p. 178, pl. ii. fig. 2 (1846); Adams and White, 'Samarang' Crust. p. 63, pl. xii. fig. 3 (1848).

Rameswaram, four males, one female (*Thurston*).

The carapace of the largest male is 6 mm. long and 9 mm. broad.

*Distribution.* Philippines (*White*); Hong Kong (*Stimpson*).

## 163. XENOPHTHALMUS OBSCURUS, n. sp. (Pl. XXXVI. figs. 18, 19.)

Gulf of Martaban, a female (*Oates*).

The carapace is moderately convex, glabrous, and somewhat uneven, with a decided anterior declivity. The gastro-branchial grooves are rather deep, and faint sulci pass forwards from them; two slight epigastric swellings are present. The lateral margins are ill-defined anteriorly, while behind they are not represented by any distinct margin. The antero-lateral margin is a very slightly marked ridge, and below it on the pterygostomial area two similar and almost parallel ridges are seen. The mid-branchial region is slightly better defined by the lateral margin, but the ridge here is not continuous with the antero-lateral ridge, and posteriorly it curves on to the surface of the carapace to form a prominent wrinkle, which extends to the posterior limit of the gastro-branchial groove. The eyes are placed somewhat obliquely, and are distinctly visible in the orbital fissures. The front when viewed from above appears obtusely bilobed, but when viewed from before it is seen to have the sides parallel and the free end truncated, with a median and two lateral slight projections.

In the single specimen—a female—the chelipedes are very minute and slender, being even shorter than the last pair of legs; superior and inferior marginal ciliated lines are seen on the hand. The ambulatory legs are faintly pubescent towards their apices, and the meropodites of the first three pairs are armed on the anterior and posterior margins with short curved spinules, which are best marked on the posterior margins. The abdominal segments are glabrous externally.

The carapace is 6.5 mm. long and 7 mm. wide; the first leg is 10 mm. long, the second leg 14 mm., the third leg 17 mm., the chelipede 7 mm., and the last leg 10 mm.

I have compared the specimen with the types of *X. pinnotheroides*. In White's species the front is obtusely rounded and without distal projections, the orbital fissures are deeper and pass straight, not obliquely, back on the carapace; there is a granular line on the postero-lateral margin of the carapace, and a second line on the post-branchial region; lastly, there is only a single obscure ridge on the pterygostomial area.

## Genus ELAMENE, Milne-Edw.

## 164. ELAMENE UNGUIFORMIS, De Haan.

*E. unguiformis*, De Haan, Crust. Japon. p. 75, tab. xxiv. fig. 1 (1850).

Gulf of Martaban, an adult male (*Oates*).

*Distribution.* Japan (*De Haan*).

165. *ELAMENE TRUNCATA*, A. Milne-Edw.

*E. truncata*, A. Milne-Edwards, Nouv. Arch. Mus. Hist. Nat. t. ix. p. 323 (1873).

Silavaturai Par; five females with ova, one male (*Thurston*).

The above specimens seem to be referable to this species, with the short description of which they entirely agree. The front is rounded and entire, with an inferior vertical prolongation which partially separates the antennules. The carapace is bounded by a slightly raised marginal line. The meral and carpal joints of the ambulatory legs each terminate in an anterior distal spine. The last abdominal segment in the female has its free margin broadly emarginate.

*Distribution.* New Caledonia (*A. Milne-Edwards*).

## Group OXYSTOMATA.

## Genus CALAPPA, Fabr.

166. *CALAPPA HEPATICA* (Linn.).

*C. hepatica* (Linn.), Miers, 'Challenger' Brachyura, p. 285 (1886), *ubi synonym.*  
(= *C. tuberculata*, Fabr.).

Rameswaram and Tuticorin (*Thurston*); Ceylon (*Haly, Nevill*); Gulf of Martaban (*Oates*).

In young individuals the postero-lateral lobes of the carapace are not nearly so strongly developed as in adults, but the margins are more strongly dentate.

*Distribution.* Throughout the Indo-Pacific Region, from the Red Sea, E. Africa, and Natal to China, the Sandwich Is., and New Zealand.

167. *CALAPPA GALLUS* (Herbst).

*C. gallus* (Herbst), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 105 (1837).

Rameswaram and Tuticorin (*Thurston*); Ceylon (*Haly, Nevill*); Gulf of Martaban (*Oates*).

There is a remarkable difference between the eyes in this species and in the last; in *C. hepatica* they are elongated and slender, in *C. gallus* short and stout.

*Distribution.* Red Sea, Mascarenes, Malay Archipelago, Pacific. If *C. galloides*, Stm., should prove identical, as Miers supposes, it occurs also in the West Indies.

168. *CALAPPA LOPHOS* (Herbst).

*C. lophos* (Herbst), De Haan, Crust. Japon. p. 72, tab. xx. fig. 1 (1850).

Ceylon (*Haly*); Gulf of Martaban (*Oates*); very common at Madras (*J. R. II.*).

In young individuals the anterior half of the carapace is provided with smooth rounded tubercles which are not seen in the adult. There is considerable variation in the size of the granulated teeth on the posterior margin, and in very young specimens they are represented by slender acute slightly curved spines.

*Distribution.* Indian Ocean, Malay Archipelago, Japan.

## 169. CALAPPA PHILARGIUS (Linn.).

*C. philargius* (Linn.), De Haan, Crust. Japon. p. 71, tab. xix. fig. 1 (1850).  
(= *C. cristata*, Fabr.).

Ceylon (*Haly*); Gulf of Martaban (*Oates*).

*Distribution.* Indian Ocean, Malay Archipelago, China, Japan.

## Genus MATUTA, Fabr.

## 170. MATUTA VICTRIX, Fabr.

*M. victrix* (Fabr.), Miers, Trans. Linn. Soc. ser. 2, Zool. vol. i. p. 243, pl. xxxix. figs. 1-3 (1877).

Tuticorin (*Thurston*); Ceylon (*Haly, Nevill*); Sind, Ganjam, Akyab (*Day*). Very common at Madras (*J. R. II.*).

*Distribution.* From the Red Sea, E. Africa, and Natal to Japan, Australia, and the Pacific (New Hebrides, Fijis, &c.).

## 171. MATUTA LUNARIS (Herbst).

*M. rubro-lineata*, Miers, Trans. Linn. Soc. ser. 2, Zool. vol. i. p. 244, pl. xxxix. figs. 5-6 (1877), nec *M. lunaris*, Miers.

Ganjam (*Day*); Madras, not uncommon (*J. R. II.*).

*Distribution.* Indian and Pacific Oceans; Chefoo (*Miers*).

## 172. MATUTA MIERSII, Henderson.

*M. Miersii*, Henderson, Madras Journ. Liter. & Science, session 1886-87, p. 66, pl. i. figs. 1-4 (1887).

Tuticorin (*Thurston*); Ceylon (*Haly, Nevill*); Madras, not uncommon (*J. R. II.*).

This species may be recognized by its colour markings and by the characters of the ridge on the outer surface of the hand, which in both sexes is composed of five short finely granulated teeth, all more or less blunt, except the second, which is subacute; the surface below the ridge is also finely granulated.

Since describing the species, I have had the advantage of examining a large series of this genus in the British Museum, and I am still of opinion that *M. Miersii* is a good species. Its nearest ally is *M. picta*, Hess (Miers), but in this the front is rounded or only very slightly emarginate, whereas in *M. Miersii* it is always distinctly bilobed. In *M. picta* there is a well-marked tubercle on the lateral margin of the carapace behind the lateral spine, which is not seen in our species. The markings are somewhat similar in the two, but in *M. picta* there is a greater tendency towards linear arrangement, and the spots are dark brown or almost black in colour; while in *M. Miersii* the maculæ consist of minute reddish or rust-coloured spots, which remain distinct and do not run into lines; indeed, they show a marked tendency to group themselves around circular or oval areas of the carapace in which there are no spots. One such oval or pear-shaped area is constantly present between the two anterior tubercles situated on the gastric area, and in fresh specimens it is always lighter in colour than the rest of the carapace. Lastly, *M. picta* reaches a considerable size, whereas *M. Miersii* is one of the smaller species of

the genus. A *Sacculina* frequently occurs on the abdomen, and I have not noticed this in the case of the two other species of the genus which occur commonly at Madras.

The largest specimen I have seen, out of several hundred examples, is a male with the carapace 26.5 mm. long and 27 mm. wide (not including the spines), while the average size is considerably less.

*Distribution.* South India and Ceylon.

#### Genus LEUCOSIA, Fabr.

##### 173. LEUCOSIA CRANIOLARIS (Linn.).

*L. craniolaris* (Linn.), Bell, Trans. Linn. Soc. vol. xxi. p. 283 (1855).

Rameswaram and Muttuwartu Par (*Thurston*); Ceylon (*Italy*); Gulf of Martaban (*Oates*); Madras (*J. R. II.*).

*Distribution.* Indian Seas, Malay Archipelago, China.

##### 174. LEUCOSIA WHITMEEI, Miers.

*L. Whitmeei*, Miers, Ann. Mag. Nat. Hist. ser. 4, vol. xvi. p. 342 (1875); id. Trans. Linn. Soc. ser. 2, Zool. vol. i. p. 238, pl. xxxviii. figs. 16-18 (1877).

Gulf of Martaban, two males (*Oates*).

The thoracic sinus is deep and well-defined, with two large flattened reniform tubercles, placed immediately over the base of the chelipede (not mentioned by Miers though shown in his figure); the anterior tubercle is somewhat larger than the posterior. The front is excavated superiorly and tridentate, with the median tooth very minute. The anterior half or more of the carapace is sparingly punctate, and towards the posterior border there are four dark spots (five according to Miers), arranged in a semilunar line, and the ground-colour of the carapace is light in the vicinity of the spots. The hand is compressed, both towards its inner and its outer margin. The male abdomen is constricted between the penultimate and antepenultimate segments; on the latter there is a T-shaped sulcus, and on the former a distal median ridge.

The carapace is 12.5 mm. long and 10 mm. broad.

*Distribution.* Samoa; Fijis (*Miers*). Shark's Bay, W. Australia (*Brit. Mus.*).

#### Genus PSEUDOPHILYRA, Miers.

##### 175. PSEUDOPHILYRA MELITA, De Man.

*P. Melita*, De Man, Mergui Crust. p. 199 (1888).

Muttuwartu Par, a female with ova and a male (*Thurston*); Gulf of Martaban, two females with ova and two males (*Oates*).

I have compared these and found them identical with one of De Man's original specimens (a young male). As the colour markings have not been described, and as they are still visible in the above examples, I add the following brief account as a supplement to the original description:—The front is dark brown, and a large irregularly circular brown

ring is seen on the anterior part of each branchial region, the two being connected posteriorly by a line which passes back in the middle of the carapace as far as the hinder margin; the hepatic region has a brownish border. The merus, carpus, and propodus of the chelipedes have each a proximal brown band, and the fingers are crossed by a similar band near their bases; the ambulatory legs show bands of pale brown.

A female is 14.5 mm. long and 13.3 mm. wide; the right chelipede 24 mm. long.

*Leucosia orbicularis*, Bell, ought, I think, to be placed in the genus *Philyra*; it has the epistome much more prominent than the front, a character which distinguishes it at once from the present species. *Pseudophilyra Perryi*, Miers, is distinguished from *P. Melita* by having a ridge on the frontal part of the carapace, passing back from the median frontal tooth. *Leucosia pubescens*, Miers, is, I think, correctly placed in the genus *Leucosia*, as it has a distinct thoracic sinus; De Man suspects its identity with his *Pseudophilyra Hoedtii*. There is some confusion in regard to the genus *Pseudophilyra*, which undoubtedly comes very near to *Philyra* and the two can scarcely be separated; at the same time *Pseudophilyra* may conveniently be retained for those species with the general facies of *Leucosia*, but with no thoracic sinus.

*Distribution.* Mergui (*De Man*).

176. PSEUDOPHILYRA PUSILLA, n. sp. (Pl. XXXVII. figs. 13-15.)

Gulf of Martaban, five females with ova, two males (*Oates*).

This species—one of the smallest of known Leucosiids—has the carapace smooth, and excavated antero-laterally, with a very slight hepatic swelling. The front is straight, except for the presence of a small obtuse median tooth, from which a faint carina runs back in the middle line of the anterior third of the carapace; the internal orbital angle is but little prominent. A finely granulated marginal line is seen bordering the carapace laterally and posteriorly. The epistome is very short and is covered by the front. The exognath of the external maxillipedes has its outer margin very slightly curved.

The chelipedes are moderately long in the male, but much shorter in the female. The merus is provided with small rounded tubercles on its proximal two thirds, which are arranged in rows and best seen on the inner surface; the carpus and propodus are smooth with the exception of a series of minute granules on the inner surface of the hand. A small articular tubercle is seen on both the inner and outer margins of the propodus at the carpal articulation.

The fingers are faintly sulcate externally, and separated by a slight basal hiatus in both sexes, which occupies slightly more than half the interval; they are feebly toothed in the male, but without teeth in the female. The ambulatory legs are smooth. The male abdomen gradually tapers to the apex and is smooth externally, with the lateral margins of the basal segments slightly wavy or irregular in outline; the female abdomen is smooth and very convex.

The front is dark brown in colour, and a short distance behind on the surface of the carapace, but separated by an uncoloured band, is an irregular semilunar mark on each branchial region, with the convexity of the curve outwards, and a few small spots are seen towards the middle of the carapace. Some transverse markings occur on the chelipedes at the

middle and distal end of the merus, and about the middle of the hand. The legs are uncoloured.

The largest male is 6 mm. long and 5 mm. broad, with the chelipede 10 mm. long; the largest female is 5.8 mm. long and 5 mm. broad, the chelipede 8.5 mm. long.

The species is distinguished at once by its small size, and there can be no doubt that the Martaban examples are adult. The nearest ally appears to be *P. tridentata*, Miers, from Japan, in which, however, in addition to the difference in size, the median frontal projection is much more prominent, and the carapace is punctulated.

#### Genus PHILYRA, Leach.

##### 177. PHILYRA SCABRIUSCULA (Fabr.).

*P. scabriuscula* (Fabr.), Bell, Trans. Linn. Soc. vol. xxi. p. 299 (1855).

Rameswaram and Tuticorin, many specimens (*Thurston*). Abundant at Madras and on the S. Indian coast generally (*J. R. II.*).

There is considerable variation as regards the amount of tuberculation on the carapace; very commonly there is a smooth rounded area on the cardiac region, and a smooth longitudinal area on each branchial region. On the post-gastric region the tubercles may be absent, but they are usually present in this locality, and some of them may be larger than those met with elsewhere. In young specimens the fingers are armed with more prominent teeth towards the apices than in adults, and are also slightly setose.

*Distribution.* E. Africa, Indian Seas, Malay Archipelago.

##### 178. PHILYRA VERRUCOSA, n. sp. (Pl. XXXVII. figs. 10-12.)

Madras, an adult male (*J. R. II.*).

This species is so closely allied to *P. scabriuscula* that only the points of difference between the two need be pointed out. The carapace is more convex, with deeper branchio-cardiac grooves, and, excepting the surface of the frontal lobes, it is everywhere uniformly covered with smooth, rounded tubercles, one of which in the centre of the post-gastric area is larger than the others. The tubercles on the anterior half of the carapace are smaller than those on the posterior half. The external orbital angle is scarcely represented, while in *P. scabriuscula* it is prominent, and the front is narrower between the eyes in our species. The small blunt lobe seen on the hepatic area in *P. scabriuscula* is not present, but this surface is crossed obliquely by a continuous tuberculated line. The external maxillipedes are uniformly granulated externally, including even the exognaths, while in *P. scabriuscula* they are almost smooth, there being at most a few granules on the endognath; the exognath is broader than the ischial joint of the endognath, and its outer margin is strongly convex, distinctly indenting the lateral margin of the carapace; in the longer known species the exognath is decidedly less convex.

The chelipedes are shorter and stouter in the new species, and with more numerous but smaller tubercles on the merus; the fingers are without small teeth or setæ. The sternum is uniformly tuberculate, whereas in *P. scabriuscula* there are merely lines of

small tubercles along the margins of the sternal segments. The basal abdominal segment is narrower and more  $\perp$ -shaped in the new species. The colour is brownish, whereas in *P. scabriuscula* it is usually grey.

The carapace is 8.7 mm. long and 10 mm. broad, the merus of the chelipedes 7.5 mm. long by 3 mm. in width, the propodus 7 mm. long and 2.8 mm. wide.

I have examined several hundred specimens of *P. scabriuscula* from different localities, including Madras where the new species was taken, and have never seen a specimen approaching the form just described; I may add that I have never seen a specimen of *P. scabriuscula*, variable as that species is in regard to tuberculation, with the anterior half of the carapace uniformly covered with tubercles or granules.

#### 179. PHILYRA ADAMSI, Bell.

*P. Adamsii*, Bell, Trans. Linn. Soc. vol. xxi. p. 301, tab. xxxiii. fig. 1 (1855).

Rameswaram and Silavaturai Par, several specimens (*Thurston*); Gulf of Martaban, a female (*Oates*).

I have compared these with the type in the British Museum. The grooves separating the branchial from the cardiac and intestinal regions of the carapace are deeper than usual, and the regions which they define are in consequence apparently swollen. The carapace in its posterior two thirds, especially on the more elevated parts, and towards the lateral and posterior margins, is covered with small rounded granules. The whole front, as in most species of the genus (but not as in *P. scabriuscula* and *P. verrucosa*), projects in advance of the eyes, and is scarcely shorter than the epistome; the median frontal projection is distinctly visible when the carapace is viewed from above. The external maxillipedes are much less dilated than in *P. scabriuscula*, and the exognath is granulated. The granules on the merus of the chelipedes are more numerous, but not so large as in *P. scabriuscula*; both the inner and outer surfaces of the hand are granulated, and there is a distinct line of granules towards the upper limit of the inner surface. In the adult male there are two distinct granules on the upper surface of the palm, opposite the base of the immobile finger.

	Adult ♂.	Adult ♀ (with ova).
	millim.	millim.
Length of carapace.....	9.5	7
Breadth „ .....	10	7.5
Length of right chelipede .....	23	11

*Distribution.* Borneo (*Brit. Mus.*).

#### 180. PHILYRA PLATYCHEIRA, De Haan.

*P. platycheira*, De Haan, Crust. Japon. p. 132, tab. xxxiii. fig. 6 (1850).

Silavaturai Par, three males and three females with ova (*Thurston*).

The immobile finger of the chelipedes bears on its inner margin a very characteristic fringe of hairs, both shown in De Haan's figure and mentioned in his description, by means of which the species is easily recognized.

*Distribution.* Japan (*De Haan*); Hong Kong (*Stimpson*); Philippines (*Bell*); Mergui (*De Man*).

181. PHILYRA GLOBOSA (Fabr.).

*P. globosa* (Fabr.), De Man, Mergui Crust. p. 202 (1888).

Rameswaram and Tuticorin (*Thurston*). Common at Madras and on the South Indian coast generally (*J. R. II.*).

*Distribution.* Indian Seas.

182. PHILYRA POLITA, n. sp. (Pl. XXXVIII. figs. 1-3.)

Madras, a series, not uncommon (*J. R. II.*).

This species is closely allied to *P. globosa*, but distinguished as follows:—The carapace is smooth, shining, punctate, and regularly convex, without grooves, the margin defined by a finely granulated line, which in the hepatic region is not perceptibly indented. In *P. globosa*, on the other hand, the carapace is finely granulated on the branchial regions, not shining, and with branchio-cardiac grooves; the marginal line carries tubercles of varying size, and is distinctly indented at the hepatic area.

The hand and carpus of the chelipedes are smooth, whereas in *P. globosa* they are granulated along the inner surface, and the granules are partly arranged in linear series. The fingers are smooth on their upper and lower surfaces, and the opposing margins are only sparingly toothed; in *P. globosa* the surfaces are finely sulcate. The inner margin of the hand and immobile finger is almost straight; in *P. globosa* it is strongly curved. The penultimate segment of the male abdomen is smooth externally, and nearly twice the length of the last segment; in *P. globosa* it carries a prominent tubercle near the distal end, and is only about one fourth of its length longer than the terminal segment. The meropodites of the ambulatory legs are smooth underneath, whereas in *P. globosa* they are finely granulated, especially those of the first pair.

The largest specimen, a male, has the carapace 19.5 mm. both in length and in breadth, the hand 18.5 mm. long, and the dactylus 10.5 mm.; in the female the carapace is very slightly broader than long.

This species has probably been confused with *P. globosa*. It is almost certainly the one referred to *Leucosia porcellana* of Fabricius, by Leach, Bell, and Milne-Edwards; but De Man, who has examined the type, has shown that Fabricius's species is a true *Leucosia*. Both Leach and Bell considered the species they examined as scarcely distinct from *P. globosa*. In the British Museum, under the name "*Philyra porcellana*, Fabr.," there are three specimens, two of the present species, and a third of a distinct undescribed form; all three carry a second label "*P. globulosa*," probably in Bell's handwriting.

In some specimens of *P. polita* the carapace is encrusted with *Membranipora Savartii*, Aud., and a species of *Hydraclinia* occurs on the arms both of this species and of *P. globosa*. I have not met with these commensals on *P. scabriuscula*, which probably burrows in the sandy bottom, while their presence in the two former indicates that they live above ground.

## Genus MYRA, Leach.

## 183. MYRA FUGAX (Fabr.).

*M. fugax* (Fabr.), Bell, Trans. Linn. Soc. vol. xxi. p. 296 (1855).

Rameswaram (*Thurston, J. R. II.*); Ceylon (*Haly*); Gulf of Martaban (*Oates*).

