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ERRATA.

Page 367, line 8 from bottom, *Bathyoscopus poceilus*, H.-Sch., read *Bythoscopus pœcilus*, Herr.-Schäff.

Page 416, line 10 from top, *Bathyscopus pocillus*, read *Bythoscopus pœcilus*, Herr.-Schäff.

THE JOURNAL

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THE LINNEAN SOCIETY.

On the Gastric Glands of the Marsupialia. By JAMES JOHNSTONE, Fisheries-Assistant, University College, Liverpool (Communicated by Prof. G. B. HOWES, Sec. Linn. Soc.)

[Read 1st December, 1898.]

(PLATE 1.)

W. A. FORBES in 1881, in an account of an investigation of the anatomy of a Koala, was led, by a consideration of many points of similarity between this animal and the Wombat, to deduce a closer degree of relationship between the two forms than was then generally admitted. The common possession of a "gastric gland," a structure which Forbes considered to be so peculiar as to render it highly improbable that it should have been independently acquired in two forms unrelated to each other, afforded him a "convincing token of their affinity." Whether or not a fuller knowledge of the nature of this structure than Forbes possessed materially strengthens his contention, does not seem certain, but this investigation into the minute structure of the gland,—an investigation suggested by reading Forbes' paper,—seems to disclose certain points worth noting.

The first mention of the presence of a gastric gland in the stomach of *Phascolomys* seems to be that made by Home (4) in 1808, who refers to it as closely resembling that of the Beaver, and "forming a very extraordinary peculiarity." Home gives a very correct figure of the external appearance of the gland, a figure which Owen (9) repeats. Owen knew of the existence of the gland in *Phascolarctus*, and described it as closely resembling that found in both *Phascolomys* and the Beaver. Later references to the gastric gland of the Marsupials in the literature are those of Huxley, 1871 (6), Flower, 1872 (2), Forbes, 1881 (1), Fleischman, 1891 (3), and Oppel, 1896 (8). Forbes had the opportunity of examining the fresh stomach of a newly-dead Koala, and described the gastric gland as red and vascular, while the surrounding mucous membrane was pale; he suggested a histological comparison of the glands of *Phascolarctus* and *Phascolomys*, with a view to finding whether the resemblance was more than an external one.

Oppel, in his important work on the comparative microscopic anatomy of the stomach, gives a very short description of the stomach of the Koala (8. pp. 291–2) and a figure of the gastric gland in section. The glands of the greater curvature and of the gastric gland itself he describes as "Fundusdrüsen." There is no exact account of the limits of the gland regions, but a reference is given to a paper by Edelmann in which the absence of the peculiar "Cardiadrüsenregion" in the Koala is described. Oppel's work (8. p. 298) contains no account of the histology of the gastric gland in *Phascolomys*.

Fleischman has a criticism of Toepfer's work (11) on the comparative anatomy of the stomach in the Rodentia, and the author makes some interesting remarks on the parallelism in structure of the stomach in the Rodents and in the Diprotodont Marsupials, which lead him to a belief in a close genetic relationship of these two groups.