In most of the specimens I have examined there is a distinct median row of granules on the carapace.

*Distribution.* Mascarenes, Malay Archipelago, China, Japan.

## 184. MYRA AUSTRALIS, Haswell.

*M. australis*, Haswell, Catal. Austral. Crust. p. 122 (1882); Miers, 'Challenger' Brachyura, p. 315 (1886).

Gulf of Martaban, four males (*Oates*).

These agree on the whole with the description, and with specimens in the British Museum from Australia. The granules on the carapace are most strongly marked along the median line, so as to give rise to a semicarinated appearance; as noted by Haswell, the intestinal region is capped by a cluster of granules, one of which is more prominent than the rest. I do not think it can be the young of *M. mamillaris*, Bell, as suggested by Miers, for the hepatic regions are quite different in the two forms.

*Distribution.* N. Australia (*Haswell, Miers*). Singapore (*Walker*).

## Genus EBALIA, Leach.

## 185. EBALIA PFEFFERI, De Man.

*E. Pfefferi*, De Man, Brock's Crust. p. 390, taf. xvii. fig. 4 (1888).

Muttuwartu Par, a female with ova (*Thurston*).

The surface is everywhere finely granulated, and the carapace rises immediately behind the front to form a convex swelling, the smaller elevations on which are less distinct in my specimen than indicated in De Man's figure, or seen in a specimen from Mauritius in the British Museum. The fingers are slightly shorter than the palm. The abdomen is covered externally with smooth rounded granules. This species comes very near and is perhaps not distinct from *Ebalia (Nucia) speciosa*, Dana, from the Sandwich Islands.

The carapace is 11 mm. long and 12 mm. wide.

*Distribution.* Amboina (*De Man*); Mauritius (*Brit. Mus.*).

## 186. EBALIA FALLAX, n. sp. (Pl. XXXVIII. figs. 4-6.)

Muttuwartu Par, a female (*Thurston*); Gulf of Martaban, a male (*Oates*).

The carapace is very convex, with the hepatic areas deeply excavated, and the surface everywhere covered with circular flat-topped polished tubercles of varying size, which are closely crowded in most places, but in the hepatic hollows are few and small. On either side of the carapace, bounding the hepatic hollow, is a rounded granulated swelling; the remainder of the lateral margin is simply rounded, and without teeth or

projections of any kind. On the most elevated part of the carapace, *i. e.* the post-gastric area, are four prominent granulated swellings or tubercles, the two anterior placed directly in front of the two posterior, which are slightly smaller. On the cardiac area there is a single median swelling, which is smaller than those in front of it. On the intestinal region are two slightly marked median elevations, and a similar slight elevation is seen on either side of the short posterior margin of the carapace. The front is narrow, and there is a deep concavity between the two rather prominent inner orbital angles. The whole under surface of the body, including the abdomen and external maxillipedes, is covered with flattened tubercles.

In the male the chelipedes are moderately long; they have been lost in the female specimen. The arm is subcylindrical, and covered on all sides with flattened tubercles; the carpus and hand are finely granulated. The fingers are about one and a half times the length of the palm (measured along the lower margin); they are compressed and carry finely granulated carinae on both surfaces. The ambulatory legs at first sight appear smooth in both sexes, but examination with a lens shows that they are minutely granulated. The male abdomen gradually tapers to its apex, and has a prominent recurved granular tooth on the penultimate segment; in the same position on the female abdomen there is a rounded swelling.

The Muttuwartu example has the carapace 18 mm. long and 19 mm. wide. The Martaban example is 10 mm. long and 10.2 mm. wide; the right chelipede is 14 mm. long, and the hand 8 mm.

The flat-topped tubercles which characterize this species probably give it a protective resemblance to a piece of eroded coral. Its general appearance is very different from that of any species known to me, but it apparently comes nearest to *E. erosa*, A. Milne-Edw., from the Pacific, and *E. fragifera*, Miers, from the Canaries. The fingers are longer and more slender than is usual in the genus; in this respect they bear a slight resemblance to those of *Arcania*.

#### Genus ARCANIA, Leach.

##### 187. ARCANIA SEPTEMSPINOSA (Fabr.).

*Iphis septemspinosa* (Herbst), Bell, Trans. Linn. Soc. vol. xxi. p. 311 (1855); nec *Arcania septemspinosa*, Bell.

Gulf of Martaban (*Oates*); Madras (*J. R. II.*).

One of the Martaban specimens belongs to what is at least a distinct variety, but as it appears to be young it need not be specially characterized. It differs from a specimen of the typical form at the same stage of growth in having a well-defined sulcus on the carapace, separating the branchial regions from each side of the intestinal, cardiac, and post-gastric areas, and a slight transverse sulcus between the cardiac and intestinal regions. The front is narrower and more prominent than in the typical form. The spines at the postero-lateral margin of the carapace are represented merely by rudiments, while the chelipedes and legs are more slender than usual, especially the fingers. The male abdomen tapers gradually to its apex. There are specimens of this variety in the

British Museum from China; it is perhaps a distinct species, but at any rate may be termed provisionally *A. septemspinosu*, var. *gracilis*.

*Distribution.* Indian Seas, Malay Archipelago, China.

188. *ARCANIA UNDECIMSPINOSA*, De Haan.

*A. undecimspinosu*, De Haan, Crust. Japon. p. 135, tab. xxxiii. fig. 8 (1850); Miers, 'Alert' Crust. p. 548 (1884).

(= *A. granulosa*, Miers).

Gulf of Martaban (*Oates*).

The single specimen, a male, 9 mm. long and 9.5 mm. wide, is identical with specimens in the British Museum from Moreton Bay, Australia.

*Distribution.* Japan (*De Haan*); Moreton Bay; Seychelles (*Miers*).

Genus *NURSIA*, Leach.

189. *NURSIA PLICATA* (Herbst).

*N. plicata* (Herbst), Miers, Trans. Linn. Soc. ser. 2, Zool. vol. i. p. 240, pl. xxxviii. fig. 28 (1877).

Gulf of Martaban, an adult female overgrown with *Membranipora Savartii*, Aud. (*Oates*); Rameswaram (*J. R. II.*).

*Distribution.* Indian Ocean, Malay Archipelago, China, Australia (?).

190. *NURSIA ABBREVIATA*, Bell.

*N. abbreviata*, Bell, Trans. Linn. Soc. vol. xxi. p. 308, tab. xxxiv. fig. 5 (1855).

Silavaturai Par (*Thurston*); Rameswaram (*J. R. II.*); Gulf of Martaban (*Oates*).

The carapace is slightly narrower and the chelipedes longer in the male; the ridges on the carapace are also more elevated in this sex. The largest male is 9.5 mm. long and 10 mm. wide.

*Distribution.* Indian Ocean (*Bell*); Moreton Bay, Australia (*Miers*).

Genus *DORIPPE*, Fabr.

191. *DORIPPE DORSIPES* (Linn.).

*D. dorsipes* (Linn.), Miers, 'Alert' Crust. p. 257 (1884), *ubi synon.*

(= *D. quadridens*, Fabr.).

Rameswaram and Silavaturai Par (*Thurston*); Ceylon (*Haly*); Madras, not uncommon (*J. R. II.*).

This species reaches a larger size than *D. facchino*. The upper surface of the carapace is roughened; the eye-stalks are rather long. I have never met with an individual protected by a shell.

*Distribution.* Red Sea, E. Africa, Indian Ocean, Malay Archipelago, China, Japan, Australia.

## 192. DORIPPE FACCHINO (Herbst).

*D. facchino* (Herbst), Miers, 'Challenger' Brachyura, p. 328 (1886).  
(= *D. sima*, Milne-Edw.)

Rameswaram and Tuticorin (*Thurston*). Very common at Madras, and on the S. Indian coast generally (*J. R. II.*).

The upper surface of the carapace is usually smooth, and individuals are often met with protected by the valve of some flat Lamellibranch, e. g. *Placuna*, to which an Actinia is attached. The eye-stalks are short. A *Lepas* is frequently found attached to the legs, and occasionally a *Balanus* on the under surface of the abdomen.

*Distribution.* From India to China and Japan.

## 193. DORIPPE ASTUTA, Fabr.

*D. astuta* (Fabr.), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 157 (1837).

Madras, several specimens (*J. R. II.*).

The carapace is narrow and remarkably flattened, with the regions well mapped out. The legs are long and slender, and the right chelipede in the male has the hand swollen.

	Adult ♂.	Adult ♀ (with ova).
	millim.	millim.
Length of carapace	11	13
Breadth	12	11
Length of second ambulatory leg	38	40

*Distribution.* Seas of Asia (*Milne-Edwards*); Indian Ocean, Philippines (*White*); Port Denison, Australia (*Haswell*); Singapore (*Walker*).

## Genus CYMOPOLIA, Roux.

## 194. CYMOPOLIA JUKESII, White.

*C. Jukesii*, White, Append. Jukes's Voyage 'Fly,' p. 338, pl. ii. fig. 1 (1847); Miers, 'Erebus' and 'Terror' Crust. p. 4, pl. iii. fig. 4 (1874); Miers, 'Challenger' Brachyura, p. 335 (1886).

Gulf of Martaban, a female with ova, and a young male (*Oates*).

I have compared these and found them identical with White's type in the British Museum, dredged off Sir C. Hardy's Is., Torres Strait, 11 fathoms, coarse sand. The carapace of the female is 6.7 mm. long and 8 mm. broad.

*Distribution.* N. Australia (*White, Haswell*). Celebes Sea (*Miers*).

## Suborder ANOMURA.

## Group DROMIDEA.

## Genus DROMIDIA, Stimpson.

## 195. DROMIDIA UNIDENTATA (Rüppell).

*D. unidentata* (Rüpp.). De Man, Mergui Crust. p. 207, pl. xiv. figs. 4, 5 (1888).

Tuticorin, two females with ova, and two males (*Thurston*); Ceylon (*Italy*).

The largest specimen, a female, is covered by a sponge; its carapace is 19.5 mm. long and 19 mm. in breadth.

*Distribution.* Red Sea (*Rüppell*); Mozambique (*Hilgendorf*); Mergui (*De Man*).

196. *DROMIDIA AUSTRALIENSIS* (Haswell).

*D. australiensis* (Haswell), De Man, Brock's Crust. p. 396, Taf. xvii. fig. 6 (1888).

Silavaturai Par, three males (*Thurston*).

These certainly belong to the species as figured and described by De Man. One specimen is covered by a sponge; the largest is only 9 mm. long.

*Distribution.* E. Australia (*Haswell*); Amboina (*De Man*).

Genus *CRYPTODROMIA*, Stimpson.

197. *CRYPTODROMIA PENTAGONALIS*, Hilgendorf.

*C. pentagonalis*, Hilgendorf, Monatsb. Ak. Wissensch. Berlin, p. 814, Taf. ii. figs. 1, 2 (1878).

Muttuwartu Par, four specimens (one covered by a sponge); Silavaturai Par, two specimens (*Thurston*).

I refer these with some uncertainty to this species, as the antero-lateral margin of the carapace is scarcely so long as represented by Hilgendorf; otherwise they agree well with it, and are identical with specimens from Mauritius named *C. pentagonalis* in the British Museum. The Silavaturai examples have a rudimentary tooth or almost an indentation on the lateral margin of the carapace, between the antero-lateral angle and the tooth which marks the cervical groove. A trace of this may also be seen in the Muttuwartu examples, but it is not represented by Hilgendorf. A more prominent tooth is seen in the same position in *C. tomentosa*, Heller (= *C. canaliculata*, Stm., fide De Man), and as the latter species otherwise resembles *C. pentagonalis* perhaps the two are not distinct.

*Distribution.* Ibo, E. Africa (*Hilgendorf*); Mauritius (*Brit. Mus.*).

Genus *DROMIA*, Fabr.

198. *DROMIA RUMPHII*, Fabr.

*D. Rumphii* (Fabr.), De Haan, Crust. Japon. p. 107, tab. xxxvii. (1850).

Ceylon (*Italy*).

*Distribution.* Red Sea, E. Africa, Mauritius, Malay Archipelago, Japan.

Genus *PSEUDODROMIA*, Stimpson.

199. *PSEUDODROMIA INTEGRIFRONS*, Henderson. (Pl. XXXVIII. figs. 7-9.)

*P. integrifrons*, Henderson, 'Challenger' Anomura, p. 16, footnote (1888).

Tuticorin, two females with ova (*Thurston*).

The carapace is smooth and polished, very sparingly pubescent, and regularly convex, both from side to side and from end to end. The surface is a little uneven, and the branchio-cardiac and cervical grooves are well marked, the latter indenting the lateral

margin of the carapace behind its middle. The front is entire and subacute, without any trace of lateral teeth; it is somewhat deflexed and the upper surface is not channelled or hollowed out, but continuous with that of the carapace. The anterolateral margin is very short, merely corresponding to the superior orbital margin; it is regularly curved and without teeth. The lateral margin is very long and entire, somewhat ill-defined, *i. e.* rounded, for the first or most anterior fourth of its length. The subhepatic region has two slight and subparallel sulci, the upper of which is very short, and contains a fissure passing back from the poorly marked external orbital angle; the pterygostomial region is membranous. The eyes are somewhat elongated, and the lower orbital margin is formed simply by the antennal peduncle. The rostrum when viewed from below is seen to have an inferior vertical extension, which partly separates the antennules, but which in this genus is not joined to the epistome, although it comes very close to it.

The chelipedes and ambulatory legs are covered with a short brown pubescence, most dense on the former. The chelipedes, with the exception of their fingers, are devoid of teeth or tubercles, and the hand is only slightly dilated. The first three pairs of ambulatory legs have strongly curved horny dactyli, and the third pair have a prominent lobe at the outer distal end of the carpus. The elongated last pair of legs have the carpal joint lying on the branchial region of the carapace in the cervical groove; the dactylus, unlike that of the other legs, is straight, and the distal end of the propodus carries three spinules. The abdominal segments in the female are smooth, with a broad rounded median carina. The sternal sulci commence opposite the coxæ of the last legs, and, converging opposite the oviductal openings, run parallel as far as the interspace between the bases of the chelipedes and first pair of legs, where they are separated by a double or saddle-shaped tubercle.

The larger specimen is without chelipedes, and has the carapace 19 mm. long, and 15 mm. broad immediately in front of the cervical groove, the distance between the external orbital angles is 7 mm.; the first leg is 20 mm. long, second leg 21 mm., third leg 14.5 mm., fourth or last leg 22 mm. (all the legs measured from below and stretched as far as possible). The smaller specimen, although also bearing ova, is only 14 mm. long.

Both specimens are enveloped in a membranous covering apparently formed by an ascidian. From *P. latens*, Stm. (Simon's Bay, Cape), the only other known species of this genus, the one just described may be distinguished at once by its entire front, whereas in Stimpson's species as is usual in the group, the rostrum is tridentate.

#### Genus CONCHÆCETES, Stimpson.

##### 200. CONCHÆCETES ARTIFICIOSUS (Fabr.).

*Dromia artificiosa*, Fabricius, Suppl. Ent. Syst. p. 360 (1798).

*Cancer artificiosa*, Herbst, Naturg. Krabben u. Krebse, Bd. iii. Heft 3, p. 54, tab. lviii. fig. 7 (1803).

*Conchæcetes artificiosus*, Stimpson, Proc. Acad. Nat. Sci. Philad., Dec. 1858, p. 226.

*Dromia conchifera*, Haswell, Catal. Austral. Crust. p. 141, pl. iii. fig. 4 (1882).

Madras, not uncommon (*J. R. II.*).

The whole surface of the body and limbs is covered with a short dense pubescence. The carapace is flattened, and smooth under the pubescence, except towards the lateral margins where a few granules occur; the whole under surface is finely granulated. The amount of granulation on the palm of the chelipedes varies in different individuals; the granules are polished and are sometimes arranged in lines. The fingers and the granules on the palm are crimson, a character mentioned by Haswell. The sternal sulci of the female end in tubercles opposite the bases of the first pair of ambulatory legs. In Herbst's figure the lateral teeth of the carapace are exaggerated in size.

In the British Museum there are specimens from Moreton Bay, Australia, labelled *Conchæcetes conchifera*, Haswell, which are not specifically distinct from those described above, and my examples also agree completely with Haswell's description and figure; so his species must therefore, I think, be united with *C. artificiosus*.

The largest male is 23 mm. long and 24 mm. broad; the right chelipede is 38 mm. long.

*Distribution.* China (*Stimpson*); N.E. Australia (*Haswell, Brit. Mus.*); Singapore (*Walker*).

#### Group RANINIDEA.

##### Genus RANINOIDES, Milne-Edw.

#### 201. RANINOIDES SERRATIFRONS, n. sp. (Pl. XXXVIII. figs. 10-12.)

Cheval Par, a female (*Thurston*).

The carapace is minutely granulated in front, especially along a line connecting the two lateral spines of the carapace and in the space between this line and the frontal margin. Fainter granulations are also seen towards the sides of the carapace, but they disappear entirely about half-way back; the remainder of the upper surface is smooth and glabrous. The median frontal projection is broad and its apex obtuse, but scarcely rounded, while the margins are armed with small spinose teeth; the rest of the frontal margin or upper orbital margin is finely serrated and presents two subequal fissures, the lobe between which is drawn out into a short spine or tooth. The outer fissure is bounded externally by the prominent antero-lateral spine. On the upper surface of the rostrum and in the middle line a slight carina runs from the apex as far back as the granulated transverse line connecting the two lateral spines. A single lateral spine occurs on each side of the carapace, a short distance behind the antero-lateral spine, and it is slightly smaller than the latter. The basal joint of the antennal peduncle, which forms the lower boundary of the orbit, is finely spinulose.

The chelipedes have the ischium unarmed and the merus dilated externally at its base; the carpus is finely granulated above, and has a short spine at the distal end of the upper and inner margins. The hand is finely granulated, and the lower margin carries three spines, of which the first or proximal is small and the other two larger and subequal; on the upper surface are two fine subparallel ridges, separated by a narrow interval. The fingers are slender, curved, and compressed; the immobile one with five denticles on its inner margin. The external maxillipedes have the merus faintly granular, and the ischium is about one third of its length longer than the merus, and almost smooth.

The pterygostomial regions are faintly granulated. The sternal region resembles that of *R. personatus*, but is narrower between the second pair of legs.

The total length of the body, with the abdomen extended, is 20 mm.; the carapace is 14 mm. long and 7.3 mm. wide.

In the British Museum there is a single specimen of this species, taken by H.M.S. 'Penguin' on Holothuria Bank, N.W. Australia, at a depth of 39 fathoms. It also is a female, but considerably larger than the Ceylon example, having a total length of 31 mm., with the carapace 22 mm. long and 11.7 mm. wide. Its nearest ally is *R. personatus*, Henderson, from Amboina, but the two are readily distinguished. In *R. personatus*, the carapace is scarcely granulated even in front, the rostrum is entire, and there is no spine or tooth between the fissures; on the chelipedes there is a spine at the inferior distal end of the ischium, two spines on the upper distal end of the carpus, and one on the propodus over the base of the mobile finger; the immobile finger also is much broader than in the new species. *R. laris*, Latr., is a much larger species, with very deep frontal fissures, and the lateral spine larger than the antero-lateral, besides other points of difference.

#### Group HIPPIDEA.

#### Genus HIPPA, Fabr.

#### 202. HIPPA ASIATICA, Milne-Edw.

*H. asiatica* (Milne-Edw.), Miers, Journ. Linn. Soc., Zool. vol. xiv. p. 325, pl. v. fig. 11 (1877).

Rameswaram (*Thurston*). Abundant at Madras and on the S. Indian coast generally, burrowing in sand at low water (*J. R. II.*).

*Distribution.* Indian Seas, Ceylon, Malay Archipelago.

#### Genus ALBUNEA, Fabr.

#### 203. ALBUNEA SYMNISTA (Linn.).

*A. symnista* (Linn.), Miers, Journ. Linn. Soc., Zool. vol. xiv. p. 326 (1877).

Rameswaram (*Thurston*). Common on the S. Indian coast in sand at low water; less common at Madras than *Hippa asiatica* (*J. R. II.*).

*Distribution.* Mascarenes, Indian Seas, Malay Archipelago.

#### 204. ALBUNEA THURSTONI, n. sp. (Pl. XXXVIII. figs. 13-15.)

Cheval Par. five specimens (*Thurston*).

The carapace is glabrous and faintly carinated in the middle line, with the same lines marking it which are seen in the other species of the genus. The surface is slightly pubescent between the frontal margin and the most anterior line on the carapace. The median frontal spine is acute, and does not extend as far as the apices of the submedian spines which bound the central concavity in which the median spine is placed. On either side of the central concavity are eight or nine spinules; the first or submedian is of moderate size, the second to fifth inclusive are small, the sixth to eighth are larger

even than the first, and the ninth is small or even absent. The second, third, and fourth spinules are rudimentary or even absent in some specimens. The antero-lateral or sub-hepatic spine is prominent (much more so than in *A. microps*). The eye-peduncles are narrow and elongated, the length exceeding twice the breadth at the base; the breadth is slightly greater at the middle than at the base, the outer margin is convex, and the apex is pointed. The cornea is minute and not placed on any special lobe.

The chelipedes and legs resemble those of the other species of the genus. The outer surface of the hand has comparatively few short pubescent ridges or lines, the longest being one which runs obliquely across nearly two thirds of the outer surface and ends on the immobile finger. The telson is ovate in outline, with the outer margin regularly arcuate and the apex subobtuse; the upper surface is non-pubescent, and has three faint carinæ confined to its middle portion, *i. e.* not running from end to end.

The largest specimen, a male, is 1.5 mm. long when the abdomen is extended, and the carapace is 7.5 mm. in breadth at the front.