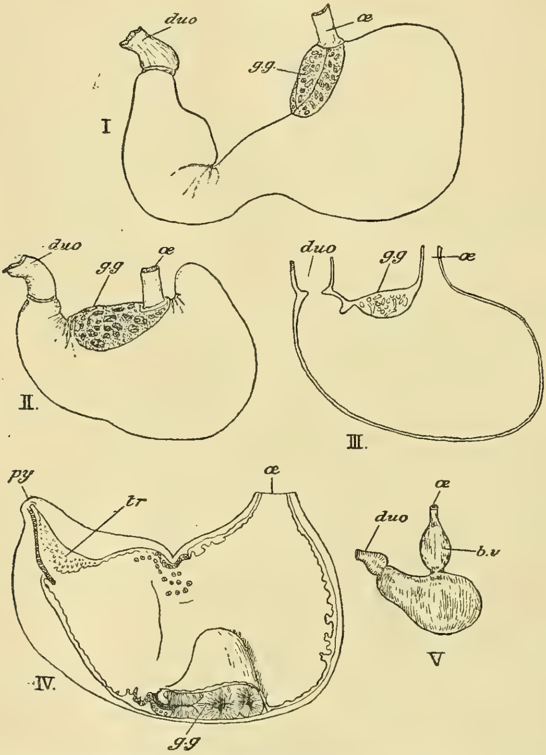
"Gastric glands" in the Mammalia outside Marsupials occur only in *Manis* among the Edentates, and in *Castor* among the Rodents. The glandular appendages on the stomach of *Manatus* evidently belong to a distinct category. The structure in the stomach of the Beaver (fig.1, I., p. 4), which seems to have been first mentioned by Schmidt (10) in 1805, was figured and described, so far as external characters are concerned, by Home (4), and its minute anatomy was more exactly described by Toepfer (11) in 1891. The stomach of *Castor* is a simple one, lined throughout by a glandular epithelium. The cuticular lining of the œsophagus ceases at the opening of that organ, and the gastric gland is situated to the pyloric side of it on the surface of the lesser curvature. Home gives a figure of a hand-section through one of the openings of the gland, which shows a number of short tubules opening into a short terminal duct, and forming a structure more closely resembling the gastric gland of *Phascolomys* than the corresponding structure in *Phascolarctus.* But the gland differs from that in the Wombat and Koala in that the openings have a serial arrangement; though, from the accounts given by various authors, the number and precise disposition of these openings is irregular. Such variation also occurs in the two Marsupials.

Manis javanica also possesses a complex glandular apparatus which may be termed a gastric gland, using the term in the same sense as in connection with the stomachs of *Castor* and the Marsupials. But the stomach of *Manis* (fig. 1, IV., p. 4), which was minutely described by Weber in 1891 (**12**), is a very specialized one; and the gastric gland is certainly morphologically a different structure from the "gastric glands" of other Mammalia. The epithelium of the stomach, with the exception of certain patches, is a non-glandular one, cuticular in nature. Three groups of openings, leading into much branched gland tubules, occur—one at the pyloric aperture, one on the lesser curvature, and one on the greater near the orifice of the gastric gland. The latter is a prominent pad on the region of greater curvature, projecting into the cavity of the stomach and opening into it by a single opening. Within there is a system of complex foldings, lined with an epithelium, which consists of closely set gland tubules possessing the characteristic central and parietal cells. At the opening of the gastric gland there is a portion of the cuticular epithelium covered over with small horny processes. A similar structure (Triturationsorgan) is found on the greater curvature at the opening of the gastric gland.

The "Vormagen" of *Myoxus avellanarius* (fig. 1, V., p. 4), and teh glandular appendage on the cardiac portion of the stomach of *Manatus australis*, which Leydig (**7**) compares with the gastric gland of the Beaver and the "Vormagen" of *Myoxus*, are evidently only analogous structures.

My material consisted of the stomachs of specimens of *Phascolomys* and *Phascolarctus.* The Wombat was a full-grown animal, and the area on the smaller curvature occupied by the glandular thickening measured 2·8 cm. along the longitudinal axis, and 3·4 cm. on the shorter axis of the stomach. The gland was situated closer to the œsophagus than in the case of the Koala, and its thickened rim partially embraced the latter, several of the openings being situated laterally to the ostium of the œsophagus. The number of these openings was about thirty, but it was difficult to count them exactly, as occasionally several seemed to open out from the bottom of little gutters, and very short ducts frequently branched quite near to the surface into several smaller tubules. Their arrangement was an irregular one, but they occupied a central position on the thickened area, leaving an annular space free. The Koala was a young one, measuring about 26 cm. from the snout along the back to the root of the tail. The gland on the lesser curvature was almost circular in shape and measured about

Fig. 1.