This species is most nearly allied to *A. microps*, Miers (Sooloo Sea and Celebes Sea), in which species, however, the eye-peduncles are shorter and broader, with the cornea on a small constricted lobe; the telson is not regularly arcuate externally, and its upper surface is pubescent. *A. speciosa*, Dana, from the Sandwich Islands, has the eye-peduncles slender, but their outer margins concave. The eye-stalks of our species resemble most those of *A. Gibbesii*, Stm., a very distinct species from the south-east coast of the United States.

I have pleasure in naming this interesting species after my friend Mr. Thurston, of the Madras Museum, by whom it was discovered.

#### Group PAGURIDEA.

#### Genus CÆNOBITA, Latr.

#### 205. CÆNOBITA RUGOSA, Milne-Edw.

*C. rugosa* (Milne-Edw.), Henderson, 'Challenger' Anomura, p. 51 (1888), *ubi synonym.*

Rameswaram, Tuticorin, and Silavaturai Par (*Thurston*). Common on the S. Indian coast (*J. R. II.*).

*Distribution.* From the Red Sea, E. Africa, and Natal to Japan, Australia, and the Pacific.

#### 206. CÆNOBITA COMPRESSA, Milne-Edw.

*C. compressa* (Milne-Edw.), Ortmann, Zoolog. Jahrbücher, Bd. 6, Abth. f. Syst. p. 318, Taf. xii. fig. 23 (1892), *ubi synonym.*

(=*C. violascens*, Heller).

Not uncommon in the back waters along the Madras coast (*J. R. II.*).

*Distribution.* E. Africa (*Hilgendorf*, *Hoffmann*); Ceylon (*Ortmann*); Nicobars (*Heller*); Mergui (*De Man*); Malay Archipelago (*Miers*, *De Man*); Japan (*De Haan*).

Genus *DIOGENES*, Dana.

Great confusion exists as to the nomenclature of the commonest and longest known members of this genus. I have therefore drawn up in tabular form below, a synopsis of the species described by last-century writers, arranged according to order of publication, and showing the probable interpretation of each, or the name which the species now bears.

Linnaeus, 1767 Syst. Nat. tom. i. pars 2.	<i>Cancer Diogenes</i> .....	Probably several species included under this name.
Fabricius, 1775 Syst. Ent.	<i>Pagurus Diogenes</i> .....	Description copied from Linnaeus.
Fabricius, 1787 Mantissa Insect. tom. i.	<i>Pagurus Diogenes</i> .....	Species unrecognizable, perhaps a <i>Pagurus</i> *.
	<i>Pagurus miles</i> .....	<i>D. miles</i> (Herbst). Fabricius had evidently seen the then unpublished figure of Herbst, for he refers the species to <i>Cancer miles</i> , Herbst.
Herbst, 1791 † Naturges. Krabben u. Krebse, Bd. ii. Heft 1.	<i>Cancer Diogenes</i> .....	<i>D. Diogenes</i> (Herbst).
	<i>Cancer miles</i> .....	<i>D. miles</i> (Herbst).
Fabricius, 1793 Ent. Syst. tom. ii.	<i>Pagurus Diogenes</i> .....	Species unrecognizable.
	<i>Pagurus miles</i> .....	<i>D. miles</i> (Herbst). (Both the above are copied from the 'Mantissa Insectorum'.)
Fabricius, 1798 Suppl. Ent. Syst.	<i>Pagurus Diogenes</i> .....	Species unrecognizable.
	<i>Pagurus miles</i> .....	Probably <i>D. Diogenes</i> (Herbst).
	<i>Pagurus custos</i> .....	Probably <i>D. custos</i> (Fabr.), Milne-Edw.
	<i>Pagurus diaphanus</i> .....	<i>D. miles</i> (Herbst).

The first writer to definitely characterize any of the species is Herbst, and on Taf. xxii. of his work he gives clear and unmistakable figures of two of the commoner forms, which I shall redescribe in the following pages as *Diogenes Diogenes* ‡ (Herbst) and *D. miles* (Herbst). The short diagnoses of Fabricius, published four years earlier in the 'Mantissa Insectorum,' were probably intended to characterize the same species, and in the case of the second, viz. *Pagurus miles*, Fabricius makes reference to the then unpublished figure of Herbst. In the 'Supplementum Entomologiæ Systematicæ,' published seven years after Herbst's description of the two above-named species, confusion is apparent—Herbst's *Cancer*

\* De Haan referred this species to *P. aspersus*, Berthold.

† Herbst's work appeared in parts published between 1782 and 1804; the date given is that of the part in which the two species of *Diogenes* are described.

‡ Identical generic and specific names are perhaps objectionable, but the other alternative, of changing a long-established specific name because it has at some later period been adopted for the genus, appears to me still more objectionable. The latter plan was adopted by Dana in the Paguridae, and his species *Olibanarius vulgaris* and *Aniculus typicus* should, in my opinion, stand as *Olibanarius olibanarius* (Herbst) and *Aniculus aniculus* (Fabr.).

*miles* is now termed *Pagurus diaphanus*, and what is probably the *Cancer Diogenes* of Herbst is termed *Pagurus miles*. A new species, *Pagurus custos*, appears in this work for the first time, and there can be little doubt that it represents the very common Indian species which Milne-Edwards and others identified from Fabricius's short diagnosis. De Man, in his Report on the Mergui Crustacea, has referred to the *Pagurus miles* of Fabricius the species which I follow Milne-Edwards in regarding as *P. custos*, Fabr.; this determination was based on an examination of the type of the former, which is unfortunately in a fragmentary state and some of the most important parts are missing, but I imagine there has been some mistake in connexion with the labelling of the specimen, for it does not agree with Fabricius's later diagnosis of *P. miles*. An examination of types is not likely to be of much service in this case, for it appears almost certain that Fabricius described two distinct species under the name of *P. miles*.

The species described by Milne-Edwards in the 'Histoire Naturelle des Crustacés' as *P. miles*, *P. custos*, and *P. diaphanus* are, in my opinion, identical with those so named by Fabricius in the 'Supplementum Entomologiæ Systematicæ,' and, as I have pointed out, Herbst's earlier names must be adopted in the case of two of these.

#### 207. DIOGENES DIOGENES (Herbst).

*Cancer Diogenes*, Herbst, Naturges. Krabben u. Krebse, Bd. ii. Heft 1, p. 17, Taf. xxii. fig. 5 (1791).

*Pagurus miles*, Fabricius, Suppl. Ent. Syst. p. 412 (1798); Milne-Edwards, Hist. Nat. Crust. t. ii. p. 235 (1837).

*Diogenes miles*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 439, pl. xxvii. fig. 9 (1852); nec *D. miles*, De Man.

Rameswaram and Tuticorin (*Thurston*). Common at Madras and on the S. Indian coast generally (*J. R. II.*).

The ophthalmic process is narrow and elongate, exceeding the ophthalmic scales by almost half its length, and the distal half is armed with well-developed lateral spinules. The eye-stalks are slender and faintly curved, slightly exceeding the penultimate joint of the antennal peduncle; the outer border of the ophthalmic scales is straight for the greater part of its course, and armed with minute spinules which increase in size towards the apex of each scale. The antennal peduncle is elongated; the antennal acicle is bifurcate and minutely spinose, with the outer process considerably longer than the inner, and extending almost to the distal end of the penultimate peduncular joint; the flagellum is rather long and sparingly pubescent. The antennular peduncle is elongated, exceeding the antennal peduncle by almost half the length of its terminal joint.

The hand of the left chelipede is armed externally and on its upper and lower margins with strong, blunt, pointed spines, which are, however, deficient on an oblique area extending from the carpo-propodal articulation to the base of the immobile finger; the dactylus is armed with two rows of similar spines—one on the upper border and the other on the outer surface. The ambulatory legs are strongly pubescent, more especially their dactyli, and the anterior surface of the three terminal joints is armed with short horny-tipped spinules, which are arranged in three rows on the propodus.

The total length of the body in a full-grown adult is about 60 mm.

*Distribution.* Indian Seas (*Fabricius, Milne-Edwards, &c.*); Madras and Nicobars

(*Heller*); Sooloo Sea (*Dana*); New South Wales (*Dana, Hess*). *Krauss* records the species from Natal, and *Richter* records it from Madagascar, but their specimens were perhaps referable to some other *Diogenes* \*.

#### 208. *DIOGENES MERGUIENSIS*, De Man.

*D. merguiensis*, De Man, Mergui Crust. p. 228, pl. xv. figs 4-6 (1888).

Muttuwartu Par, an adult male (*Thurston*); not uncommon at Madras (*J. R. II.*).

This species has been so fully described by De Man that only the more important differences between it and the foregoing species—to which undoubtedly it is closely allied—need be pointed out. The ophthalmic process is narrow and slender, but not twice the length of the ophthalmic scales; it ends in a pointed spine and is sparingly provided with lateral spinules, which appear to arise from the dorsal surface. The eye-stalks, antennal and antennular peduncles, are comparatively shorter than those of *D. Diogenes*. The ophthalmic scales are somewhat narrow, with the marginal spinules rather prominent towards the apex. The antennal acicle is deeply cleft, the outer process passing beyond the distal end of the penultimate peduncular joint, while the inner process scarcely extends so far; both processes are sparingly spinose on the inner margin. The antennular peduncle exceeds that of the antenna only by about one-fourth of its last joint.

The chelipedes and ambulatory legs are covered with short hairs or setæ, which in most places radiate from tubercles. The hand of the left chelipede is short and broad, and the outer surface is covered with subacute setigerous tubercles, which are somewhat deficient on the immobile finger. The upper margin of the whole chelipede is distinctly spinose. The anterior margin of the ambulatory legs is also spinose, the spines being most strongly developed on the carpi; the dactyli are shorter and less strongly curved than those of *D. Diogenes*, with the posterior surface hollowed out from side to side, and the spinules of the anterior margin almost obsolete.

The largest specimen I have seen was 53 mm. in total length. In a young specimen only 14 mm. long, all the distinctive features are recognizable, but as usual there is a tendency to exaggerated spinulation.

Although this is perhaps the species figured by Milne-Edwards as *Pagurus miles* (*Ann. Sci. Nat. sér. 2, Zool., t. vi. pl. xiv. fig. 2, 1836*), yet his description applies much better to *D. Diogenes*.

*Distribution.* Mergui (*De Man*).

#### 209. *DIOGENES MILES* (Herbst).

*Cancer miles*, Herbst, Naturges. Krabben u. Krebse, Bd. ii. Heft 1, p. 19, Taf. xxii. fig. 7 (1791).

*Pagurus diaphanus*, Fabricius, Suppl. Ent. Syst. p. 412 (1798); Milne-Edwards, Hist. Nat. Crust. t. ii. p. 236 (1837).

Rameswaram and Silavaturai Par (*Thurston*); common at Madras (*J. R. II.*).

This species lives invariably in shells with a narrow aperture, and its marked peculiarities of form are due to this fact; at Madras it is nearly always found in *Oliva* shells, and the adult, so far as I know, always selects the shell of *Oliva gibbosa*, Born. The

\* In the British Museum collection there are examples of a large and perfectly distinct species from Natal.

body is remarkably flattened, and the hand of the left chelipede is bent almost at a right angle to the rest of the limb; the left carpus is produced into a strong blunt lobe on the inner margin. The ophthalmic process is narrow and exceeds the ophthalmic scales by nearly half its length; the distal two thirds are laterally spinulose. The ophthalmic scales are very slightly arcuate externally, and spinulose, the largest spinule being situated at the apex. The antennular peduncles are short, the eyes reaching almost to the middle of the last peduncular joint. The antennal acicle reaches the distal end of the penultimate peduncular joint; it is very slightly produced internally, but not bifurcate, and the inner margin is spinulose. The eyes slightly exceed the end of the antennal acicle on each side. The antennal flagellum is short and fringed with long hairs.

The hand of the left chelipede is almost smooth externally, but granulated on the upper and lower margins; the upper margin of the mobile finger is serrate. The ambulatory dactyli are faintly serrate along the anterior margin and are very long, being exactly twice the length of the propodi when both are measured along the anterior margin.

It attains a somewhat smaller size than the last species.

*Distribution.* Indian Seas (*Herbst, Fabricius, Miers*); Ceylon (*Miers*).

#### 10. *DIOGENES CUSTOS* (Fabr.).

*Pagurus custos*, Fabricius, Suppl. Ent. Syst. p. 412 (1798); Milne-Edwards, Hist. Nat. Crust. t. ii. p. 236 (1837); nec *Diogenes custos*, Dana.

*Diogenes miles*, De Man, Mergui Crust. p. 232, pl. xv. figs. 7-9 (1888).

Rameswaram (*Thurston*). Abundant on the S. Indian coast; at Madras it is the commonest species of the genus (*J. R. II.*).

The ophthalmic process is narrow and elongated, exceeding the ophthalmic scales by half its length, and the distal three-fourths are armed with lateral spinules which increase in size towards the apex. The eye-stalks scarcely exceed the penultimate joint of the antennal peduncle; the ophthalmic scales are subtriangular, with the outer border spinulose and the largest spinule situated at the apex. The antennal acicle is spinulose and bifurcated, the inner process scarcely reaching the middle of the penultimate peduncular joint, while the outer process extends quite to the end of this joint; the antennal flagellum is moderately long and fringed with long hairs. The antennular peduncle scarcely exceeds the antennal peduncle.

The hand of the left chelipede is granulated externally, the granules being often less strongly marked in adults on a circular area at the lower proximal surface. The lower margin of the hand is somewhat flattened proximally, and usually this part is strongly granulated, while the upper margin is dentate; the dactylus is granulated externally, but dentate above, and both fingers are provided with bundles of setæ on their inner margins. The left merus is broad, and the antero-external margin (at the carpal articulation) is armed with a row of short spinules; the left carpus is convex externally and strongly granulated. The ambulatory legs are pubescent, more especially their dactyli; the anterior surface of the meri and carpi is armed with short stout spines; the propodi are granulated externally, and their anterior margin, as well as that of the dactyli, is armed with short subspinose tubercles.

The total length of an adult is about 55 mm.

There is considerable variation in this species as regards the amount of granulation on the larger chela; indeed, I have met with a few specimens in which the granules are almost subspiniform. The marginal teeth of the carpus, hand, and finger are much more prominent in some individuals than in others, but are never absent; the form of the hand also varies slightly. I met with a specimen in which the left chela had the characters of a fully-developed right chela; it had probably been repaired, but in any case illustrated a reversion to the primitive state of equal and similar chelipedes. De Man has recently described an allied species *D. intermedius*, from Celebes (Max Weber's Crust. p. 352), which is apparently distinguished among other characters by its more deeply cleft antennal aciele, the inner fork of which extends beyond the middle of the penultimate peduncular joint, and by the granules on the outer surface of the larger chela being less numerous, but sharp and subspiniform.

*Distribution.* Indian Seas (*Fabricius, Milne-Edwards*); Mergui (*De Man*).

211. *DIOGENES AFFINIS*, n. sp. (Pl. XXXIX. figs. 1, 2.)

*D. custos*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 439, pl. xxvii. fig. 10 (1852); Henderson, 'Challenger' Anomura, p. 53 (1888), nec *D. custos*, Fabr.

Madras, eight specimens; not common (*J. R. II.*).

This species is closely allied to *D. custos*, but distinguished as follows:—The ophthalmic process is short, and broad especially towards its distal end, extending only to the ends of the ophthalmic scales, or very slightly beyond these, with the lateral spinules almost obsolete, but the terminal ones well developed and in line with the spinules of the scales. The eye-stalks, antennal and antennular peduncles, are relatively shorter and stouter than in *D. custos*; the antennal flagellum is stout and not twice the length of the peduncle, with long fringing hairs, whereas in *D. custos* it is considerably longer. The antennal aciele does not reach the end of the penultimate peduncular joint, and is scarcely produced internally at its base, certainly not bifurcate as in *D. custos*. The antennular peduncles are barely as long as the antennal peduncles, whereas in *D. custos* they are slightly longer.

The hand of the left chelipede is shorter and broader, also more compressed and the fingers more abbreviated than in *D. custos*, while the lower margin of the immobile finger is thin and slightly sinuous. In other respects the two species closely agree.

The largest specimen is 35 mm. long, and a female with ova is only 20 mm. in total length.

All my specimens share the above characters and do not vary to any great extent from each other. I have compared them with a large series of *D. custos* of similar size, from Madras. The species may be recognized at once by the characters of the ophthalmic process, but as a general shortening seems to have taken place in connection with the eye-stalks, antennal and antennular peduncles, it may possibly come to be regarded as merely a variety of *D. custos*; I do not, however, think this probable, and in any case it is worthy of a distinctive name. There can be no doubt that it is the species figured by Dana as *D. custos*; I have re-examined the Australian specimen which I referred to *D. custos*, in the Report on the 'Challenger' Anomura, and I find it identical with the

Madras examples. The *D. custos* of Stimpson, Hess, and Ortman, from New South Wales and Queensland, is also probably referable to the present species.

*Distribution.* New South Wales (*Dana, Henderson*); Madras (*J. R. II.*).

212. *DIOGENES VIOLACEUS*, n. sp. (Pl. XXXIX. figs. 3, 4.)

Madras, common; many specimens (*J. R. II.*).

The ophthalmic process is elongated, exceeding the ophthalmic scales by nearly half its length, with the distal two thirds laterally spinulose, and the terminal spinules rather long. The outer margin of the ophthalmic scales is straight and spinulose, the distal spinule being larger than the others. The antennal acicle is short, with a very slightly produced inner process, and the outer process scarcely reaches the commencement of the last peduncular joint. The eye-stalks slightly exceed the penultimate joint of the antennal peduncle. The antennular peduncles are short, and do not extend beyond the antennal peduncles. The antennal flagellum is short, with comparatively few long fringing hairs.

The left chelipede has the carpus, hand, and fingers elongated, and the outer surface of all uniformly and finely granulated; a faint dentate line is seen on the upper margin of the carpus, hand, and mobile finger, and the lower and outer surface of the carpus is subsulcate. The lower margin of the immobile finger is placed in the same straight line as the lower margin of the hand. On the outer surface of the hand, at the carpal articulation, starting from the proximal and lower angle, is an oblique suberistiform elevation. The fingers are slightly incurved, their apices are acute, and a few small tufts of hair are seen on the opposing edges. The ambulatory legs have the anterior margin of the carpi and propodi faintly dentate and pubescent; the dactyli are slender.

Length of body 26 mm., of left chelipede 28 mm., carpus 7 mm., propodus 12 mm. long and 6 mm. in height, dactylus 7.5 mm. long, and the second ambulatory leg 28 mm. long.

The colour in fresh specimens is violet. This species differs from *D. custos* in size, colour, and the form of the left chelipede. It is distinguished from all the smaller species of the genus by its spinulose ophthalmic process.

213. *DIOGENES PLANIMANUS*, n. sp. (Pl. XXXIX. figs. 5, 6.)

Rameswaram, one specimen (*J. R. II.*); Madras, not common, four specimens (*J. R. II.*).

The ophthalmic process is narrow and lanceolate, tapering towards the apex, and only exceeding the ophthalmic scales by about one third of its length; it is sparingly armed with minute lateral spinules, of which a subapical pair are most prominent. The ophthalmic scales have the lateral margin straight and spinulose, the spinules slightly increasing in size towards the apex. The antennal acicle is short, not reaching the end of the penultimate peduncular joint; it is slightly produced internally, but scarcely bifurcate, and the spinulose inner margin appears regularly concave. The eye-stalks

reach the middle of the last antennal peduncular joint, and the antennal peduncles are about equal in length to the antennular peduncles.

The left chelipede has the merus more distinctly trigonal than usual, the upper border being rather thin and compressed, and armed with acute teeth, the most distal of which is most prominent. The carpus has a longitudinal row of pointed tubercles on its outer surface, from four to seven in number, and of which one near the distal end is most prominent; between this row and the dentate inner margin, on which there are about thirteen teeth, is a comparatively smooth and almost sulcate surface; the remainder of the outer surface is slightly tuberculate, and on the antero-external margin bounding the carpo-propodal articulation are three well-marked spinose tubercles. The left hand is slightly bent at an angle to the carpus, as in *D. miles*. The palm is covered externally with small glabrous granules, which are most crowded along the lower margin; the outer surface is flattened, more especially on the lower half, and the flattened portion is bounded proximally by a short ridge, which runs parallel to the carpal articulation, and on which the granules are almost subspinose. The upper margin of the hand and mobile finger is finely dentate. The ambulatory legs are comparatively smooth, the most prominent spinules being seen on the carpi, and especially towards their distal ends; the dactyli are rather broad, and only about one third longer than the propodi. The propodus of the second left leg presents glabrous tuberculiform elevations on its upper margin.

A female is 30 mm. long, the left chelipede (which cannot be fully straightened) is 18 mm. long, carpus 6 mm., hand 11 mm. long and 6 mm. in height, dactylus 6.5 mm. long; second ambulatory leg 28 mm. long, its propodus 7 mm., and its dactylus 10.5 mm.

This species is sufficiently characterized by the form of its ophthalmic process, the flattened hand of the left chela, and the armature of the carpus.

#### 214. *DIOGENES AVARUS*, Heller.

*D. avarus*, Heller, 'Novara' Crust. p. 83, Taf. vii. fig. 2 (1865).

Tuticorin (*Thurston*); Rameswaram, between tide-marks; Madras and Ennore, not uncommon (*J. R. II.*).