Schematic representations of the stomachs of—I. *Castor* (after Home), II. *Phascolomys* (Home), III. *Phascolarctus* (Oppel), IV. *Manis* (Weber), V. *Myoxus* (Toepfer). I. and II. have their inner surfaces everted; III. and IV. are in sagittal section. All the figures reduced.—*b.v.*, bulbus ventriculi; *duo*, duodenum; *g.g.*, gastric gland; *œ*, œsophagus; *py*, pylorus; *tr*, "Triturationsorgan."

10 mm. in diameter. Although it had not attained its greatest development in point of size, I have no reason to suspect that its anatomical details differed in any essential respects from those characteristic of the gland in the fully-grown Koala. The openings were much smaller than those in the Wombat, 25 in number, and occupied a central portion of the glandular thickening, round which was a part of the thickened area of mucous membrane free from openings. Unlike *Phascolomys*, the gland was situated nearly midway between the œsophagus and pylorus.

PHASCOLOMYS.

A section of the gland in the Wombat, taken parallel to the surface of the stomach, some little distance below the surface but before the bifurcation of the tubules has taken place, shows a number of tubules of varying diameter and of irregular distribution. The area of the gland is sharply bounded by a circularly running tract, which contains the cardiac glands of the surrounding epithelium of the stomach, and in which those glands are cut somewhat obliquely: this appearance is due to the plane of the section passing through the thickening of the gastric gland and surrounding epithelium. The gland itself is a somewhat lenticular shaped pad, due entirely to the complex folding which the mucous membrane has undergone. The surface of this thickening, facing the interior of the stomach, is slightly depressed. Towards the external surface the gland presents a convex border. In relation to each tubule there is a closely investing sheath of muscularis mucosæ, which accompanies it in its evagination outwards. This sheath consists mostly of a layer of plain muscle fibres, running transversely in relation to the long axis of the tubule, and, external to this transverse layer, of a very meagre, and in many places discontinuous, sheath of fibres running in the direction of the long axis of the tubule. Between these tubules is a space which is an extension of the submucosa of the general gastric epithelium, and which is occupied by areolar tissue containing blood vessels, lymph spaces, and muscle fibres. The latter are of two kinds—bundles of plain muscle fibres and of less abundant striated fibres. These are almost entirely derived from the muscular coats of the stomach, but probably also to some extent from the muscularis mucosæ. The primary tubules in the epithelium lining the evaginations which make up the gland are continuous with those in the cardiac region of the stomach, and, like these, contain the typical central and parietal cells. In sections taken parellel to the surface of the gland, these tubules are for the most part cut longitudinally, though many are obliquely and even transversely cut.

In a nearly sagittal section (Pl. **1**. fig. 1), taking in pyloric and œsophageal orifices, the extent of the gland exhibited is rather less than in one passing to one side of the œsophagus. This is due to the extension of the gastric gland laterally to the œsophageal opening. All the layers of the stomach-wall are present. The serosa (*ser.*) is scanty in the middle line, but can be recognized; the muscularis (*musc.l.*, *musc.t.*) is rather reduced; the submucosa (*sm.*) is largely encroached on by the folded mucosa and the presence of muscle bundles between these folds. The mucosa itself (*muc.*), to which the great thickness of the wall is due, is seen to have undergone an elaborate folding. At the pyloric extremity there is a gradual transition between tubules containing the parietal cells, which are present in the gland, and the epithelium immediately adjoining on the pylorus (*muc.py.*), in which the primary gland-tubules contain only central cells. At the œsophagus there is a sharp transition between those parietal-celled tubules which are present on the epithelium to the left of the former and the stratified œsophageal lining.