This small species is easily recognized by its narrow elongated left chelipede, the carpus of which is longer than the palm. The antero-lateral margins of the carapace are either unarmed, or at most provided with nearly imperceptible spinules. The ophthalmic process is narrow and entire, scarcely reaching the apices of the ophthalmic scales. The ophthalmic scales are subentire, with merely a few marginal spinules towards the apex. The antennal acicle is short and straight.

The carpus and hand of the larger chela are finely granulated externally, and minutely dentate along the upper margin. The hand is subcostate externally, the costa being ill-defined; the immobile finger is deflexed and not in the same straight line as the lower margin of the hand. The ambulatory legs are smooth.

The largest specimen I have examined is only 20 mm. in length; Heller's type was 22 mm. long.

The specimen from Singapore, figured by Walker as perhaps a variety of *D. avarus*, is not, I think, referable to this species.

*Distribution.* Bay of Bengal—Nicobars (*Heller*); Mergui (*De Man*).

215. *DIOGENES COSTATUS*, n. sp. (Pl. XXXIX. figs. 7, 8.)

Rameswaram, one specimen; Tuticorin, one specimen (*Thurston*); Madras, not common, twelve specimens (*J. R. II.*).

The ophthalmic process is very narrow and entire, not reaching the apices of the ophthalmic scales. The ophthalmic scales are subtriangulate, with merely two or three spinules towards the apex. The antennal acicle is straight, scarcely reaching the distal end of the penultimate peduncular joint, with no trace of bifurcation, and with from six to eight well-marked spinules on the inner margin. The eye-stalks scarcely reach the middle of the last antennal peduncular joint. The antennular peduncles are longer than the antennal peduncles by nearly half the length of their last (antennular) joint. The antero-lateral margin of the carapace is armed with about seven spinules.

The left chelipede has the merus dentate along its inferior margin. The carpus is granulated externally, and the upper margin carries about twelve short teeth, of which the distal one is larger than any of the others; the antero-external margin, bounding the carpo-propodal articulation, carries about six small teeth, and a few are also seen on the lower distal margin. The hand is almost smooth externally, but has a prominent, though short, oblique granulated ridge, commencing at the proximal inferior angle and passing for some distance parallel to the carpal articulation; the upper margin is provided with subspiniform granules, and a few more slightly marked granules are seen on the lower margin, which is faintly concave, *i. e.* the immobile finger is not in the same straight line, but is somewhat deflexed. The upper margin of the mobile finger is finely crenated. The ambulatory legs are almost smooth, with the anterior margins pubescent and very faintly toothed.

Length of body 18 mm., of left chelipede 20 mm., of carpus 5.5 mm.; the propodus is 8.8 mm. long and 4.8 mm. in height, the dactylus 5.8 mm. long, and the second ambulatory leg 21 mm. long.

This species is distinguished by the ridge on the proximal outer surface of the hand. It is separated from *D. avarus*, which has a faint longitudinal ridge, by the very different form of the left chelipede, and by other characters. A trace of the hand ridge is also seen in the Atlantic *D. varians* (*Costa*), but although this species agrees in some respects with ours, the form of the left chelipede, the armature of the carpus, and the proportions of this joint are quite different in the two species. *D. granulatus*, *Miers* (from West Australia), judging from the type, which is dried and not in very good order, is an allied species, but in it the ophthalmic scales are entire, the antero-lateral margin of the carapace is unarmed, the carpus is less strongly toothed, and has no antero-external spinules, while the hand is uniformly granulated externally, and has only a very slight carina.

216. *DIOGENES RECTIMANUS*, Miers.

*D. rectimanus*, Miers, 'Alert' Crust. p. 262, pl. xxvii. fig. C (1884).

Madras, common; a large series (*J. R. II.*).

The ophthalmic process is narrow and entire, not exceeding the ophthalmic scales; the latter are rounded, and with few marginal spinules. The antennal aciele is undivided, with the inner margin spinulose. The lower margin of the left hand is straight and spinose; the outer surface of this joint is flattened and slightly pubescent, with a few spinules chiefly arranged along an oblique line near the upper margin, which is itself dentate; the fingers are very short, and the lower border of the immobile one is in a straight line with the lower border of the hand.

The average length is about 25 mm.

*Distribution.* Prince of Wales Channel, N. Australia; 7 fathoms (*Miers*).

Genus *PAGURUS*, Fabricius.217. *PAGURUS PUNCTULATUS*, Olivier.

*P. punctulatus* (Oliv.), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 222 (1837); Dana, Crust. U.S. Explor. Exped. pt. i. p. 451, pl. xxviii. fig. 4 (1852).

Tuticorin (*Thurston*); common on the reef at Rameswaram (*J. R. II.*).

This common species reaches a considerable size. The eye-stalks, even in spirit specimens, are of a very deep red colour, and the cornæ are defined by a white line.

The *Cancer megistos* figured by Herbst is undoubtedly a representation of the present species, but the draughtsman has supplied it with an altogether fanciful abdomen.

*Distribution.* From the Red Sea and E. Africa to China, Australia, and the Pacific.

218. *PAGURUS HESSII*, Miers.

*P. Hessii*, Miers, 'Alert' Crust. p. 264, pl. xxviii. fig. A (1884).

*P. similimanus*, Henderson, 'Challenger' Anomura, p. 59, pl. vi. fig. 6 (1888).

Gulf of Martaban, two specimens (*Oates*); Madras, not uncommon (*J. R. II.*).

This species, in regard to its chelipedes, has the general appearance of a *Clibanarius*, but its cephalic region is that of a true *Pagurus*. The colour-markings are characteristic, the hands being red, especially on the under surface, while the under surface of the propodus of the first and second ambulatory legs, and the sides of the eye-stalks, are banded with reddish brown. The figure in the 'Alert' Crustacea somewhat exaggerates the size of the eyes, and Miers states that the antennular peduncles scarcely reach the end of the eye-stalks, whereas they slightly exceed these, and this arrangement is shown in his figure. I have re-examined my type of *P. similimanus*, and find it identical with that of *P. Hessii*.

The largest specimen, a male, is 65 mm. long, the right chelipede 50 mm., and the eye-stalks 10 mm. long.

*Distribution.* Arafura Sea (*Miers*); Celebes Sea (*Henderson*).

219. *PAGURUS DEFORMIS*, Milne-Edw.

*P. deformis*, Milne-Edwards, Ann. Sci. Nat. sér. 2, Zool. t. vi. p. 272, pl. xiii. fig. 4 (1836); id. Hist. Nat. Crust. t. ii. p. 222 (1837).

Tuticorin (*Thurston*); Rameswaram (*J. R. H.*).

*Distribution.* From E. Africa to the Pacific (Ousima, Fijis, Tahiti &c.).

220. *PAGURUS VARIPES*, Heller.

*P. varipes*, Heller, Sitzungs. Akad. Wiss. Wien, Bd. xlv. p. 244, Taf. i. fig. 1, Taf. ii. figs. 2, 3 (1862); De Man, Brock's Crust. p. 436 (1888).

(= ? *Cancer pedunculatus*, Herbst).

Tuticorin, a male in the shell of a *Bulla*; Muttuwartu Par, a male in the shell of a *Fusus* (*Thurston*).

In both cases the shells carry several examples of an Actinia. As noted by Miers and De Man, this species is distinguished from *P. deformis* mainly by the absence of a carina from the immobile finger of the larger chelipede, and by having the penultimate joint of the third left leg rounded and not ridged on its outer surface. Both specimens present a white band on a reddish background, encircling the eye-stalks, and in one the larger chelipede is mottled with violet. *P. dearmatus*, Henderson, from the Admiralty Is., is a closely allied species, but distinguished by the elongated form of the larger hand, the outer surface of which is uniformly and finely granulated, without tubercles. Herbst's figure of *Cancer pedunculatus* is not recognizable.

*Distribution.* Red Sea (*Heller, De Man*); E. Africa (*Hilgendorf*); Malay Archipelago (*Miers, De Man*); Australia (*White*).

221. *PAGURUS SETIFER*, Milne-Edw.

*P. setifer*, Milne-Edwards, Hist. Nat. Crust. t. ii. p. 225 (1837); De Haan, Crust. Japon. p. 209 (1850); non *P. setifer*, Hilgendorf, nec De Man, nec Ortmann.

*P. sculptipes*, Stimpson, Proc. Acad. Nat. Sci. Philad. Dec. 1858, p. 246; Ortmann, Zool. Jahrb. Bd. vi. Abth. f. Syst. p. 287 (1892).

*P. pavimentatus*, Hilgendorf, Monatsb. Akad. Wiss. Berlin, p. 816, Taf. iii. figs. 1-5 (1878).

Tuticorin (*Thurston*); Gulf of Martaban (*Oates*); Madras, not uncommon (*J. R. H.*).

Much confusion is apparent in regard to this widely distributed and probably common species. I sent a Madras specimen to Prof. A. Milne-Edwards, who kindly informed me that it was referable to *P. setifer*, Milne-Edw., and that in his opinion *P. sculptipes*, Stm., is the same species. I had formerly referred my specimens to *P. pavimentatus*, Hilgendorf, with the description and figures of which they closely agree, except that in Hilgendorf's figure the left hand is somewhat shorter in proportion to its breadth than is usual in Indian examples. The sculpture of the two terminal joints of the second left ambulatory leg is very characteristic.

*Distribution.* E. Africa (*Hilgendorf*); Japan (*De Haan, Stimpson, Ortmann*); Australia (*Milne-Edwards, Brit. Mus.*); "Isle of Pines" (*Brit. Mus.*).

## Genus TROGLOPAGURUS, n.

The front is scarcely produced in the middle. The eyes are moderately slender, the ophthalmic scales narrow, triangular, and closely approximated. The antennal acicle is short and robust; the antennal flagellum rather short, and fringed with long hairs. The chelipedes are shorter than the ambulatory legs, and the left is larger; the fingers are almost vertical, and their apices are calcareous. The ambulatory legs are slender, and similar on the two sides.

The species described below inhabits small holes in coral. The genus comes nearest to *Pagurus*, in which, however, the chelipedes are longer, and the fingers have corneous apices, the antennal flagellum is long and not ciliated, the ophthalmic scales are broader, and separated by a wide interval which is occupied by a calcified nodule or sclerite; the ambulatory legs are usually dissimilar on the two sides, and the species are of much larger size. In some respects it resembles *Paguristes*, but in this genus the chelipedes are subequal, and the first, or first and second abdominal segments, carry genital appendages. *Gryllopagurus*, Zietz (Trans. Roy. Soc. S. Austral. vol. x. 1888), which inhabits cavities in loose stones, has the ophthalmic segment exposed, and provided with a mobile scale (presumably as in *Diogenes*), and its structure is otherwise very different.

## 222. TROGLOPAGURUS MANAARENSIS, n. sp. (Pl. XXXIX. figs. 9-11.)

Tuticorin and Muttuwartu Par (*Thurston*).

The carapace is well calcified anteriorly, and somewhat rugose, with a rather deep semicircular impressed line a short distance behind the front. The median projection of the front is obtuse, and but slightly produced. The ophthalmic scales are narrow and triangular, with about six spinules on the outer margin, of which the apical one is largest. The eye-stalks are slender, reaching the middle of the last antennal peduncular joint. The antennular peduncles are slightly larger than the antennal peduncles. The antennal acicle is short and broad, scarcely extending beyond the commencement of the penultimate peduncular joint, with about five small spinules on its inner or subterminal margin; the antennal flagellum is about twice the length of the peduncle, and fringed inferiorly with very long hairs.

The left or larger chelipede has the carpus, hand, and fingers spinose and pubescent above. On the carpus the spines are almost confined to the inner margin and the upper anterior margin; on the hand they occur chiefly along the inner margin, extending on to the border of the dactylus, while on the upper surface and outer margin, especially towards the immobile finger, some smaller ones are seen. The fingers are finely and irregularly toothed, with their inner margins practically in contact when closed. The right chelipede reaches as far as the commencement of the dactylus of the left chelipede; it is strongly pubescent, but has fewer spines than the left. The ambulatory legs are slender, and similar on the two sides, with the joints moderately pubescent, but otherwise smooth; the dactyli have horny tips, and are almost as long as the propodi. The margin of the telson is finely dentate. The abdomen and its appendages are similar to those of a *Pagurus*.

The largest specimen, a female with ova, is about 20 mm. long; the chelipedes cannot be fully straightened, but measured from below the left is 8.3 mm. long, and the right 7 mm.; the first ambulatory leg is 11 mm. long.

Of about thirty specimens the majority are females carrying eggs, and many are considerably smaller than the above. Mr. Thurston informed me that the species lived in minute cavities in coral.

#### Genus ANICULUS, Dana.

##### 223. ANICULUS ANICULUS (Fabr.).

*Pagurus aniculus* (Fabr.), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 230 (1837).

*Aniculus typicus*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 461, pl. xxix. fig. 1 (1852).

Tuticorin and Muttuwartu Par (*Thurston*).

In addition to the transverse strigose lines on the chelipedes and ambulatory legs, many long marginal hairs are present, especially on the upper margin of the hands and on the ambulatory dactyli. The eye-stalks are slightly constricted towards the middle. The ophthalmic scales are somewhat approximate, and each ends in a single acute spinule. The rostral projection is separated by a distinct transverse groove from the rest of the carapace, and, as pointed out by Dana, the median areolet of the anterior portion of the carapace is distinctly defined, and fusiform in shape. Long hairs are present at the sides of the carapace, on the antennal and antennular peduncles, and even on the eye-stalks.

*Distribution.* From E. Africa to Japan, Australia, and the Pacific (Wake Is., Paumotu Is., Samoa, Fijis, New Zealand, &c.).

##### 224. ANICULUS STRIGATUS (Herbst).

*Cancer strigatus*, Herbst, Naturges. Krabben u. Krebse, Bd. iii. Heft 4, p. 25, tab. lxi. fig. 3 (1804).

*Pagurus strigatus*, Hilgendorf, Monatsb. Akad. Wiss. Berlin, p. 820, Taf. ii. fig. 8 (1878); Ortman, Zool. Jahrb. Bd. vi. Abth. f. Syst. p. 285 (1892).

Tuticorin, two specimens (*Thurston*).

This species evidently lives in shells with a narrow aperture—probably in Cones—and its body has, in consequence, undergone great flattening. It is distinguished from *A. typicus* by the absence of long hairs from the chelipedes and legs, its front is obtuse, the apex of the ophthalmic scales is bidentate, and the general form and colour are different. The colour when fresh is very brilliant, the ground tint a deep red becoming orange in spirit, with the legs and chelipedes encircled by blue lines which soon fade and disappear. Herbst's figure gives a fair idea of the form, and colour in a faded specimen.

This species, along with three others belonging to different genera of Paguridæ, one of which has already been referred to in this paper, illustrates a remarkable modification in the body-form of these hermit-crabs, brought about by a habit which has become constant, of the species selecting a shell with a narrow elongated mouth or aperture.

In each the body has become greatly compressed, with the carapace, thoracic sterna, and abdominal tergites proportionately widened, and the chelipedes so formed as to adapt themselves to the closing of the aperture. They are:—*Diogenes miles* (Herbst), *Aniculus strigatus* (Herbst), *Pagurus platythorax*\*, Stm., from the Loo Choo Is., and *Clibanarius eurysternus*, Hilgendorf, from Mozambique and the Malay Archipelago. In the last-mentioned species the flattening is less apparent.

*Distribution.* East Indies (*Herbst*); Ibo, E. Africa (*Hilgendorf*); Tahiti (*Ortmann*).

#### GENUS CLIBANARIUS, Dana.

##### 225. CLIBANARIUS CLIBANARIUS (Herbst).

*Pagurus clibanarius* (Herbst), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 227 (1837).

*Clibanarius vulgaris*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 162 (1852).

Madras, not uncommon (*J. R. II.*).

The colour (in spirit) is a reddish orange, and the legs show indistinct and pale longitudinal bands. My largest specimen, a male, is 70 mm. long, the right chelipede 45 mm. long.

*Distribution.* ? E. Africa (*Bianconi, Krauss*); Penang (*Brit. Mus.*); Singapore (*Walker*); Borneo (*Miers*); ? Hong Kong and Gaspar Strait (*Stimpson*).

##### 226. CLIBANARIUS INFRASPINATUS, Hilgendorf.

*C. infraspinatus* (Hilg.), De Man, Mergui Crust. p. 237 (1888).

Madras, less common than the former species (*J. R. II.*).

De Man proposes to unite this species with the preceding, but in my opinion they are probably distinct. I have never seen a specimen that I had any difficulty in referring to one or the other form; they occur in the same locality, and in examining a number of specimens I find the characters of each constant at all stages of growth. In *C. infraspinatus* the ground-colour is paler, the banding more distinct, a strong conical tubercle is present on the under surface of the merus of the chelipedes, at the inner proximal margin of the joint, and the size is much less than in the other species. In *C. clibanarius* the body and legs, generally, carry much more numerous and longer hairs, the spinose tubercles on the upper surface of the chelipedes are more strongly marked, and there is no trace of the inferior meral tubercle.

*Distribution.* Red Sea (*Ortmann*); Bombay (*Brit. Mus.*); Mergui (*De Man*); Singapore (*Hilgendorf, Brit. Mus.*); Philippines (*Brit. Mus.*); Sydney (*Ortmann*).

##### 227. CLIBANARIUS PADAVENSIS, De Man.

*C. padavensis*, De Man, Mergui Crust. p. 242, pl. xvi. figs. 1-5 (1888).

Tuticorin (*Thurston*); Rameswaram, Eunnore, Madras (*J. R. II.*).

\* This species presents many of the characters of *A. strigatus* (Herbst), to judge from Stimpson's short diagnosis; but, as no mention is made of the strigose lines on the chelipedes and legs, it is probably distinct.

This species is very common in the backwaters along the Madras coast; I do not know whether or not it also lives in the sea. Young specimens are found in great numbers inhabiting the shells of a common brackish-water Cerithiid. The largest example I have seen is about 40 mm. long.

*Distribution.* Mergui (*De Man*).

228. CLIBANARIUS ARETHUSA, De Man.

*C. Arethusa*, De Man, Mergui Crust. p. 252 (1888).

Muttuwartu Par (*Thurston*); Rameswaram; Madras, living among large stones in the harbour (*J. R. II.*).

The following characteristic colouring is observable:—The cephalothorax is grey, the eye-stalks, antennal peduncles, chelipedes, and ambulatory legs deep brick-red, without bands; the chelipedes and ambulatory legs are tipped with black, and several minute black spinules are seen on the under margin of the propodi of the second and third legs. The largest specimen is 35 mm. long. One example has the right eye-stalk only half the length of the left, probably in process of repair.

*Distribution.* Mergui (*De Man*).

Genus CATAPAGURUS, A. Milne-Edwards.

229. CATAPAGURUS ENSIFER, n. sp. (Pl. XXXVIII. figs. 16–19.)

Gulf of Martaban; three females with ova, and two males in shells of *Nassa*, sp., and *Natica*, juv. (*Oates*).

The carapace is glabrous, with merely a few hairs towards the margins; the frontal projections are obtusely rounded. The eye-stalks are moderately long and stout, being little shorter than the antennal peduncles. The ophthalmic scales are narrow, but well developed, and with the inner edge slightly convex. The antennal acicle is short and almost straight, not reaching the distal end of the penultimate peduncular joint; the flagellum is more than twice the length of the body. The antennular peduncle exceeds the antennal peduncle by nearly the two distal peduncular joints.

The chelipedes are longer than usual, the right being considerably stouter but not much longer than the left, with the surface very faintly granulated, but the granules subspinulose on the carpus. The hands are glabrous above, merely a few granules being seen with a lens. The right carpus is nearly equal in length to the right palm, and the fingers are about half this length; the left carpus is much shorter than the left palm, and on this side the fingers are about equal in length to the palm. The ambulatory legs are almost smooth, with merely a few slight hairs on the anterior margin of the broad flattened meri; the propodi and dactyli, which are about equal in length, are elongated and flattened, without fringing hairs. Each dactylus bears a strong resemblance to a curved sword-blade (hence the specific name), and is slightly broader than the propodus, measuring both at the broadest point. The male copulatory organ (protruded vas deferens or ductus ejaculatorius) is very long and slender; com-

mencing at the base of the fifth right leg, it curves completely over the abdomen as far as the base of the fifth left leg.

Length of body in a male 9 mm., right chelipede 12 mm., left chelipede 10.5 mm. A female is about the same size.

This small species comes nearest to *C. Sharreri*, A. Milne-Edw., common in deep water off the east coast of the United States, but is distinguished at once from the American form by its non-ciliated ambulatory (or perhaps swimming) dactyli and propodi, and by its longer and more slender male organ. The only previously known Indo-Pacific species is *C. australis*, Henderson, from the Arafura Sea and Fiji, in which the chelipedes are shorter and quite differently armed, with the ambulatory legs not specially flattened.

#### Genus SPIROPAGURUS, Stimpson.

##### 230. SPIROPAGURUS SPIRIGER (De Haan).

*Pagurus spiriger*, De Haan, Crust. Japon. p. 206, tab. xlix. fig. 2 (1850).

Gulf of Martaban (*Oales*); Madras, not uncommon (*J. R. II.*).

*Distribution.* Malay Archipelago, China, Japan, Torres Strait, Admiralty Is.

#### Genus EUPAGURUS, Brandt.

##### 231. EUPAGURUS ZEBRA, n. sp. (Pl. XXXIX. figs. 12-15.)

Muttuwartu Par, a single specimen 13 mm. long (*Thurston*).

This specimen is preserved in the same bottle with a Hydroid, *Aglaophenia urens*, Kirchenpauer, to which several examples of *Avicula zebra*, Reeve, are attached, and which have a similar coloration, so that the Mollusc and Crustacean probably live together, and are protected by the similarity of their markings to the dark ramuli of the Hydroid. In the British Museum there is a much larger specimen, taken by H.M.S. 'Penguin,' on Holothuria Bank, N.W. Australia, at a depth of 53 fathoms, from which the following description and also the figures are taken.