In any one section in such a plane (Pl. **1**. fig. 1) one or more of the openings (*o*) of the gland are cut through. These are then seen to lead into a more or less complex system of cavities, into which the mucosa is prolonged. There appear, also, isolated portions of the mucosa often containing a lumen, and in which the primary gland tubules are cut in all possible planes. Accompanying each of the secondary tubules making up the gastric gland is a sheet of muscularis mucosæ (Pl. **1**. fig. 3, *mm.*). As stated above, this consists of a tunic containing fibres mostly running transversely to the long axis of the tubule.

The muscularis is present over the whole surface of the gland. Passing from the pyloric to the cardiac extremity, the strongly developed layer of transversely running fibres forming the pyloric sphincter (*m.py.*) thins out with the commencement of the gland-thickening, and is almost entirely replaced by a layer of striated muscle fibres (Pl. **1**. fig. 1, *musc.t.*). The course of these is both transverse and longitudinal to the long axis of the stomach; and the arrangement is such that the longitudinal bundles (fig. 1, *musc.l.*) are external and the transverse ones (*musc.t.*) internal. But many are cut obliquely, and over the area occupied by the gastric gland (*i. e.* almost the whole of the lesser curvature) the oblique and longitudinal bundles form the greater part of the muscularis. Mixed with these striated muscle bundles there are strands of plain muscle fibres (Pl. **1**. fig. 3, *mp.*), the number and masses of which diminish towards the œsophagus. Striated muscle fibres are found over the region of the pyloric glands, and indeed form the musculature of the gastric-gland thickening. Delicate strands of both plain and striated (Pl. **1**. fig. 3, *m.int.*) muscle fibres penetrate into the submucosa, between the secondary tubules of the gland, although most of these are unstriated fibres, and are derived probably both from muscularis and muscularis mucosæ.

The course taken by the secondary tubules or involution of the gastric gland is, in *Phascolomys*, a comparatively simple one. Many openings on the surface of the gland lead into simple pits, but others are more complex, and a single tubule divides into a small number (2–6) of branches. But the length of these side tubules relatively to their diameter is much less than in *Phascolarctus*. The lumen is always a narrow one; and the thickness of the epithelium lining these tubules is generally greater than that on the free surface of the stomach.

PHASCOLARCTUS.

The most striking differences in the structure of the gastric gland of the Koala and that just described for the Wombat, lie in the greater compactness of the former and greater complexity in the ramifications of the tubules, and in the nature of the muscular coat. The latter is arranged in an external longitudinal (Pl. **1**. fig. 2, *musc.l.*) and an internal circular layer (*musc.t.*). But the musculature over the gastric gland, which in *Phascolomys* was composed predominantly of striated fibres, is here made up entirely of nonstriated fibres (Pl. **1**. fig. 4, *musc.l.*, *musc.t.*). The muscularis is less strongly developed than in *Phascolomys*, and the transverse bundles are the more numerous. At the œsophagus striated muscle fibres (Pl. **1**. fig. 2, *m.œ.*) are present; and the transition from these to plain fibres is, on the pyloric side of the œsophageal opening, a sharp one. On the cardiac side, however, the longitudinal musculature of the œsophagus extends for a short distance unmixed with nonstriated fibres over the surface of the stomach. The striated, transverse œsophageal musculature is gradually replaced by the nonstriated musculature of the stomach. On the pyloric side, the distribution of striated muscle fibres is coterminous with that of the œsophageal epithelium. On the cardiac side this double line of demarcation between œsophagus and stomach is not so clear, but exists to a large extent.

The primary gland tubules, as in the case of *Phascolomys*, are made up of central and parietal cells. But the tubules which in the Wombat are straight and unbranched, are here more complex. A single tubule (Pl. **1**. fig. 6) is lined at its opening on the surface of the stomach with columnar cells (*cn.*), which in the neck are replaced by clear cubical cells. At the first bifurcation the parietal cells (*cp.*) appear. In the tubule figured a group of eight lesser tubules is brought about by a triple bifurcation. Other of the glands are simpler or more complex, but this type seems to be the more general.