The colour-markings of this very beautiful species are so striking as to distinguish it at once from all other known species. They take the form of dark blood-red parallel lines along both surfaces of the two pairs of ambulatory legs, on the left or smaller chelipede, on the merus and inner margin of the right chelipede, on the sides of the anterior portion of the carapace, on the upper surface of the antennal peduncles, and as a thin line, interrupted on each segment, along either side of the entire antennal flagella. The ocular corneae are dark green, and the contiguous portion of the eye-stalk is encircled by a yellow band. The median frontal projection and the ophthalmic scales are yellow.

The median frontal projection is prominent and acute, reaching to about the middle of the ophthalmic scales, which latter are small, subtriangular, and entire. The eye-stalks are long, and but little shorter than the antennal peduncles. The antennal acicle is slender and slightly curved, reaching the level of the end of the eye-stalks. The

antennular peduncles exceed those of the antennæ by nearly half the length of their terminal joint.

The right or larger chelipede gradually increases in width, as far as the base of the mobile finger, where it is widest; the fingers open transversely. The merus has a rather prominent inferior projection. The upper surface of the carpus and propodus is somewhat flattened, and armed with not very numerous spinose granules, which are most prominent on the anterior margin of the carpus, bordering the articulation with the hand, and along an area near the middle of the hand surface. The outer margin of the hand is thin and finely serrated, while internally there is a deep or vertical finely granulated surface. The fingers are considerably shorter than the palm and somewhat deflexed, with the mobile one strongly carinated along its inner margin, which is also finely serrated. There are no prominent teeth on the opposing margins of the fingers. The left chelipede is slender, and smooth but for the presence of a few hairs; its carpus is longer than the hand and fingers taken together. The ambulatory legs are smooth and very sparingly pubescent; the second pair are unequally developed, that of the right side being longer and proportionately broader than the left, and the two terminal joints are faintly sulcate longitudinally, an arrangement which is not seen on the left side. On both sides the dactyli are longer than the propodi.

The Australian example, a female, is about 21 mm. long; the right chelipede (which cannot be fully extended) is 18 mm. long, the left chelipede 14 mm., the second left ambulatory leg 20 mm., and the second right ambulatory leg 23 mm.

#### Group GALATHEIDEA.

#### Genus PETROLISTHES, Stimpson.

#### 232. PETROLISTHES DENTATUS (Milne-Edw.).

*Porcellana dentata* (Milne-Edw.), De Man, Mergui Crust. p. 216 (1888).

(=*P. bellis*, Heller; *P. Haswelli*, Miers).

Tuticorin and Muttuwartu Par (*Thurston*); Rameswaram, common under coral blocks between tide-marks (*J. R. II.*).

I have compared my specimens with examples from Mergui examined by De Man and with the types of *Petrolisthes Haswelli*, and find that all belong to the same species. According to Ortmann, *Porcellana dentata* of De Man is not the *P. dentata* of Milne-Edwards, but is synonymous with *P. speciosa*, Dana; he seems to have overlooked the fact, however, that the Mergui specimens were examined by Prof. A. Milne-Edwards and pronounced identical with *P. dentata*, Milne-Edw. The carpus of the chelipedes is usually about twice as long as broad, though sometimes shorter. There is considerable variation in regard to the number and form of the denticles on the anterior and posterior margins of the carpus; as a rule, there are three on the hind margin. The lobe on the inner margin of the merus is always obtuse.

*Distribution.* Nicobars (*Heller*); Mergui (*De Man*); Singapore (*Walker*); Java (*Milne-Edwards*); Malay Archipelago (*De Man*); N. and N.E. Australia (*Miers*).

## 233. PETROLISTHES BOSCH (Audouin).

*Porcellana Boschii* (Aud.), De Man, Mergui Crust. p. 217 (1888).

(= *P. rugosa*, Milne-Edw.)

Rameswaram and Muttuwartu Par (*Thurston*); Rameswaram, not uncommon (*J. R. II.*).

This species is allied to the last, but distinguished by the very different sculpture, especially of the chelipedes. The carpal denticles are liable to considerable variation. The lobe at the inner distal end of the merus is acute, and on the upper distal margin of the same joint one or occasionally two spinules are met with.

*Distribution.* Red Sea (*Audouin, Heller, Kossmann, De Man*); Mergui (*De Man*); Kurachi (*Brit. Mus.*); N. Australia (*Brit. Mus.*).

## 234. PETROLISTHES MILITARIS (Heller).

*Porcellana militaris* (Heller), De Man, Brock's Crust. p. 410 (1888).

*Petrolisthes annulipes*, Miers, 'Alert' Crust. p. 270, pl. xxix. fig. B (1884).

Muttuwartu Par and Cheval Par (*Thurston*); Rameswaram (*Thurston, J. R. II.*).

My specimens are identical with the types of *P. annulipes*, and at the same time are referable to *P. militaris*, as defined by De Man. A supra-orbital spinule is present, but the lateral frontal margins are simply crenulated and not spinulose. Behind the outer orbital angle are two or three spines, the first placed on the margin and the others on the branchial surface, while about the middle of the branchial margin are from two to four spinules. De Man regards *P. annulipes* as identical with *P. scabricula*, Dana; but in the latter the frontal margins are spinulose. I have, however, seen examples of the present species in which the normal crenulations have become almost spinulose, so that this identity may yet be established by further research; in the meanwhile the two are perhaps best kept apart.

*Distribution.* Nicobars (*Heller*); Seychelles (*Miers*); W. coast of Java (*De Man*); Philippines (*White*); N. Australia (*Miers, Henderson*); Loo Choo Is. (*Ortmann*).

## Genus RAPHDOPUS, Stimpson.

## 235. RAPHDOPUS INDICUS, n. sp. (Pl. XXXIX. figs. 19-22.)

Madras, a male (*J. R. II.*).

The carapace is convex from side to side and from before backwards, with the regions ill-defined and almost smooth, there being merely a few faint elevations on the branchial areas, some of which, in particular posteriorly, form short granulated lines; two very slight elevations rise almost in the centre of the carapace. The front is nearly straight when viewed from above, but looked at from before three projections can be seen, of which the median is slightly the most prominent. On the lateral margin of the carapace about a quarter of the distance back, is a well-defined notch, and between this and the external orbital angle is a sharp obscurely crenulated margin. Behind the notch the margin is convex and distinctly crenulated, but terminates abruptly by passing on to the surface of the carapace, leaving the posterior fourth of the side of the carapace simply rounded and marked by some of the elevated lines already referred to. The eyes are small.

The antennal peduncle is elongated, the penultimate joint being longest; the flagellum is long and naked.

The chelipedes are long and subequal, the right being but slightly larger. The merus is short and massive, granulated above, and with a small projecting lobe on the inner distal end of the upper surface; on the right side there is a sharp moderately long spine on the middle of the lower anterior surface. The carpus is about twice the length of the merus, with the upper surface uneven but scarcely granulated, the anterior margin moderately sharp and crenulated but without teeth, and the posterior margin rounded. The hand is slightly granulated above, the granules being more numerous on the smaller chela; the lower and outer surfaces, including both fingers, are densely pubescent. The fingers are strongly curved at their apices, and even when closed there is a considerable intervening hiatus; a single tooth is present on the immobile finger slightly beyond the middle; the mobile finger has a small basal tooth and is crenulated along the inner margin, its upper surface is rounded and granulated chiefly in the smaller chela. The ambulatory legs are long and slender, with the joints simply pubescent; the dactyli are entire, slender, and straight, about two thirds the length of the propodi, densely hairy above, and with a sulcus on the anterior surface.

The carapace is 6.5 mm. long and 9.5 mm. broad, the right chelipede 23 mm. long, the first ambulatory leg 14.5 mm. long.

This little-known genus bears some resemblance to *Polyonyx*, from which it is distinguished by the form of the front, the smaller eyes, the longer antennal peduncle, longer legs, and especially by the form of the ambulatory dactyli. The only previously known species, *R. ciliatus*, Stm., from China and Japan, has the carapace flatter and narrower, with the regions well defined; the postero-lateral margin of the carapace carries two or three spines, and the carpus of the chelipedes has a median row of tubercles on its outer surface.

#### Genus PACHYCHELES, Stimpson.

##### 236. PACHYCHELES TOMENTOSUS, n. sp. (Pl. XXXIX. figs. 16-18.)

Kuraehi; four males, and five females all bearing ova (*Brit. Mus.*).

The carapace is flattened, glabrous, and depressed anteriorly, with the regions not defined, the protogastric lobules slightly prominent, and the surface slightly uneven towards the sides of the anterior branchial regions, which are raised above the level of the lateral margin. A few faint lines or wrinkles cross the posterior rounded lateral margin in passing to the under surface, and the remainder of the lateral border is defined by a somewhat sharp entire convex edge; opposite the penultimate joint of the antennal peduncle is a shallow depression or notch in the margin. The front is depressed, obscurely tridentate, and most prominent in the middle, with its upper surface densely tomentose. The upper orbital margin is obtusely rounded, and the eyes are of moderate size.

The chelipedes are unequal, and either may be the larger; they are granulated and densely tomentose above, the hairs being arranged in short tufts. The merus has a denticulated lobe on its inner and superior distal margin. The carpus is slightly convex and densely

hairy above, with three longitudinal rows of white polished tubercles on the proximal half, and usually four or five tubercles in each row; the anterior or inner margin has three denticulated lobes or teeth, the first two of which are subequal and the distal one smaller, but in some cases the denticulations normally present on the edges of the primary teeth are absent, and the first tooth may be double, making four in all. The hand is flattened above, with a few tubercular granules scattered over the entire surface, most of which give rise to hairs; the long outer margin is denticulated, while the under surface is glabrous and finely granulated, especially on the outer side. The mobile finger is denticulated along its upper margin, finely tubercular and tomentose above, sparingly granulated and glabrous below, with a rounded tooth near the base on the inner margin; the fingers show a wide hiatus when closed, and the tip of the mobile one is bent underneath the tip of the other. The smaller chelipede is similar to the one just described, *i. e.* the larger, except that the margins of the hand and fingers are more strongly denticulate. The ambulatory legs are short and fringed with hairs, the under surface of the propodus presents two spinules at its distal end, and the dactyli have three minute horny spinules on the posterior margin of their proximal half.

The carapace of a female is 11·3 mm. long and 13 mm. broad, the left or larger carpus is 6·5 mm. long and 6 mm. broad, the propodus 12 mm. measured along its outer margin, the first ambulatory leg 15 mm. long.

It is distinguished from *P. grossimanus* (Guérin) by its densely tomentose and sparingly granulated chelipedes, and by the denticulated fingers. *P. pectiniscarpus*, Stm., is very briefly characterized and agrees in some respects, but its carpus is described as having the anterior margin "pectinated with eight small equal spiniform teeth," and no mention is made of hairs on the chelipedes, while the carpus is much broader than long. In *P. Stevensii*, Stm., the chelipedes are not described as hairy, and the hand of the smaller chela is longitudinally bisulcate.

#### GENUS PORCELLANELLA, White.

##### 237. PORCELLANELLA TRILOBA, White.

*P. triloba*, White, in Macgillivray's Voyage H.M.S. 'Rattlesnake,' vol. ii. Appendix, p. 394, pl. v. fig. 2 (1852).

Rameswaram (*Thurston*).

I have examined White's type of *P. triloba*, as well as original specimens of *P. picta*, Stm., from Hong Kong, in the British Museum, and can find only the following differences:—In White's species the median frontal projection but slightly exceeds the lateral ones, and its apex is rounded, while the first or most proximal of the four spinules on the ambulatory dactyli is very small; in Stimpson's species the median frontal tooth is slightly longer and subacute, and the four spinules on the dactyli are subequal. The two species may yet be united, but at present may be kept separate.

*Distribution.* N. Australia (*White*); Celebes Sea (*Henderson*); Falkland Is. (*Henderson*).

## Genus POLYONYX, Stimpson.

## 238. POLYONYX OBESULUS, Miers.

*P. obesulus* (White), Miers, 'Alert' Crust. p. 272, pl. xxix, fig. D (1884).

Rameswaram and Tuticorin (*Thurston*). Common at Rameswaram, both free and in sponges (*J. R. II.*).

I have compared my specimens with the types in the British Museum. The median frontal projection is obtusely rounded and but little prominent. The ambulatory dactyli are triunguiculate, the middle claw being slightly stouter and larger than the distal one, whereas the proximal one is much smaller. Sexual dimorphism is seen in regard to the chelipedes and the width of the carapace. In both sexes the right chelipede (which is usually the smaller of the two) has the hand more or less carinated inferiorly, and the carina often minutely dentate; the fingers are in contact throughout, or almost so, in males, the opposing margins being finely dentate and without any prominent tooth. In females and young males the left chelipede, which is as a rule slightly the larger, is similar to the right, whereas in adult males it is more strongly developed; the fingers have a wide gape, and are not in contact even at the apices when closed; while a prominent tooth is present on the inner margin of the lower finger. The male probably holds the chelipede of the female during copulation.

In *P. biunguiculatus* (Dana) the median frontal projection is prominent and acute, while the ambulatory dactyli are biunguiculate, the first or proximal claw, present in *P. obesulus*, being scarcely visible and represented merely by a minute seta. On the chelipedes the lobe of the inner margin of the merus is more prominent, and the carpus is usually longer than in Miers's species. In some specimens the outer surface of the hand is granulated. There are examples in the British Museum of Dana's species from the Gulf of Suez, the Seychelles, and the Amirantes. De Man has suggested that *P. obesulus* is identical with *P. biunguiculatus*, and that the *P. biunguiculatus* described by Miers is a distinct species; but I cannot agree with this suggestion.

The following measurements are taken from Rameswaram specimens:—

	Male.	Female.
Length of carapace .....	6·7 mm.	6·2 mm.
Breadth „ .....	8·3 „	8·5 „
Length of left hand.....	11·5 „	8·5 „
Breadth „ .....	5·5 „	4·3 „
Length of left carpus .....	7·5 „	5·7 „

The colour is a pale red, turning white in spirit. One individual—a male—carries a *Sacculina*.

*Distribution.* Madjicosima Is. (*White*); N. Australia (*Miers, Henderson*); Amboina (*De Man*); Singapore (*Walker*).

## 239. POLYONYX TUBERCULOSUS, De Man.

*Porcellana (Polyonyx) sp. (tuberculosa in text)*, De Man, Brock's Crust. p. 424, pl. xiii. fig. 1 (1888).

Cheval Par (*Thurston*); Rameswaram, common (*J. R. II.*).

I doubtfully refer to the above species a large series of specimens with the following characters:—The median frontal projection is subacute when viewed from before. The chelipedes are tuberculate on the upper surface of the carpus and hand; the merus is produced internally into a finely-toothed lobe; the inner margin of the carpus has a few subacute teeth, while the outer margin of the hand is carinated and finely serrated. The ambulatory dactyli are four-clawed, the two proximal spinules being very minute, while the terminal claw is longer and slightly stouter than the penultimate one. The ambulatory legs are fringed anteriorly with hairs. This species is certainly distinct from *P. obesulus* or *P. biunguiculatus*, and, as De Man represents his species with the carpus smooth above, and with very few tubercles present on the hand, our specimens may also be distinct from *P. tuberculosa*. The ambulatory dactyli of the last species are not described by De Man. I have noticed in one or two specimens of *P. obesulus* a slight tendency towards tuberculation on the hand, chiefly in small individuals; but our species may be distinguished from this variety by the greater tuberculation and the different ambulatory dactyli. De Man had only a single small specimen, and it may have belonged to this variety of *P. obesulus*, in which case a new name will be necessary for the form which is here briefly characterized.

A male is 7.3 mm. long and 8 mm. broad.

*Distribution.* Amboina (*De Man*).

## Genus GALATHEA, Fabricius.

## 240. GALATHEA ELEGANS, White.

*G. elegans* (White), Adams & White, 'Samarang' Crust. pp. i, ii, pl. xii. fig. 7 (1848).

Tuticorin, four specimens (*Thurston*); Gulf of Martaban, two specimens (*Oates*).

There appears to be considerable variation in the coloration and in the form of the rostrum; perhaps *G. grandirostris*, Stm., and *G. deflexifrons*, Haswell, are merely varieties of this species.

*Distribution.* Philippines and Borneo (*Adams & White*); Singapore (*Walker*); Amboina (*De Man*); Celebes Sea (*Henderson*); N. Australia (*Miers, Haswell*).

## 241. GALATHEA SPINOSIROSTRIS, Dana.

*G. spinosirostris*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 480, pl. xxx. fig. 9 (1852); De Man, Brock's Crust. p. 456 (1888).

Muttuwartu Par, two females with ova (*Thurston*); Gulf of Martaban, a male (*Oates*).

I refer these with some doubt to this species. The Muttuwartu specimens, the larger of which is only 10 mm. in total length, are without gastric spinules at the base of the rostrum, and in this respect agree with *G. corallicola*, Haswell, which was regarded by Miers as a variety of *G. australiensis*, Stm. The Martaban specimen has a rudimentary

pair of gastric spinules, but otherwise closely agrees with the Muttuwartu examples. It seems probable that *G. australiensis* is identical with Dana's species, so I refer my specimens to the latter.

*Distribution.* Sandwich Is. (*Dana*)?; E. Australia (*Stimpson*, *Haswell*, *Miers*); Amirantes (*Miers*); Amboina (*De Man*); Mauritius (*Richters*); Arafura Sea (*Henderson*).

#### Genus MUNIDA, Leach.

##### 242. MUNIDA SPINULIFERA, Miers.

*M. spinulifera*, Miers, 'Alert' Crust. p. 279, pl. xxxi. fig. B (1884).

Muttuwartu Par, a female with ova (*Thurston*); Gulf of Martaban, a male (*Oates*).

The male is 13 mm. long and the female somewhat smaller; in both specimens the abdominal segments are without dorsal spinules.

*Distribution.* Arafura Sea (*Miers*); Amboina (*Henderson*).

#### Suborder MACRURA.

##### Group THALASSINIDEA.

#### Genus GEBIOPSIS, A. Milne-Edw.

##### 243. GEBIOPSIS DARWINII, Miers.

*G. Darwinii*, Miers, 'Alert' Crust. p. 281, pl. xxxii. fig. A (1884).

*G. intermedia*, De Man, Mergui Crust. p. 256, pl. xvi. fig. 2 (1888); id. Brock's Crust. p. 462 (1888).

Rameswaram, Tuticorin, and Cheval Par (*Thurston*). Common at Rameswaram, usually living in sponges (*J. R. II.*).

I have compared my specimens with (1) a single type-specimen of De Man's species in the British Museum, (2) the types of Miers's species, and in my opinion the two species are identical. The antennal and antennular peduncles are alike in both, and are incorrectly figured by Miers. I find, however, on examining a number of specimens, that there is some variation in the length of the penultimate antennal peduncular segment. The row of minute spinules (or tubercles) on the meropodites of the chelipedes, mentioned by De Man, occurs also in Miers's species. The two spines described by De Man as present on the carpopodites are liable to variation; sometimes the lower one is rudimentary or even absent (it is rudimentary in De Man's specimen in the British Museum), while the upper one is often similarly reduced. The last pair of legs are wrongly figured by Miers; his specimens agree perfectly with De Man's—*i. e.* the last legs are chelate, and the carpus is but slightly longer than the propodus.

The only differences I can find are—(a) in size De Man's specimens are much larger than Miers's, but this is evidently of little importance, for one of the Rameswaram males is 36 mm. long, while a female with eggs from the same locality is only 23 mm. long; (b) in Miers's specimens the inferior spine of the carpopodite is absent or represented by a mere rudiment, and the upper one is greatly reduced, but, as previously noted, these

characters vary. De Man has more recently described a variety *amboinensis* in which the lower carpal spine is wanting.

*Distribution.* N. Australia (*Miers*); Amboina (*De Man*); Singapore (*Walker*); Mergui (*De Man*).

Group ASTACIDEA.

Genus THENUS, Leach.

244. THENUS ORIENTALIS (Fabr.).

*T. orientalis* (Fabr.), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 286 (1837).

Common at Madras and on the South Indian coast generally (*J. R. II.*).

The three teeth in the mid-dorsal line of the carapace are prominent and subacute in young individuals, blunt and ill-defined in adults.

*Distribution.* Madagascar, Seychelles, Indian Seas, Malay Archipelago, China, W. Australia.

Genus PANULIRUS, Gray.

245. PANULIRUS ORNATUS (Fabr.).

*Palinurus ornatus* (Fabr.), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 296 (1837).

*Panulirus ornatus* (Fabr.), Stimpson, Proc. Acad. Nat. Sci. Philad. Jan. 1860, p. 24.

*Senex ornatus* (Fabr.), Ortmann, Zool. Jahrb. Bd. vi. Abth. f. Syst. p. 34 (1892), *ubi synonym.*

Ceylon (*Italy*).

*Distribution.* From E. Africa to Japan, N. Australia, and the Pacific (Samoa).

246. PANULIRUS PENICILLATUS (Olivier).

*Palinurus penicillatus* (Oliv.), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 299 (1837).

*Panulirus penicillatus* (Oliv.), Stimpson, Proc. Acad. Nat. Sci. Philad. Jan. 1860, p. 24.

*Senex penicillatus* (Oliv.), Ortmann, Zool. Jahrb. Bd. vi. Abth. f. Syst. p. 28 (1892), *ubi synonym.*

Ceylon (*Holy*).