Each opening (*o*) on the surface of the gastric gland leads into a relatively wide tubule which, after remaining undivided for a length equal to twice or more than twice its own diameter, branches into two or more divisions, from which other branches are given off, either laterally or terminally. These branches end blindly ; in diameter they are about 0·5 mm. There are no anastomoses. In the end a very complex cluster of short tubules is produced. The course of these branch tubules is generally transverse to the long axis of the stomach, so that in sections taken through the pylorus and œsophagus they are mostly cut transversely. In sections in the same plane, passing through the more peripheral portion of the glandular thickening, where there are no openings on to the internal surface of the stomach, the whole gland-pad consists of a closely packed mass of these branched tubules bound together by muscular and connective tissue. I have counted as many as 35 of them cut transversely in a section passing through the peripheral portion of the gland.

As might have been expected from their external form and situation, the gastric glands of *Phascolomys*, *Phascolarctus*, and of *Castor* do not exhibit any essential points of difference in their minute anatomy. From Toepfer's account (**11**), the gland in the

Beaver, except in the arrangement of its openings on the internal surface of the stomach, is not dissimilar from the structures I have described in the Koala and Wombat. In each case the cavity of the stomach is prolonged by means of a variable number of evaginations into short tubular extensions which, branching frequently, end in series of tubules which do not anastomose but end blindly. The mucous membrane covering the general surface of the stomach is prolonged without interruption into, and forms the walls of, these systems of branching cavities. But whereas in *Phascolomys* the ramifications of the proximal portions of the evaginations are comparatively simple, the terminal portions short, the branches few, and the lumen a contracted one, in *Phascolarctus* each separate evagination forms a very complex system of tubules communicating with the stomach, which simulate the form of a true racemose gland. The terminal portions are relatively long and their lumina conspicuous. The primary gland tubules making up the gastric epithelium of the gland in both cases are cardiac glands similar to those found on the cardiac portion of the stomach and contain parietal cells. In *Phascolomys* these glands (Pl. **1.** fig. 5) form a close-set series of straight unbranched tubules, in length about 0·56 mm., in which parietal cells extend from near the neck to the base of the gland, although they are rather concentrated at the middle of the tubule; while in *Phascolarctus* each gland (Pl. **1.** fig. 6), which is about 0·3 mm. in length, consists of a terminal neck portion, lined with columnar or cubical cells (*cn.*), which branches several times, forming a series of long tubules opening through a common orifice at the lumen of the gastric-gland involution. As in *Phascolomys* and the Beaver, the gland contains both central (*cn.*) and parietal (*cp.*) cells.

Only the mucosa and muscularis mucosæ of the various coats of the stomach take part in the formation of the gastric gland. Submucosa and muscularis are only passively affected. In *Phascolarctus* the musculature over the thickened area is the layer consisting of outer longitudinally and inner transversely disposed fibres, which is characteristic of the other parts of the stomach. But in *Phascolomys* the musculature consists almost entirely of bundles of striated fibres; and the division of these into external longitudinal and internal transverse layers is not so evident as in the case of *Phascolarctus*, most of the bundles pursuing a more or less oblique course.