*Distribution.* From the Red Sea and Mauritius to the Malay Archipelago, N. Australia, and the Pacific (Fijis, New Hebrides, Tahiti).

247. PANULIRUS DASYPUS (Latr.).

*Palinurus dasypus* (Latr.), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 300 (1837).

*Senex dasypus* (Latr.), Ortmann, Zool. Jahrb. Bd. vi. Abth. f. Syst. p. 33, (1892), *ubi synonym.*

Silavaturai Par (*Thurston*). Common at Madras (*J. R. II.*).

The Silavaturai example is very young, measuring only 45 mm. in length, but is apparently referable to this species. It has two pairs of spines, arranged as if at the angles of a square, on the antennal segment, the posterior pair being smaller than the anterior pair; at a later stage small spinnles are developed towards the centre of the square.

*Distribution.* Indian Ocean (*Milne-Edwards*); Ceylon and Madras (*Heller*); Muscat (*Brit. Mus.*); Moluccas (*Herklot*).

## Group CARIDEA.

## Genus CARIDINA, Milne-Edwards.

## 218. CARIDINA WYCKII (Hickson).

*C. Wyckii* (Hickson), De Man, Max Weber's Crust. p. 386, Taf. xxiv. fig. 29 (1891).

Madras, common in wells and in ponds with clear fresh water (*J. R. II.*).

I can find no difference, except in size, between Madras specimens and Hickson's types in the British Museum, the Indian examples being considerably larger, and reaching a length of about 35 mm., including the rostrum; they also completely agree with De Man's excellent description and figures. I first observed the species in a swimming-bath at Northwick, Madras, the residence of my friend the Rev. Dr. Miller. As De Man has pointed out, it is very closely related to *C. nilotica*, Roux (= *C. longirostris*, Milne-Edw.), from N. and E. Africa, and perhaps the two species are not distinct.

A *Caridina* from Roorkee, in the Day collection, is represented by a single damaged specimen which cannot be satisfactorily identified.

*Distribution.* Celebes, in fresh water at an altitude of 2000 ft. (*Hickson*); Celebes, Saleyer, and Flores, in fresh and brackish water (*De Man*).

## Genus ALPHEUS, Fabricius.

## 219. ALPHEUS MALABARICUS, Fabr. (Pl. XL. figs. 1-3.)

*A. malabaricus*, Fabr. Suppl. Ent. Syst. p. 405 (1798); non *A. malabaricus*, De Haan, nec Hilgendorf, nec Ortman.

Common in the backwater at Pulicat, and apparently burrowing in a muddy bottom (*J. R. II.*).

The ocular hoods are prominent, but simply rounded, and placed closer together than usual. The rostrum is acute, reaching the level of the basal antennular scales, and not extending back on the carapace behind the posterior limit of the eyes, though clearly distinct from the latter. The antennal and antennular peduncles are subequal in length. The antennular scales do not reach the end of the proximal peduncular joint by about one fourth the length of the latter, and the second peduncular joint is fully twice the length of the distal one. The antennal scales are about equal in length to both the antennal and antennular peduncles, and the outer distal spine is minute.

The larger chelipede, which may be either the right or the left, is slender proximally, but has a massive hand. The merus has a slight tooth on its upper distal surface, and a well-marked spine on the inner distal margin. The hand is moderately compressed, with a distinct sulcus crossing the upper margin behind the insertion of the mobile finger, and a second sulcus immediately underneath on the lower margin; both the upper and lower margins behind the sulci are well rounded. On both the inner and the outer surfaces of the hand a wide shallow furrow with ill-defined margins passes back from the upper sulcus; the outer of these furrows passes somewhat obliquely towards the proximal inferior angle of the joint, while the inner, which is scarcely so

large, passes close to the upper margin. On the inner surface of the hand a shallow furrow connects the two marginal sulci and extends across the long axis of the joint. The dactylus is strongly curved and carinated dorsally, with the apex curving beyond that of the lower immobile finger. No ridges are present on the larger hand. The smaller chelipede is very long, slender, and unarmed; the fingers are slightly incurved and very long, being about three and a half times the length of the hand in adults, and in close apposition—*i. e.* they are parallel and with scarcely any hiatus at the base when closed. The mobile finger has a distinct basal tooth, and long hairs clothe the inner edges of both fingers. The second chelate legs have the first and second carpal joints long and subequal, the third and fourth short and subequal, and the fifth slightly longer than either the third or the fourth. The ambulatory legs are slender and unarmed. The apex of the telson is obtusely rounded, with the terminal lateral spinules very minute.

An adult male is 30 mm. long, the larger chelipede 27 mm. long, the hand 11 mm. long, and the fingers 7 mm.; the smaller chelipede is 29 mm. long, the hand 4 mm., and the fingers 13.5 mm. In the female the chelipedes are slightly smaller.

This species, originally collected by Daldorf in South India, has apparently been lost sight of for nearly a hundred years. I think there can be little doubt that the species just described is identical with that of Fabricius; it completely agrees with his short diagnosis, while the Japanese species referred to *A. malabaricus* by De Haan and others does not conform to the original description in one important respect—it exhibits a wide gape or hiatus between the fingers of the smaller chela, which Fabricius expressly states are parallel. De Haan's species is termed *A. malabaricus* in the description (Crust. Japon. p. 177), but *A. brevicristatus* on the plate (tab. xlv. fig. 1), so that the latter designation may be conveniently retained for it, provided that the earlier described *A. dispar*, Randall, should not prove to be synonymous, as some writers have supposed. In the British Museum is a specimen of our species from Pondicherry, bearing a MS. name, "*A. forceps*," White. *A. dolichodactylus*, Ortmann, from Japan, is nearly allied, and has both the hand sulci present, but it has a wide gape between the fingers of the smaller chela, and the dactylus is apparently without a tooth; it has also a distinct tooth on the upper margin near the base of the larger dactylus, which is not seen in our species. *A. brevicristatus*, De Haan, is easily distinguished by its larger hand, which is ridged externally; the inferior marginal sulcus is absent, and there is a wide gape between the fingers of the smaller chela.

*Distribution.* South India (*Fabricius*).

## 250. ALPHEUS EDWARDSII (Audouin).

*A. Edwardsii* (Aud.), Miers, 'Alert' Crust. p. 284 (1881), *ubi synon.*

Rameswaram, Tuticorin, and Muttuwartu Par (*Thurston*); Gulf of Martaban (*Oates*); Kuraichi (*Brit Mus.*). Very common on the reef at Rameswaram (*J. R. II.*).

*Distribution.* Atlantic Region—from N. Carolina to Brazil, West Indies, Cape Verd Is. Indo-Pacific Region—from the Red Sea and E. Africa to Japan, California, Samoa, the Fijis, Tahiti, &c.

## 251. ALPHEUS HIPPOTHOË, De Man.

*A. Hippothoë*, De Man, Mergui Crust. p. 268, pl. xvii. figs. 1-5 (1888).

Rameswaram, six specimens (*J. R. II.*).

This species is allied to *A. Edwardsii*, which it resembles in size, the rounded ocular hoods, and the general form of the chelæ, but is distinguished by its stouter ambulatory legs, those of the second and third pairs with the meral joints broad and flattened, and armed with a distal spine on the lower margin; the rostrum is more strongly marked than in *A. Edwardsii*, and in some cases extends back on the carapace, though faintly, almost to the middle.

*Distribution.* Mergui; Pulo Edam and Amboina (*De Man*).

## 252. ALPHEUS FRONTALIS, Say.

*A. frontalis* (Say), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 356 (1837); id. Atlas, Cuv. Règne Anim. pl. liii. fig. 2 (1849).

Tuticorin (*Thurston*).

*Distribution.* Australia (*Milne-Edwards*); Tahiti (*Heller*); Loo Choo Is.; Samoa; South Sea (*Ortmann*).

## 253. ALPHEUS LÆVIS, Randall.

*A. lævis* (Rand.), Ortmann, Zool. Jahrb. Bd. v. Abth. f. Syst. p. 487 (1891), *ubi synonym.*

Rameswaram and Tuticorin (*Thurston*). Not uncommon on the reef at Rameswaram (*J. R. II.*).

*Distribution.* From the Red Sea and E. Africa to Japan, Sydney, and the Pacific (Tonga, Fijis, Tahiti, Sandwich Is., &c.).

## 254. ALPHEUS NEPTUNUS, Dana.

*A. Neptunus*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 553, pl. xxxv. fig. 5 (1852).

Kurachi (*Brit. Mus.*). Common on the reef at Rameswaram (*J. R. II.*).

Both Miers and De Man regard this as merely a variety of *A. minor*, Say, which is common on the east coast of the United States.

*Distribution.* From the Red Sea to China, Japan, Port Jackson, and the west coast of Central America.

## Genus DORODOTES, Bate.

## 255. DORODOTES LEVICARINA, Bate.

*D. levicarina*, Bate, 'Challenger' Maerura, p. 680, pl. exii. fig. 5 (1888).

Gulf of Martaban (*Oates*).

The single specimen is a female with ova, measuring 51 mm. in length, including the rostrum, which is 11 mm. long.

*Distribution.* Arafura Sea, 28 fathoms (*Bate*).

Genus *ANGASIA*, Bate.

*Angasia*, Bate, Proc. Zool. Soc. p. 498 (1863).

*Tozeuma*, Stimpson, Proc. Acad. Nat. Sci. Philad. p. 26, Jan. 1860.

I propose to substitute this generic name for the older *Tozeuma*, Stimpson, which, in its correctly spelt form *Toxeuma*, had been previously applied by Walker to a genus of Hymenoptera. Stimpson gives the derivation of his name, so that the spelling has perhaps been due to a printer's error which he has allowed to pass.

256. *ANGASIA STIMPSONII*, n. sp. (Pl. XI. figs. 18-20.)

Gulf of Martaban, two specimens (*Oates*).

The body is compressed laterally, with the rostrum about equal in length to the abdomen, omitting the telson. The rostrum is slightly upturned, with an obtuse or rounded dorsal carina, bounded on either side by a slight groove, but thin or laminar, and finely serrated, below; seen from the side it is deepest immediately in front of the eyes, from which point it gradually tapers to the apex. The carapace is provided with an acute antero-lateral spine. The eyes occupy orbits, which are formed partly by the rostrum, and partly by the antennal peduncles. The antennular peduncles are not half the length of the antennal scales, and their flagella, which otherwise agree with Stimpson's description of those in *A. lanceolata*, reach only to about the middle of the scale; the basal peduncular segment has an external flattened acute process. The antennal peduncle has an acute spine on the under surface of its basal joint, about equal in size to the antero-lateral spine of the carapace; the flagellum extends considerably beyond the rostrum, although incomplete in both specimens. The antennal scale is very long and narrow, being almost half the length of the rostrum.

The abdominal segments are obtusely carinated, and the third, fourth, and fifth are each prolonged posteriorly into a dorsal tooth. The telson is very long, narrow, and acuminate, slightly exceeding the last appendages, and with three pairs of lateral spinules. The legs are as described by Stimpson in *A. lanceolata*, the wrist of the second pair being three-jointed.

The larger specimen, a female with ova, is imperfect, but the smaller gives the following measurements:—length of body, measured from the eye to the tip of the telson, 43 mm., rostrum 22 mm., antennal scale 9·7 mm. long and 1·2 mm. in greatest breadth, telson 9·3 mm. long.

In some respects this species seems to agree with *A. lanceolata* (Stm.) from Hong Kong, but Stimpson, in his short description of the latter, states that the rostrum is "scarcely a fourth part shorter than the body," and that the antennule equal in length the antennal appendices or scales; he also describes the antennæ as shorter than the rostrum, the antennal scales as one third the length of the rostrum, and the breadth of each scale as being equal to one fourth of its length. Our species may therefore be distinguished at once by its very much longer and narrower antennal scale. *A. pavonina*, Bate, from South Australia, has the rostrum with only four teeth below, the antennal scale reaching nearly to the end of the rostrum, and the apex of the telson obtuse. The only other species known, so far as I am aware, is *A. carolinensis* (Kingsley), from

the east coast of the United States. The *Tozeuma serratum* of A. Milne-Edwards, from the West Indies, is probably, as Bate has remarked, referable to some other genus, for in it the carpus of the second legs is multiarticulate.

Genus RHYNCHOCINETES, Milne-Edwards.

257. RHYNCHOCINETES RUGULOSUS, Stimpson.

*R. rugulosus*, Stimpson, Proc. Acad. Nat. Sci. Philad. Jan. 1860, p. 36.

Tuticorin, four specimens (*Thurston*).

The body is marked dorsally by fine transverse or somewhat concentric impressed striae. The rostral formula in three specimens is  $\frac{3+2+2}{9}$ , and in the fourth  $\frac{3+2+2}{8}$ , the first three upper teeth being situated on the carapace; whereas according to Stimpson the rostrum is tridentate above near the apex, and has twelve teeth below. These differences may be due to local variation, or possibly the Tuticorin examples are referable to a distinct and new species, but I do not venture to separate them. A few spinules are present on the meral joints of the last three pairs of legs, and the first pair have a spine at the upper distal end of both the merus and the carpus, while the latter joint is carinated superiorly along its entire length. The apex of the telson is acuminate, and carries two pairs of subterminal spinules, of which the inner pair exceed the terminal portion of the telson, and are about three times the length of the outer pair.

*Distribution.* Port Jackson (*Stimpson*).

Genus PONTONIA, Latreille.

258. PONTONIA TRIDACNAE, Dana.

*P. tridacnae*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 571, pl. xxxvii. fig. 1 (1852).

(= *Conchodytes tridacnae*, Peters).

Tuticorin (*Thurston*); Rameswaram, in the mantle-chamber of a large *Pinna* (*J. R. H.*).

*Distribution.* Red Sea (*Hilgendorf*); E. Africa (*Peters, Hilgendorf*); N. and N.E. Australia (*Miers*); Samoa (*Dana, Ortmann*); Fijis (*Miers*).

Genus LEANDER, Desmarest.

This genus was founded by E. Desmarest in 1849 (Ann. Soc. Ent. de France, sér. 2 t. vii. p. 91), but poorly characterized, most stress being laid on the gibbosity of the abdomen; indeed, the characters furnished by this writer might apply to either the fresh-water or the marine forms. He, however, figures as the type an undoubted marine form, *L. erraticus*, Desm. (= *L. natator*, Milne-Edw. fide Spence Bate). Stimpson, in 1860, was the first to separate *Leander* and *Palæmon*, and to properly characterize them, placing the marine species in *Leander* and the fluviatile species in *Palæmon*, an arrangement which has been followed by most subsequent writers. Spence Bate, in his Report on the 'Challenger' Maerura, partially reverses this arrangement and refers the marine species to *Palæmon*, partly because he regarded Desmarest's diagnosis as valueless, and because Leach, Milne-Edwards, Bell, and others had termed the common

European marine species *Palæmon*, while he places the freshwater forms in the genus *Bithynis*, founded by Philippi in 1860. A reference to Fabricius's writings shows that he, without naming any special type, described the freshwater forms first, and his name *Palæmon* ought therefore to be taken for these; this is the plan adopted by Dr. Ortmann, who has recently prepared a useful and much needed revision of the genus. Ortmann correctly limits the genus *Bithynis* to a single species, *B. Gaudichaudii* (Milne-Edw.), from Chili and Peru, in which the hepatic spine is absent, and the chelipedes are unequal and greatly enlarged.

### 259. LEANDER LONGIROSTRIS (Say).

*Palæmon longirostris* (Say), Milne-Edwards, Hist. Nat. Crust. t. ii. p. 394 (1837).

Kurachi, four specimens (*Brit. Mus.*); Sunderbunds, four specimens; Mergui, one specimen (*Day*); Gulf of Martaban, three specimens (*Oates*).

The rostrum, which is upturned distally, exceeds the antennal scales by half or more of its length; the basal crest ends opposite the articulation between the last two joints of the antennular peduncle. The first lower rostral tooth is placed under the most distal tooth of the basal crest. The shortest of the three antennular flagella exceeds the antennal scales by more than half its length. On the earapace the antennal or upper spine is minute, while the branchiostegal or lower one is well developed. The spine on the outer margin of the antennal scale is placed at some distance from the apex, the distance equalling nearly one third of the total length of the outer margin.

The first pair of legs reach to or slightly exceed the antennal scales. The second legs have the ischium and merus cylindrical and subequal, the carpus slightly shorter and dorsally dilated; the propodus is shorter than the carpus, and considerably swollen in the adult of both sexes, with its outer surface sulcate, and the sulcus bounded by two ridges, an arrangement which is best seen on the distal two thirds of the band, terminating opposite the base of the mobile finger. The fingers are very long and slender, being about half its length longer than the palm; they have sharp cutting-edges, but no teeth, and are strongly curved at their apices. The remaining feet are slender and slightly longer than the first pair. The last four abdominal segments are dorsally more or less carinated. The telson is dorsally smooth and rounded, with the very slender and acute apex placed opposite the spine on the outer margin of the exopodite of the sixth pair of abdominal appendages; the two minute subterminal spinules are greatly exceeded in length by the apex of the telson.

A female from the Sunderbunds is 64 mm. long from the orbit to the apex of the telson, the rostrum 20 mm. long, the second leg 68 mm. long.

The following are the rostral formulæ in specimens from the different localities:—

Kurachi.— $\frac{5+3}{9}$ ,  $\frac{6+3}{9}$ ,  $\frac{6+3}{8}$ .

Sunderbunds.—Three specimens  $\frac{6+2}{9}$ , one specimen  $\frac{5+2}{8}$ .

Martaban.— $\frac{6+1}{7}$ ,  $\frac{6+1}{8}$ .

Mergui.— $\frac{6+1}{8}$ .

The *L. longirostris*, var. *japonicus*, of Ortmann, which is distinguished by the form of its telson and rostrum, is, I think, a distinct species, while the var. *carinatus*, of the same author, from China, founded on the carination of the abdominal segments which is seen in Milne-Edwards's species, may or may not be distinct. De Man (Notes Leyden Museum, vol. iii. p. 141, 1881) describes the branchiostegal spine as smaller than the antennal spine in the Chinese examples which he referred to *L. longirostris*, but this is probably an error of description.

*Distribution.* Sunderbunds (*Milne-Edwards*); China (*De Man, Ortmann*).

260. LEANDER TENUIPES, n. sp. (Pl. XL. figs. 14, 15.)

Bombay, two imperfect specimens (*Day*); Gulf of Martaban, five specimens (*Oates*); Madras, ten specimens (*J. R. II.*).

The rostrum is slender, and exceeds the antennal scales by about half its length, with the distal two thirds styliform and upturned; the basal crest scarcely reaches the end of the proximal antennal peduncular joint. The first lower rostral tooth is minute, and placed under or in front of the distal tooth of the basal crest; both the upper and lower distal teeth are placed at some distance from the apex of the rostrum. The shortest of the three antennular flagella does not reach the end of the antennal scales. The spine on the antennal scale is placed much nearer the apex than in *L. longirostris*. The antennal spine is minute, but the branchiostegal one is well developed.

The first pair of legs are slightly longer than the antennal scales. The second legs have the merus more than twice the length of the ischium, and the former joint is proximally compressed, with an ill-defined sulcus on the upper surface, but its distal half is narrow and less compressed; the carpus is about equal in length to the ischium, while the palm, which is slightly dilated and smooth, is a little longer than the carpus. The fingers are nearly twice the length of the palm, but otherwise similar to those of *L. longirostris*. The remaining feet are extremely long and slender, more especially due to a lengthening of their terminal joints, which are more slender than even the antennal and antennular flagella; they increase in length on passing back, the last pair being longest. It is impossible to give accurate measurements of these legs, as in most cases they appear to be imperfect. This extraordinary lengthening is not confined to the legs, but is seen also in the antennal and antennular flagella, which are certainly more than twice the length of the body. The last three abdominal segments are strongly compressed laterally, and narrowed above but not carinated. The telson is smooth and rounded dorsally, except for the presence of a shallow sulcus towards the apex; the apex is blunt, and not produced to the level of the spine on the exopodites of the last appendages, with the subterminal pair of spinules considerably longer than the free end of the telson.

The colour noted in fresh specimens is grey, with the thoracic viscera presenting an orange hue under the carapace, and the attached or fertilized ova in the female yellowish green.

A Madras specimen, measured like the last species, is 55 mm. long, the rostrum 19 mm., the second leg 36 mm., and the last leg 75 mm. Although the dactylus of the last leg in this example is broken at the tip, it still measures 15 mm. in length.

The rostral formulæ are as follows:—

Martaban.—Three specimens  $\frac{5+1}{4}$ , two specimens  $\frac{5+1}{3}$ .

Madras.—Five specimens  $\frac{6+1}{4}$ , two specimens  $\frac{5+1}{4}$ , one specimen  $\frac{5+1}{3}$ , one specimen  $\frac{6+1}{5}$ .

This species in some respects, as in the form of the rostrum, the compressed abdominal segments, the small antennal spine, and the form of the hand and fingers, is allied to *L. longirostris*, but may be distinguished at once by its greatly elongated and excessively slender legs, the form of the second legs, telson, antennal scales, &c. I at first felt inclined to establish a new genus for its reception, but on further consideration I think it better to regard it as an aberrant species of *Leander*, for all its more important structural features are such as vary considerably among the different known species of this genus.

#### 261. LEANDER MODESTUS, Heller.

*L. modestus*, Heller, 'Novara' Crust. p. 111, Taf. x. fig. 6 (1865).

Madras, six specimens (*J. R. II.*).

The apical third or more of the rostrum is edentulous and upturned, while the proximal part carries eight or nine small teeth; three teeth are found on the lower margin, the most distal of which in all my specimens is placed in advance of the most distal upper tooth, while in Heller's figure the two are represented as placed opposite each other.