The great development of striated muscle fibres over the gastric gland seems remarkable, but since the posterior limit of the striated musculature characteristic of the upper part of the œsophagus seems to vary in different animals, this extension into the region of lesser curvature of the stomach is probably without any special significance. But it suggests a comparison with the glandular "bulbus ventriculi" of *Myoxus avellanarius*—an organ which, though not strictly homologous with, probably belongs to the same category of structures as, the gastric glands of the other mammals mentioned, and in which the musculature is a striated one. This organ was first described by Home (**5**), who compared it with the gastric gland of the Beaver, with which he found it to correspond "very minutely in its internal structure." It appears as a bulb-like enlargement of the lower portion of the œsophagus resting on the stomach, from which it is separated by a deep constriction. The cuticular lining of the œsophagus ceases at its anterior extremity, and is replaced by a very thick layer of glandular epithelium containing glands made up of central and parietal cells. Home describes these glands as having an arrangement similar to those in the glandular pad of the Beaver's stomach. "Each orifice," he says, "exposes three small openings, these again lead to smaller processes, as has been described and delineated in the glandular structure of the Beaver." Leydig (**7**), speaking of the glandular appendage on the cardiac part of the stomach of *Manatus*, where a compound tubular gland is found, refers to the "Vormagen" of *Myoxus* as something similar. Meckel regarded it as a truly avian structure. Toepfer (**11**), who investigated the structure of this organ, found it to be provided with a thick layer of striated muscle-bundles which are a direct continuation of those found in the upper part of the œsophagus; and, in a discussion as to its morphological nature, he regards the presence of the epithelium rich in glands as affording a more reliable test of the morphological nature of the organ than the presence of an œsophageal musculature. If the bulbus is gastric and not œsophageal in origin, then the whole stomach of *Myoxus*—*i. e.* the true stomach and bulbus ventriculi—is homologous with the simple stomach of *Castor* provided with a concentration of cardiac glands on the region of its smaller curvature, since in *Myoxus* such a concentration occurs round the entrance of the œsophagus.

In the Beaver, as in *Phascolomys* and *Phascolarctus*, there is the important difference in the disposition of the gland regions of the stomach as compared with *Myoxus*, that the cardiac glands of the latter, that is the glands composed of parietal and central cells, are restricted to the bulbus ventriculi, and the rest of the stomach contains only pyloric glands ; while in the three first mentioned forms the whole stomach is glandular, and cardiac glands, although predominantly crowded together in the gastric-gland thickening, are not wholly restricted to it as they are to the bulbus of *Myoxus,* but are found to a certain extent over the region of the fundus. The area on the stomach of the Beaver occupied by cardiac glands is therefore to be regarded (on Toepfer's view) as homologous with the "Vormagen" of *Myoxus.* The extent to which these glands extend over the lateral walls and region of greater curvature of the stomach has not been investigated, nor have the precise limits of the pyloric glands been determined, either for *Castor* or for the Marsupials referred to.

In *Manis*, although the gastric gland on the greater curvature of the stomach cannot be regarded as homologous with those in other mammals, it is more comparable to the bulbus ventriculi of *Myoxus* than to any of the others, for here there is a definite restriction of the cardiac glands to a portion of the stomach-wall, where they are arranged as a complex glandular organ, the rest of the stomach being non-glandular, with the exception of certain patches which contain glands probably homologous with the pyloric glands of the other mammalia. Here, too, it seems that a direct correlation with the nature of the food and the other parts of the alimentary canal and disposition of the mucous membrane of the stomach exists ; a proposition that can hardly be made with regard to the gastric glands of either the Marsupialia or the Rodentia. There are simple stomachs unprovided with any complex glandular apparatus in the Phalangers, as in the *Myoxidæ* other than *M. avellanarius.*

The formation of the "gastric gland" as we find it in the Marsupials seems to be explicable in one of two ways. First, as the result of a tendency to localization of the gland regions,—a tendency which finds its expression alike in the structures I have described, in the glandular cardiac appendage of *Manatus*, and more completely in the "gastric gland" of *Manis* and the bulbus ventriculi of *Myoxus.* But we may also with Oppel (8. pp. 402–3) in the case of the Beaver and the Marsupials, regard it as due to the necessity for increase in the area of the gastric epithelium containing cardiac glands ("progressive development"), and in *Manis* as due to the restriction of that area ("retrogressive development"). In the first case it is related to the necessity of digestion of an exceeding large amount of food-material; and in the second to the digestion of a small quantity of easily assimilated food.