*Distribution.* Shanghai (*Heller*).

#### Genus PALEMON\*, Fabricius.

#### 262. PALEMON CARCINUS (Fabr.).

*P. carcinus* (Fabr.), Ortmann, Zool. Jahrb. Bd. v. Abth. f. Syst. p. 700, Taf. xlvii. fig. 1 (1891).

A large series from Bombay; Ganjam; Calcutta; Sunderbunds; Sittoung, Burmah; Tavoy (*Day*); Burmah (*Oates*).

The colour is characteristic, the chelipedes, carapace, and abdomen being marked with purple, as indicated in the figure of Herbst.

The examination of a large series from different localities has left me in considerable doubt as to the limitations of this species. I find great variation as regards the length of the chelipedes in adult males, and the length and toothing of the rostrum, in specimens taken along with, and which I cannot separate from, the typical form. In some specimens from Bombay, Madras, and Ganjam, in both sexes the rostrum is scarcely longer than the antennal scales, while the number of teeth is greatly reduced; and, as

\* There are several species of *Palemon* in the Day collection which are probably new, but I have not ventured to characterize them, owing to deficiency of material; nor have I as yet attempted to identify my Madras specimens. An example from Ganjam (*Day*), without chelipedes, and which, therefore, cannot be satisfactorily identified, carries a Bopyrid parasite, and some time ago I forwarded a specimen, taken in fresh water at Madras, to Prof. Giard and M. Bonnier, with a similar parasite. These authors have recorded two freshwater Bopyrids from the Malay Archipelago.

they are normal in other respects, I am forced to regard them as belonging to a variety in which the apical growth of the rostrum has been arrested.

I refer to the *P. Lamarrei*, of Milne-Edwards, described from Bengal, certain specimens from Ganjam, in which the rostrum exceeds the antennal scales by about half its length, and is upturned distally, with six or more teeth below, and the upper teeth most marked proximally, in which the telson is narrow and acute, with the subterminal spinules at some distance from the apex. These were taken with typical examples of *P. carcinus*, and I regard them as being merely the young of this species. De Man and Ortmann regard *P. Lamarrei* as identical with a species found in Brazil; but it seems to me improbable that, in a freshwater genus apparently so plastic as *Palæmon*, the same species should occur in such widely separate localities.

*Distribution.* India, Burmah, Siam, Malay Peninsula, and the Malay Archipelago (Sumatra, Java, Borneo, Philippines, Celebes, New Guinea).

#### 263. *PALÆMON DISPAR*, von Martens.

*P. dispar* (v. Mart.), Ortmann, Zool. Jahrb. Bd. v. Abth. f. Syst. p. 718 (1891), *ubi synon.*; De Man, Max Weber's Crust. p. 427, Taf. xxvi. fig. 34 (1891).

Calcutta, several specimens (*Day*).

I refer these with some hesitation to this species. The rostrum is almost straight, reaching the end of the antennal peduncles, and in some specimens even the end of the antennal scales, with from nine to thirteen teeth above, and four or more, rarely five, below, the first two upper teeth separated by a wider interval than the others, and the third placed above the orbital margin. The carapace is slightly scabrous. The chelipedes are very long, slender, and unequal, with the surface scabrous; the carpus exceeds the palm by half its length, and the fingers are about half the length of the palm. Both fingers in the male have a row of tubercles on the inner margin, while in the female there is simply a sharp edge. The telson is rather broad towards the apex, but pointed, with the inner subterminal spinules more than twice the length of the outer ones, or of the apical spine of the telson; the terminal setæ are slightly longer than the inner spinules. The largest specimen is 73 mm. long, not including the rostrum, and the larger chelipede 145 mm. long.

*Distribution.* Réunion, Mauritius, Rodriguez, Malay Archipelago (Adonara, Timor, Flores, Saleyer, Celebes, Amboina), Samoa.

#### 264. *PALÆMON SCABRICULUS*, Heller.

*P. scabriculus*, Heller, 'Novara' Crust. p. 117, Taf. x. fig. 9 (1865); Ortmann, Zool. Jahrb. Bd. v. Abth. f. Syst. p. 710 (1891); De Man, Max Weber's Crust. p. 462, Taf. xxvii. fig. 41 (1891).

Kotri, on the River Indus, several specimens (*Brit. Mus.*).

The rostrum is deep, and scarcely reaches the end of the antennal scales; the teeth are more erect than usual, and in number  $\frac{11-15}{2}$ , the fourth or fifth upper tooth placed above the orbital margin. The carapace is scabriculate anteriorly and on the branchial areas, but punctate behind. The chelipedes in the male are about equal in length to the body,

pubescent and slightly scabriculate, with the carpus about equal to the palm; the fingers are longer than the palm, and slightly curved in the male, with their opposed margins finely toothed and pubescent. The right chelipede is usually larger than the left. In the female the chelipedes are less elongated, and the fingers may be slightly shorter than the palm. The telson is truncated, but obtusely pointed at the apex, with the inner spinules and the setæ very long.

A male is 42 mm. long, not including the rostrum, the right chelipede 15 mm., and the left chelipede 33 mm.

*Distribution.* Ceylon (*Heller*); Salcyer and Celebes (*De Man*).

265. *PALEMON DAYANUS*, n. sp. (Pl. XL. figs. 7-13.)

A large series from Orissa, Jubbulpore, Calcutta, Beerbhoom, Debroo\*, Delhi, Roorkee, Hurdwar, Loodiana, River Jumna, Lahore (*Day*).

The rostrum is usually almost straight, and extends to the end of the antennal scales, with the formula  $\frac{7-9}{5-6}$ ; on the upper margin the six proximal teeth are equidistant, and separated by a wider interval from two, or more rarely three, smaller subapical teeth, which are placed close together, while the second, occasionally the third, proximal tooth is placed above the orbital margin; on the lower margin the teeth are equidistant, and slightly decrease in size towards the apex. The free end of the antennal scale is rounded, and scarcely angulated internally. The carapace is smooth, with the hepatic spine rather small, and a faint sulcus which commences below the level of the latter extends back almost to the middle of the side wall of the carapace.

The first legs exceed the antennal scales by the length of their fingers. The second legs are of equal size, and rather short, being shorter than the body, but moderately stout; they are pubescent, and very slightly scabrous. The merus and carpus are subequal in length, the latter being very slightly the longer; the carpus widens slightly towards its distal end, and is equal in length to the palm or occasionally a little longer; the palm is practically cylindrical, and slightly wider than the carpus. The fingers are two thirds or more the length of the palm, and pubescent, with sharp cutting-edges in both sexes, and one or two minute basal teeth; when examined with a lens after removal of the hairs, they are seen to be finely ridged longitudinally on all sides, and punctate between the ridges. The ambulatory legs are rather slender. The telson is shorter than the terminal appendages; its apex is rather broad, but with a short median spine; the inner spinules are considerably longer than the median point, and more than twice the length of the outer spinules. The fertilized eggs carried by the female are remarkably large (in some specimens nearly 2 mm. in diameter), and this perhaps points to direct development occurring in the species.

An adult male from Roorkee is 48 mm. long, not including the rostrum; the first legs are 19.5 mm. long, and the second legs 36 mm. long. An adult female from the same locality is 45 mm. long, the first legs are 17.5 mm., and the second legs 29 mm. The largest specimen is a male from Beerbhoom 55 mm. long; and a female with ova from the

\* The locality thus expressed on the label of the bottle is probably the River Dibru in Assam.

Punjab is 38 mm. long. The second legs give the following measurements in the best preserved examples :—

	Roorkee ♂.	Roorkee ♂.	Lahore ♂.
	mm.	mm.	mm.
Length of merus .....	7·8	7·6	8·3
„ carpus .....	8	8	9
„ palm .....	8	7·8	9
„ fingers .....	5·3	5·6	6·7

This species, which is apparently very common in North India, exhibits considerable variation in the length, form, and toothling of the rostrum. In some specimens the rostrum is considerably shorter than the antennal scales, while in others it exceeds these by nearly one third of its length, and is somewhat upturned distally; the most diverse forms occur, however, in the same localities, and are connected by transitional forms. The upper rostral teeth vary in number from five to ten, according to the length of the rostrum, but in nearly all cases two are subterminal, and the distance between these and the proximal teeth depends upon the length of the rostrum, *i. e.* it is greatest in the long-rostrum forms; the lower teeth are much more constant, their number being from five to seven.

*P. Dayanus* belongs to that small section of Ortmann's group *Eupalæmon* in which the carpus and merus are subequal, or the carpus only slightly longer, and it is distinguished from the other species by the characters of its rostrum, second legs, and especially by the peculiar ridging of the fingers. *P. Malcolmsonii*\*, Milne-Edw. (Jaquemont's Voyage dans l'Inde, Crust. p. 8, pl. iii. 1844), from Nagpore, has the rostrum elevated proximally, with a single subapical tooth, the chelipedes longer than the body, the mobile finger with a velvety covering of hair, and it is a much larger species, attaining a length of 155 mm.

#### 266. PALEMOM ALTIFRONS, n. sp. (Pl. XL. figs. 4-6.)

Delhi, three specimens; River Jumna, six specimens; Lahore, six specimens (*Day*).

The rostrum reaches the end of the antennal peduncles, and is vertically deep, with the teeth  $\frac{9-12}{2-3}$ . The upper teeth are subequal and more erect than usual, with their interspaces ciliated, and the fourth tooth, occasionally the third, placed above the orbital margin; the three, or more rarely two, lower teeth are subequal in size. The upper margin of the rostrum is convex, but the apex is placed in the same horizontal line as the surface of the carapace; the apex forms an acute and slightly upturned tooth. The free end of the antennal scale is rounded internally. The carapace is slightly scabriculate anteriorly, and the hepatic spine is rather small.

The first legs have the middle of the palm opposite the end of the antennal scale.

\* This species has, so far as I am aware, not been referred to since Milne-Edwards published his description, nor is it included by Ortmann in his revision of the genus. In the characters of its rostrum it bears considerable resemblance to *P. Weberi*, De Man, from Celebes.

The second legs are subequal, or slightly unequal, in the adult male; they are about equal in length to the body, with all the joints roughened by small thorny points, and practically cylindrical. The carpus is a little shorter than the merus, and the former is slightly expanded distally; the palm is longer than the merus, though scarcely broader than the distal end of the carpus; the fingers are more than half the length of the palm, and smooth above and below, with two or three small teeth on the inner surface of the proximal half of each, the distal halves with a sharp cutting edge, and the apices yellow, horny, and incurved. The thorny spinules, though fewer in number here, are specially developed on the inner surface of the hand and immobile finger. The ambulatory legs are robust, and the posterior margin of the propodi is furnished with setæ. The apex of the telson is rather broad and obtusely pointed; the subterminal spinules are short, the inner pair being only slightly longer than the outer pair, while the terminal setæ are very long.

An adult male from Delhi is 52 mm. long, second legs 50 mm., merus 10·5 mm., carpus 9·5 mm., palm 14 mm., fingers 7·8 mm. An adult female from the Jumna is 50 mm. long, and the second legs 40 mm. long.

In adult females the fingers are not toothed internally, and the entire inner edges are thin; in young individuals the chelipedes are almost smooth, and in one specimen the fingers are even slightly longer than the palm. The carapace is much more scabriculate in some examples than in others.

In some respects this species resembles *P. scabriculus*, but in the latter the fingers are longer than the palm, and there are other important differences. It comes nearest to *P. equidens*, Dana, as defined by De Man (= *P. acutirostris*, De Man, Mergui Crust.), with which it agrees in having the carpus shorter than the merus, but in Dana's species the rostrum is not nearly so deep, and has usually four teeth below, while the inner subterminal spinules of the telson are very long. *P. asperulus*, v. Mart., from Shanghai, has a similar rostral formula, and also a short carpus, but its rostrum is longer and not so deep, with the upper margin straight. Our species belongs to that small section of *Eupalaemon* in which the carpus is shorter than the merus; it is characterized by the form of its rostrum, particularly the great depth and acute apex. *P. lanceifrons*, Dana, from the Philippines and Ceylon, has a somewhat similar rostrum, but the carpus in this species is much longer than the merus.

#### Genus NIKA, Risso.

##### 267. NIKA PROCESSA, Bate.

*N. processa*, Bate, 'Challenger' Macrura, p. 527, pl. xcv. (1888).

Gulf of Martaban, five specimens (*Oates*).

This species may be distinguished from *N. macrognatha*, Stm., recorded from Mergui by De Man, by its longer rostrum, which equals or is even slightly longer than the eye-stalks. It is very nearly allied to the European *N. edulis*, Risso, and distinguished, according to Bate, merely by its smaller size and longer legs. A female with ova is 31 mm. long.

*Distribution.* Amboina, 15 fathoms (*Bate*).

Genus *ÆGEON*, Risso.268. *ÆGEON ORIENTALIS*, n. sp. (Pl. XL. figs. 16, 17.)

Gulf of Martaban, a female (*Oates*).

The rostrum is shorter than the eyes, and excavated dorsally, with the apex obtuse and minutely bidentate; a small tooth is placed on either side of the middle of the rostrum. The carapace has a median and three lateral rows of teeth on each side, running the entire length from end to end. The median row is composed of five equal teeth, the first placed at a short distance from the rostrum. The submedian row is composed of seven subequal teeth, the most anterior of which is placed in front of the first of the median row. The lateral row is also composed of seven teeth, but they gradually diminish in size on passing backwards, and the most anterior is placed on the same level as the first tooth of the median row. The lateral marginal row is composed of seven teeth, the first placed immediately behind the large antero-lateral spine of the carapace, and well developed; the second is smaller, and the rest are minute, becoming almost imperceptible behind. A prominent spine occurs on the anterior margin of the carapace, external to the eye, but it is only about half the size of the antero-lateral spine.

The first legs are rather stout; the second pair slender and chelate, scarcely reaching the middle of the propodus of the first pair; the third pair very slender, and slightly longer than the first pair; the last two pairs rather stout. The antennal scale is short and broad, only slightly longer than the antennular peduncle, with a dense fringe of long hairs on its inner margin. The terminal segment of the antennular peduncle extends to the middle of the last joint of the antennal peduncle. The external maxillipedes are slightly longer than the first legs. The abdominal segments have a series of submedian and lateral dorsal keels; on the first segment a submedian pair, and a lateral pair on either side; on the next three segments a single median keel, with a single lateral one on either side; and on the fifth and sixth segments a submedian pair, with a single lateral keel on each side. The submedian keels on the third and fourth segments are more pronounced than any of the others. The telson is acuminate, and faintly channelled dorsally.

The single specimen is 27.5 mm. long, measured between the apices of the rostrum and telson.

The Burmese species bears a general resemblance to *A. calaphractus* (Oliv.), from the Mediterranean, but the latter has the teeth of the carapace both more prominent and more numerous, while there is a concavity on each hepatic region, in addition to other differences. There can be no doubt, however, that the two species are congeneric.

Group *PENÆIDEA*.Genus *PENÆUS*, Fabricius.

I have included all the species of *Penæus* referred to in this paper, provisionally at least, in a single genus, though, so far as I know, only *P. monodon* and *P. indicus* belong

to that genus, as restricted by Prof. S. J. Smith; most of the species are probably referable to *Parapenæus*, Smith, which is characterized chiefly by the absence of branchiæ from the last thoracic segment\*. A revision of the Penæidæ, based on a large collection both of shallow-water and deep-water forms, is much needed, for at present the genera are in a state of considerable confusion, and Spence Bate appears to have worked independently of the results previously arrived at by Smith. Too much stress has perhaps been laid on certain features of the branchial arrangement, as, for instance, the number of epipodites, in drawing up generic characters.

#### 269. PENÆUS MONODON, Fabr.

*P. monodon* (Fabr.), Bate, 'Challenger' Macrura, p. 250, pl. xxxiv. fig. 1 (1888).

(= *P. semisulcatus*, De Haan).

Bombay, Madras, Ganjam, many specimens (*Day*); very common on the South Indian coast and the chief edible species (*J. R. H.*).

The rostrum is about equal to the antennal peduncles, though sometimes longer, and is continued as a sulcate ridge almost to the hind margin of the carapace; the tooth-formula is  $\frac{6-8}{1-3}$ , with usually three teeth below. The antennular flagella are about equal in length to the peduncle. A short longitudinal ridge occurs on the carapace below the hepatic spine, and parallel to the free margin. The basal joint of the first legs is bispinose, that of the second legs unispinose. The fourth, fifth, and sixth abdominal segments are carinated. The species reaches a length of about a foot. *P. tahitensis*, Heller, and *P. carinatus*, Dana, are perhaps referable to this species.

*Distribution.* From the Red Sea and E. Africa to Japan, Australia, and the Pacific (Fijis).

#### 270. PENÆUS INDICUS, Milne-Edw.

*P. indicus* (Milne-Edw.), Bate, 'Challenger' Macrura, p. 249, pl. xxiii. fig. 2 (1888).

(= *P. merguensis*, De Man).

Kurachi, Madras, Ganjam, Calcutta, Akyab, many specimens (*Day*); very common at Madras (*J. R. H.*).

The rostrum is styliform distally, and varies considerably in length; in young examples it is usually considerably longer than the antennular peduncles, whereas in adults it is generally shorter than in the young, and is continued as a prominent crest to about the middle of the carapace; the tooth-formula is  $\frac{7-9}{3-7}$ , with, as a rule, four to six small teeth below. On the carapace the rostrum forms a faint and obscurely sulcate ridge posteriorly, which, however, does not reach the hind margin. The antennular flagella

\* The genus *Metapenæus*, Wood-Mason (Ann. Mag. Nat. Hist. ser. 6, vol. viii. p. 271, 1891), is separated from *Parapenæus* by very slight characters, the most important of which is the presence of a rudimentary anterior arthrobranch on the penultimate thoracic segment, a character which is absent in one of the species referred by Wood-Mason to the genus.

apparently vary in length, but are usually longer than the peduncles. There is no hepatic ridge on the carapace. The species reaches a length of about eight inches.

*Distribution.* Indian Seas, Malay Archipelago.

271. *PENÆUS AFFINIS*, Milne-Edw.

*P. affinis* (Milne-Edw.), Bate, Ann. Mag. Nat. Hist. ser. 5, vol. viii. p. 179, pl. xii. fig. 6 (1881).

(=? *P. monoceros*, Fabr.).

Kurachi (*Brit. Mus.*); Bombay, Canara, Madras, many specimens (*Day*); common at Madras (*J. R. H.*).

The rostrum is straight, or only slightly sinuous, reaching the end of the antennular peduncles, and continued back as a faint ridge almost to the hind margin of the carapace; the tooth-formula is  $\frac{8-11}{0}$ , the first tooth placed above the hepatic spine, and the second slightly behind the orbit. The antennular flagella are much shorter than the peduncle. The first three pairs of legs are unispinose at the base. The fourth, fifth, and sixth abdominal segments are carinated. A small sulcus is seen at the side of the base of the rostrum, termed by Stimpson the gastro-frontal sulcus. The fifth pair of legs in the male have a short projecting process bounding a notch near the proximal end of the ischium, but this is either faintly marked or absent in young males. Probably this species will prove to be synonymous with the older *P. monoceros*, Fabr. It is much smaller than either of the foregoing species.

*Distribution.* Indian Seas, Malay Archipelago.

272. *PENÆUS SCULPTILIS*, Heller.

*P. sculptilis* (Heller), De Man, Mergui Crust. p. 286 (1888).

(= *P. Hardwickii*, Miers).

Kurachi (*Brit. Mus.*); Malabar, Sunderbunds, many specimens (*Day*); Gulf of Martaban, several specimens (*Oates*); Madras (*J. R. H.*).

The rostrum is upturned and styliform distally, varying considerably in length, but usually a third or more of its length longer than the antennular peduncles, and continued back as a more or less sulcate ridge almost to the hind margin of the carapace; the tooth-formula is  $\frac{6-10}{0}$ , and the first two teeth are placed as in the last species. The antennular flagella vary considerably in length, but are usually longer than the peduncles. The first and second legs are unispinose at the base. All the abdominal segments may be carinated, but the first three indistinctly so, and sometimes not at all. This species bears some resemblance to *P. affinis*, but is distinguished at once from the latter by the presence of three crack-like marks or fissures in the integument, one (which may be absent) on the edge of the pleuron of the first abdominal segment, the second on the branchiostegite behind the middle of the carapace, and the third on the carapace, commencing above the antennal spine and running parallel to the rostral ridge, as far as a point beyond the middle of the carapace. In the adult male the meropodite of the fourth pair of legs is slightly dilated, but the fifth pair are not notched.

Considerable variation is seen in the length of the telson, and in some specimens the marginal spinules are well developed, especially the subapical pair, while in others the whole series is scarcely marked, or even altogether absent.

*Distribution.* Indian Seas, Malay Archipelago.

### 273. PENÆUS DOBSONI, Miers.

*P. dobsoni*, Miers, Proc. Zool. Soc. p. 302, pl. xvii. fig. 2 (1878).

Madras: a female specimen, probably from fresh water (*J. R. II.*).

The surface of the body is slightly pubescent. The rostrum is styliform and slightly upturned distally, with the dental formula  $\frac{8}{0}$ , the first tooth at some distance from the second, and the fourth above the orbital margin. The antennular flagella are about equal in length to the peduncle. The first three pairs of legs are unispinose at the base. The fifth pair of legs are rudimentary in the female, being represented merely by a basal protuberance on each side (while in males they are normal, according to Miers). The genital bursa or thelycum\* in the female is trefoil-shaped, with a central depression. The total length of the Madras specimen is 103 mm.

*Distribution.* Mangalore, Western India (*Miers*).