The terms "gastric gland" of English authors and "grosse Magendrüse" employed by the Germans, are alike misnomers. The organ, as both Oppel and Toepfer have pointed out, is not a gland in the sense in which that term is legitimately employed, but a complex evagination of the gastric wall, bearing, in common with the rest of the stomach, true glands; and as such it does not seem as if its value can be very great as affording any trustworthy indication of the phylogenetic history of the animal in which it occurs. In the case of two forms like *Phascolarctus* and *Phascolomys*, known, from other considerations, to be nearly related to each other, the common presence of a "gastric gland" may indeed afford reason for their closer approximation; and in these animals the organ does seem to be homologous, although in the Koala its structure is more specialized than in the case of the Wombat. But statements as to an organ in the Rodentia resembling the "gastric gland" of Marsupialia, and conclusions as to a closer degree of genetic relationship of these two groups, deducible therefrom, in view of the great specialization of the stomach occurring in some Rodents, must, I think, be received with hesitation.

I am indebted to Prof. G. B. Howes for supplying me with the material reported on, and for kindly furnishing me with many of the works cited. Part of this investigation was done while I was still a student under him in the Research Laboratory of the Royal College of Science, London.

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EXPLANATION OF PLATE 1.

Fig. 1. Vertical section through the gastric gland of *Phascolomys* parallel to the long axis of the stomach, but passing to one side of the œsophageal and pyloric apertures. × 6 diameters.

Neither in this nor in figs. 2, 3, & 4 has any attempt been made to represent the histological details of the mucous epithelium. But broken lines and circles are employed to indicate the direction in which the primary gland-tubules are cut.

Fig. 2. Vertical section through the gastric gland of *Phascolarctus* parallel to long axis of the stomach but passing to one side of the œsophagus. × 8 diameters.

Fig. 3. Portions of three contiguous tubules of the gastric gland in *Phascolomys* from its pyloric extremity. Vertical section, parallel to longitudinal axis of stomach. × 20 diameters.

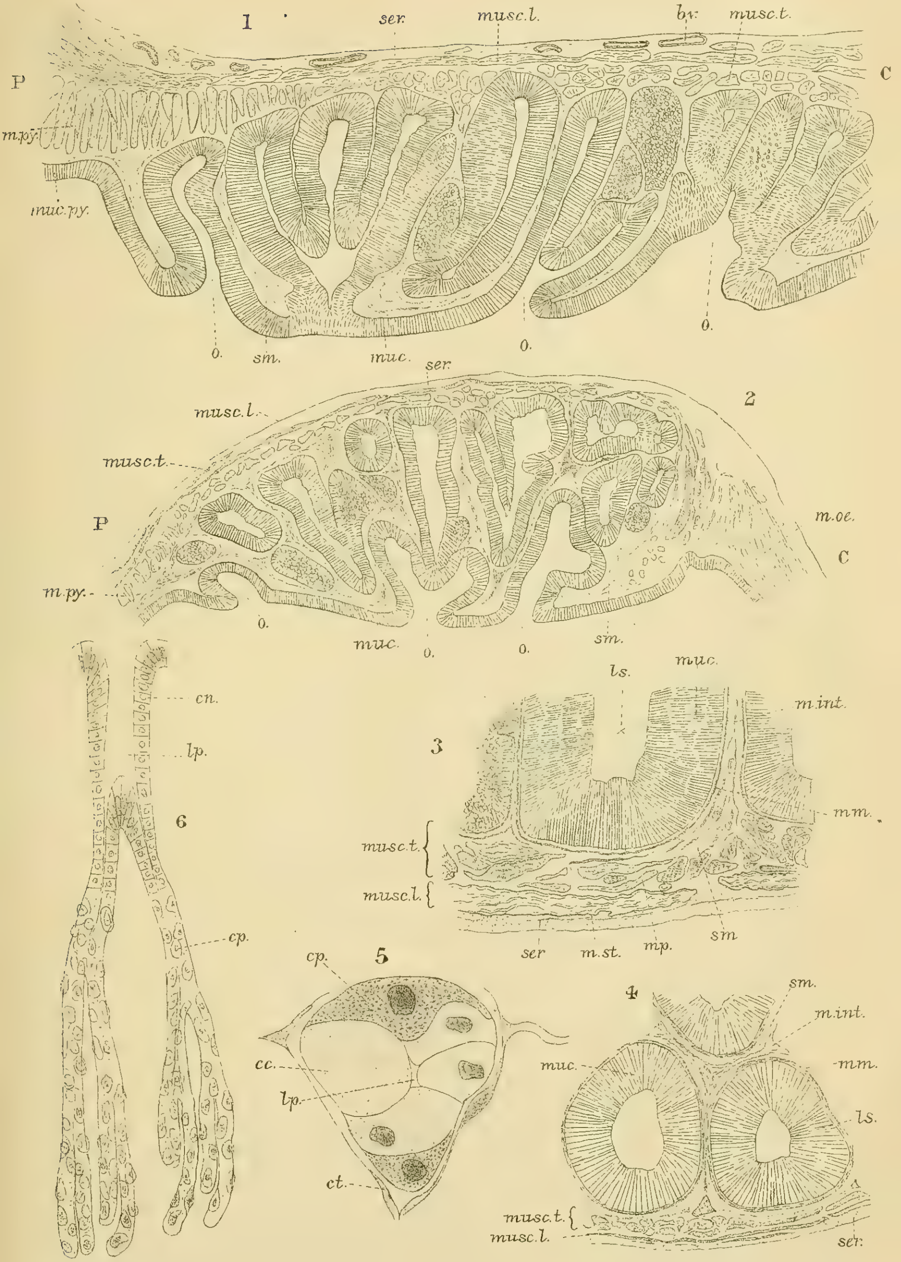
Fig. 4. Three contiguous tubules of the gastric gland of *Phascolarctus*. Vertical section, parallel to longitudinal axis of stomach. × 30 diameters.