### 274. PENÆUS VELUTINUS, Dana.

*P. velutinus* (Dana), Bate, 'Challenger' Macrura, p. 253, pl. xxxiii. fig. 1 (1888).

Gulf of Martaban, a series (*Oates*).

The rostrum is straight, or rises slightly from the base to the apex, and scarcely reaches the end of the antennular peduncles, while posteriorly it does not extend behind the middle of the carapace; the dental formula is  $\frac{6-8}{0}$ , the lower margin with long cilia, and the first upper tooth separated by a wide interval from the second. The antennular flagella are very short, being scarcely as long as the two terminal joints of the peduncle. The entire surface of the body is pubescent. The eyes are of larger size than usual. The last four abdominal segments are carinated, and the distal half of the telson is armed with well-developed lateral spines. The petasma in the male is asymmetrical. The largest Martaban example is 65 mm. long.

*Distribution.* Red Sea (*Miers*); Mauritius (*Richters*); Singapore (*Walker*); Malay Archipelago (*Bate*); N. Australia (*Bate*); W. Australia (*Miers*); Loo-choo Is. (*Stimpson*); Japan (*Stimpson, Bate, Ortmann*); Sandwich Is. (*Dana*). It occurs also in the Atlantic region, on the coast of Senegambia (*Miers*), and in the West Indies is represented by the closely allied *P. pubescens*, Stm., which Miers regarded as scarcely distinct.

\* Although good specific characters are probably to be obtained from this organ, and from the petasma in the male, I have not attempted to describe them in the other species, owing to the difficulty of doing so without reference to figures.

275. *PENÆUS BREVICORNIS*, Milne-Edw.

*P. brevicornis*, Milne-Edwards, Hist. Nat. Crust. t. ii. p. 417 (1837).

*P. avirostris*, Dana, Crust. U.S. Explor. Exped. pt. i. p. 603, pl. xl. fig. 3 (1852).

Kurachi, two specimens (*Brit. Mus.*); Calcutta, one specimen (*Day*).

The rostrum is short, only slightly exceeding the eyes, with the dental formula  $\frac{6}{0}$ ; the distal half is styliform and unarmed, while the proximal half is slightly elevated above the level of the apical portion; the two proximal teeth are separated by a wider interval than any of the others. The antennular flagella are about equal in length to the peduncle. The hepatic spine is minute. The first three pairs of legs are unispinose at the base, while the fifth legs in the male are slender, with a proximal notch and ridge. The fourth, fifth, and sixth abdominal segments are carinated.

The specimens appear to belong to Dana's species, with which they closely agree, and they are probably also referable to Milne-Edwards's *P. brevicornis*. *P. Lysianassa*, De Man, from Mergui, is an allied species, but distinguished by its much shorter rostrum, which is also more elevated; the petasma has a different form, and the fifth leg in the male is not only notched, but provided with a hooked process.

*Distribution.* Indian Seas (*Milne-Edwards*); Mauritius (*Richters*); Singapore (*Dana*); Borneo (*Miers*).

276. *PENÆUS CANALICULATUS*, Olivier.

*P. canaliculatus* (Oliv.), Bate, 'Challenger' Macrura, p. 245, pl. xxxi., pl. xxxii. fig. 1, pl. xxxvii. fig. 2 (1888).

Gulf of Martaban, a single specimen (*Oates*).

The rostrum is slightly curved, and with the dental formula  $\frac{12}{1}$  (in the species generally it is  $\frac{9-12}{1}$ ); posteriorly it is continued to the hind margin of the carapace as a deeply sulcate ridge, on either side of which is a well-marked lateral sulcus. The first and second pairs of legs are unispinose at the base. The telson is unarmed, or provided with very minute lateral spinules. *P. caranote*, Risso, from the Mediterranean, and *P. brasiliensis*, Latr., from Eastern America, are closely allied.

*Distribution.* From the Red Sea and E. Africa to Japan, Australia, and the Pacific (Tahiti, Fijis).

277. *PENÆUS COMPRESSIPES*, n. sp. (Pl. XL. figs. 21, 22.)

Gulf of Martaban, a female (*Oates*).

The rostrum is short and straight, only slightly exceeding the eyes, and continued as a faint ridge almost to the hinder margin of the carapace, with the dental formula  $\frac{8}{0}$ ; the first tooth is placed some distance behind the level of the hepatic spine, almost half-way back on the carapace, and separated by a wide interval from the second, the third tooth nearly above the orbit; the upper teeth are continued to the apex, and the lower margin is ciliated. The eyes are rather small, with slender peduncles. The antennal scales are

elongated and narrow; the flagella are wanting in the single specimen. The antennular peduncles are long, and about equal in length to the antennal scales, with the two flagella subequal, and slightly longer than the carapace. The cervical groove is faintly marked on the carapace.

The first four pairs of legs are rather short, with the meral and carpal joints broad and flattened, and the lower margin of all the joints fringed with moderately long but not very numerous hairs; no spines are visible at the bases of any of the legs. The second and third chelate pairs have the fingers long and slender, almost twice the length of the palm. The last pair of legs, in the female at least, are elongated and slender, especially the last three joints, which are cylindrical and very narrow. The thelyceum shows two prominent parallel ridges bounding its lateral moieties internally. The last three abdominal segments are carinated, and there are traces of a carina on the third segment. The telson and last appendages are rather short, the former with a lateral basal notch on each side, but the margins otherwise entire, and without spinules, the apex not specially narrowed.

The branchial formula given below requires confirmation, as taken from a single specimen in which the gills readily became detached. There can be no doubt, however, that the last thoracic segment is without branchiæ, and the penultimate carries merely a single arthrobranch; the presence of a pleurobranch on segment VII. is unusual.

Segments . . . . .	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	Total.
Epipodites . . . . .	0	1	0	1	1	1	0	0	(4)
Podobranchiæ . . . . .	0	1	0	0	0	0	0	0	1
Arthrobranchiæ . . . . .	0	2	2	2	2	2	1	0	11
Pleurobranchiæ . . . . .	0	1	1	1	1	0	0	0	4
Total . . . . .	0	5	3	4	4	3	1	0	4+11+1+(4)

The length of body, not including the rostrum, is 39 mm., of the rostrum 3.3 mm., and of the antennal scales 7.5 mm.

Although there is only a single specimen of this species, I have ventured to describe it as new, for it possesses very decided characteristics, in the broad flattened feet, the narrow elongated last pair of legs, the long antennular flagella, and the toothling of the rostrum; these characters are sufficient to distinguish it from the other described species. It does not belong to the restricted genus *Penæus*, and is perhaps typical of a new generic division. In some respects it bears a resemblance to certain species of *Hemipenæus*, Bate, but in the diagnosis of this genus the hepatic spine is said to be absent, while it is present in our species.

## Genus SOLENOCERA, Lucas.

## 278. SOLENOCERA CRASSICORNIS (Milne-Edw.).

*Penæus crassicornis*, Milne-Edwards, Hist. Nat. Crust. t. ii. p. 418 (1837).

Gulf of Martaban, a single specimen (*Oates*); Madras, a single specimen (*J. R. H.*).

The rostral formula is  $\frac{10}{0}$ , the first tooth situated on the gastric area at some distance from the others, the lower margin ciliated. The antennular flagella are longer than the carapace; the broad outer flagellum longitudinally grooved or concave along its inner surface, and enveloping the slender internal flagellum. The third pair of legs have the carpus elongated, with the proximal half swollen, and the distal half narrow and cylindrical.

Spence Bate, in his 'Challenger' Report, refers this species to his genus *Philonicus*, but in the latter the antennular flagella, though long, are otherwise normal.

*Distribution.* Shores of India (*Milne-Edwards*); Waltair, Madras Presidency (*Sir Walter Elliot*, fide *Spence Bate*).

## Genus ACETES, Milne-Edwards.

## 279. ACETES INDICUS, Milne-Edw.

*Acetes indicus* (Milne-Edw.), Bate, 'Challenger' Macrura, pl. lxxv. fig. 1 (1888).

Gulf of Martaban, two specimens (*Oates*).

The larger specimen is 26 mm. long. In this aberrant genus the last two pairs of thoracic appendages are absent.

*Distribution.* Mouth of the Ganges (*Milne-Edwards*); India (*Sir W. Elliot*, fide *Spence Bate*); Singapore (*Dana*, *Walker*).

## Order STOMATOPODA\*.

## Genus LYSIOSQUILLA, Dana.

## 280. LYSIOSQUILLA MACULATA (Fabr.).

*L. maculata* (Fabr.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 5, pl. i. figs. 1, 2 (1880).

Madras (*Brit. Mus.*, *J. R. H.*); Tuticorin (*Thurston*).

*Distribution.* Red Sea, Rodriguez, Indian Seas, Malay Archipelago, Japan, and the Pacific (Samoa, Fijis, Sandwich Is., &c.).

## Genus SQUILLA, Fabricius.

## 281. SQUILLA NEPA, Latr.

*S. nepa* (Latr.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 25, pl. ii. fig. 13 (1880).

Madras (*Brit. Mus.*); Ceylon (*Haly*); Tuticorin (*Thurston*). Very common at Madras (*J. R. H.*).

\* Mr. Pocock has kindly furnished me with a list of the Indian Stomatopoda in the collection of the British Museum, and I have incorporated their localities with my own notes.

This is the commonest Stomatopod on the South Indian coast. My largest specimen is 147 mm. long.

*Distribution.* From India to China, Japan, Australia, and the Pacific generally, as far as New Zealand and the coast of Chili.

## 282. SQUILLA AFFINIS. Berthold.

*S. affinis*, Berthold, Abhandl. königl. Gesellsch. Wiss. Göttingen, Bd. iii. p. 26. Taf. iii. figs. 1, 2 (1847).

*S. oratoria*, De Haan, Crust. Japon. p. 223. pl. li. fig. 2 (1850); Heller, 'Novara' Crust. p. 124 (1865).

Madras; Sunderbunds (*Brit. Mus.*); Rameswaram (*J. R. II.*).

This species is closely allied to *S. nepa*, with which it has probably often been confused, and the two are not separated by Miers in his Revision of the Squillidæ: the distinguishing characters, though slight, appear however to be constant. The two species are separated by Dr. H. J. Hansen, who has recently examined the Stomatopoda in the British Museum.

In *S. affinis* the eyes are much larger than in *S. nepa*, with their corneal portions greatly dilated and oblique; the free thoracic and abdominal segments are more strongly carinated dorsally; and very constantly the median line or sulcated carina of the carapace widens anteriorly to enclose a very short oval space, situated behind the frontal plate, whereas in specimens of *S. nepa*, of similar size, the space so enclosed is fully twice as long, and extends almost half-way back between the frontal plate and the transverse line which interrupts the median carina.

*Distribution.* Japan (*De Haan*); China (*Berthold. Brit. Mus.*); Port Curtis, Australia (*Brit. Mus.*); Ceylon (*Heller*). Probably some of the localities recorded for *S. nepa* refer to the present species.

## 283. SQUILLA SCORPIO. Latr.

*S. scorio* (Latr.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 18. pl. ii. fig. 7 (1880).

Madras, not uncommon (*J. R. II.*).

The colour-markings are characteristic. Four almost confluent dark spots are arranged transversely on the dorsal surface of the second abdominal segment, a large spot is seen on the proximal joint of the exopodite of the terminal abdominal appendages, and the lateral process of the first free thoracic segment is also dark in colour.

*Distribution.* From India to China and Australia.

## 284. SQUILLA RAPHIDEA. Fabr.

*S. raphidea* (Fabr.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 27 (1880).

Sunderbunds (*Brit. Mus.*); Madras (*J. R. II.*).

A specimen from Madras in the Madras Central Museum measures thirteen inches in length.

*Distribution.* From East Africa to Japan.

## Genus PSEUDOSQUILLA, Dana.

## 285. PSEUDOSQUILLA CILIATA (Fabr.).

*P. ciliata* (Fabr.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 30, pl. iii. figs. 7, 8 (1880).

India (*Brit. Mus.*); Madras (*J. R. II.*).

*Distribution.* From the Red Sea to Australia and the Pacific (Fijis, Sandwich Is., &c.). It has also been recorded from the West Indies by Von Martens and Brooks.

## Genus GONODACTYLUS, Latreille.

## 286. GONODACTYLUS CHIRAGRA (Fabr.).

*G. chiragra* (Fabr.), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 40 (1880).

India; Andamans; Galle, Ceylon (*Brit. Mus.*).

*Distribution.* From the Red Sea and East Africa to Australia, and the Pacific. It is also recorded from the Mediterranean, the West Indies, and the coast of Florida.

## 287. GONODACTYLUS GLABER, Brooks.

*G. glabrous*, Brooks, 'Challenger' Stomatopoda, p. 62, pl. xiv. fig. 5, pl. xv. figs. 7, 9 (1886).

Ceylon (*Brit. Mus.*); Tutieorin, Rameswaram, and Silavaturai Par, many specimens (*Thurston*); very common between tide-marks and on the reef at Rameswaram (*J. R. II.*).

*G. glaber* is closely allied to *G. graphurus*, Miers, but the differences appear constant in a large series; I have not met with the latter species, nor does the British Museum possess Indian specimens.

In *G. graphurus* the first five abdominal segments have a distinct dorsal impressed line or groove ("suture" of Brooks), which, commencing near the mid-dorsal line of each somite, passes to the lateral surface, and takes a rounded anterior curve so as to resemble a fish-hook; on the fourth and fifth segments the two lateral grooves almost meet in the middle line. Two smaller grooves are also present on the pleura of the same segments, one arising from the convex bend of the hook, the other rising from the anterior margin of the pleuron, and taking a curved course. In *G. glaber* the dorsal surface of the abdominal segments is perfectly smooth, and merely faint grooves are seen on the pleura. In *G. graphurus* there is a short median carina on the sixth abdominal segment, placed between the submedian longitudinal elevations; whereas in *G. glaber* this carina is usually absent, or at most but faintly indicated. According to Brooks the projections on the sixth abdominal segment and telson are more sharply defined and less swollen in *G. glaber*; but this character appears to be of doubtful value, for in the type-specimen of *G. graphurus* (originally named by White in MS.) the elevations are sharply defined, and even narrower than in my examples of *G. glaber*.

My series includes specimens from 15 mm. in length up to a length of 64 mm.

*Distribution.* Samboangan (*Brooks*); Aden; Massowah; Eastern Seas; Sooloo Sea; Sir C. Hardy's Island, N. Australia (*Brit. Mus.*).

## 288. GONODACTYLUS DEMANII, n. sp. (Pl. XL figs. 23, 24.)

*Gonodactylus*, n. sp.? De Man, Broek's Crust. p. 574, Taf. xxii. a, fig. 7 (1888).

Rameswaram; four females, two males (*J. R. II.*).

I have pleasure in naming this species after Dr. J. G. De Man, who, in his Report on the Crustacea collected by Dr. Brock in the Malay Archipelago, describes and figures a single specimen from Pulo Edam, pointing out that it is probably new, but without giving it a name. It is closely allied to *G. chiragra*, but the differences seem to me other than varietal, and are not due to the specimens being young, for the following comparison has been made with examples of *G. chiragra* of similar size, and from various localities, in the British Museum collection.

In *G. chiragra* the median of the three bosses or elevations on the dorsal surface of the telson is always narrow and longitudinally oval, with its distal end frequently embraced by a horse-shoe-shaped or semicircular elevation, but without spinules. In *G. Demanii* the central elevation is much broader, and indeed subglobular; when viewed in profile it is also seen to rise much higher above the level of the telson than in the other species. A series of from five to seven spinules is placed at the distal end of this elevation, usually arranged in a somewhat semicircular form, but there is no trace of the semicircular elevation seen in *G. chiragra*, unless the spinule-bearing region represents it. The narrow lateral bosses, which are not sufficiently defined in De Man's figure, carry one or two spinules at their distal ends, and two or three spinules also occur at the base of each of the two submedian terminal spines of the telson. None of these spinules occur in *G. chiragra*, and in this species the four inner longitudinal and spinule-tipped elevations on the sixth abdominal segment are subequal in size, or at most the median pair are only very slightly larger, whereas in all my specimens of *G. Demanii* the median pair are distinctly larger. The lateral processes of the frontal plate are more acute than in *G. chiragra*, but this part appears to vary slightly in the latter species. In all the specimens, round black pigment spots occur on the dorsal surface of the hinder portion of the carapace, on the second free thoracic segment, and on the first, third, fourth, and fifth abdominal segments; this may be a juvenile character, but in similar-sized examples of *G. chiragra* the mottlings, when present, are neither so well marked nor so regularly distributed.

The largest specimen, a female, is 23 mm. long, and the largest male 20.5 mm.; but the second male, although only 12 mm. long, has the sexual appendages developed. De Man's specimen, a female, was 17 mm. long.

*Distribution.* Pulo Edam (*De Man*).

## Genus PROTOSQUILLA, Brooks.

## 289. PROTOSQUILLA TRISPINOSA (Dana).

*Gonodactylus trispinosus* (Dana), Miers, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 44, pl. iii. fig. 10 (1880).

Rameswaram (*Thurston*); Gulf of Martaban; Ceylon (*Brit. Mus.*).

*Distribution.* Mauritius (*Hoffmann*); West Australia and Amboina (*Miers*); Auckland, New Zealand (*Heller*); Fijis (*Dana*).

## EXPLANATION OF THE PLATES.

## PLATE XXXVI.

- Fig. 1. *Hoplophrys Oatesii*, gen. et sp. n. × 3.  
 2. Ditto, cephalic region from below.  
 3. Ditto, chelipede.  
 4. Ditto, abdomen.  
 5. *Micippa margaritifera*, sp. n. × 2.  
 6. Ditto, deflexed region of carapace viewed from the front.  
 7. Ditto, ambulatory leg.  
 8. *Lophactea fissa*, sp. n. × 2.  
 8 a. Ditto, chelipede.  
 9. *Hypocælus rugosus*, sp. n. × 2.  
 10. Ditto, chelipede. × 3.  
 11. Ditto, pterygostomial cavity.  
 12. *Hypocælus granulatus*, de Haan, pterygostomial cavity.  
 13. *Halimede Thurstoni*, sp. n. × 2.  
 14. Ditto, chelipede.  
 15. *Actumnus verrucosus*, sp. n. × 2.  
 16. Ditto, chelipede.  
 17. *Sarmatium indicum*, var. *malabaricum*, n., chelipede.  
 18. *Xenophthalmus obscurus*, sp. n. × 2.  
 19. Ditto, cephalic region from before.

## PLATE XXXVII.

- Fig. 1. *Telphusa Masoniana*, sp. n., nat. size.  
 2. Ditto, cephalic region from before.  
 3. Ditto, external maxillipede.  
 4. Ditto, abdomen of male.  
 5. *Telphusa Pocockiana*, sp. n., nat. size.  
 6. Ditto, cephalic region from before.  
 7. Ditto, external maxillipede.  
 8. Ditto, abdomen of male.  
 9. *Kraussia nitida*, Stm., front of carapace.  
 10. *Philyra verrucosa*, sp. n. × 2.  
 11. Ditto, cephalic region from below.  
 12. Ditto, abdomen of male.  
 13. *Pseudophilyra pusilla*, sp. n. × 4.  
 14. Ditto, cephalic region from below.  
 15. Ditto, abdomen of male.

## PLATE XXXVIII.

- Fig. 1. *Philyra polita*, sp. n., nat. size.  
 2. Ditto, cephalic region from below.  
 3. Ditto, abdomen of male.  
 4. *Ebalia fallax*, sp. n.  $\times 2$ .  
 5. Ditto, abdomen of male.  
 6. Ditto, chelipede.  
 7. *Pseudodromia integrifrons*, sp. n.  $\times 2$ .  
 8. Ditto, thoracic sternal region of female.  
 9. Ditto, cephalic region from below.  
 10. *Ramnoïdes serratifrons*, sp. n.  $\times 2$ .  
 11. Ditto, cephalic region from below.  
 12. Ditto, chelipede.  
 13. *Albanca Thurstoni*, sp. n.  $\times 2$ .  
 14. Ditto, chelipede.  
 15. Ditto, telson.  
 16. *Catapagurus ensifer*, sp. n., front from above.  
 17. Ditto, small chelipede.  
 18. Ditto, large chelipede.  
 19. Ditto, abdomen of male, showing copulatory organ.

## PLATE XXXIX.

- Fig. 1. *Diogenes affinis*, sp. n., front from above.  $\times 4$ .  
 2. Ditto, large chelipede.  $\times 3$ .  
 3. *Diogenes violaceus*, sp. n., front from above.  $\times 4$ .  
 4. Ditto, large chelipede.  $\times 3$ .  
 5. *Diogenes planimanus*, sp. n., front from above.  $\times 4$ .  
 6. Ditto, large chelipede.  $\times 3$ .  
 7. *Diogenes costatus*, sp. n., front from above.  $\times 4$ .  
 8. Ditto, large chelipede.  $\times 3$ .  
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 10. Ditto, large chelipede.  
 11. Ditto, small chelipede.  
 12. *Eupagurus zebra*, sp. n.  $\times 2$ .  
 13. Ditto, front from above.  
 14. Ditto, large chelipede.  
 15. Ditto, small chelipede.  
 16. *Pachycheles tomentosus*, sp. n.  $\times 2$ .  
 17. Ditto, frontal region from before.  
 18. Ditto, large chelipede.  
 19. *Rhaphidopus indicus*, sp. n.  $\times 3$ .  
 20. Ditto, cephalic region from before.  
 21. Ditto, large chelipede.  
 22. Ditto, ambulatory leg.

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 2. Ditto, large chelipede.  
 3. Ditto, small chelipede.  
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