Fig. 5. Transverse section of a primary gland-tubule from the gastric gland of *Phascolomys*. × 694 diameters.

Fig. 6. A primary tubule from the gastric gland of *Phascolarctus*, seen in optical section. × 266 diameters.

Reference Letters.

bv.	Blood-vessels.
cn.	Neck-cell in primary gland tubule.
cp.	Parietal cell.
cc.	Central cell.
ct.	Connective tissue between primary gland tubules.
lp.	Lumen of primary gland tubule.
ls.	Lumen of gastric-gland tubule.
musc.l.	Longitudinal layer of muscularis.
musc.t.	Transverse layer of muscularis.
m.int.	Nonstriated muscle fibre between gastric-gland tubules.
mp.	Nonstriated muscle fibres.
mst.	Striated muscle fibres.
mm.	Muscularis mucosæ.
m.œ.	Œsophageal musculature.
m.py.	Pyloric sphincter.
muc.	Mucosa.
muc.p.	Pyloric mucosa.
o.	Opening of the gastric-gland evaginations into the stomach.
ser.	Serosa.
sm.	Submucosa.
C.	Cardiac extremity of gastric gland.
P.	Pyloric extremity of gastric gland.



J. Johnstone del.
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GASTRIC GLANDS OF MARSUPIALIA.

On some Spiders from Chili and Peru collected by Dr. Plate of Berlin. By F. O. PICKARD-CAMBRIDGE. (Communicated by Prof. G. B. HOWES, F.R.S., Sec.L.S.)

[Read 17th November, 1898.]

(PLATE 2.)

THE present paper contains a list of the Spiders collected by Dr. Plate on a voyage extending from Tumbez in North Peru, down the coast of Chili, to Cape Horn. The collection contained nineteen species, of which seven are new to science. One species has been described in MS. for some years by Mr. R. I. Pocock, of the British Museum of Natural History, and this description has recently been published. There is nothing very striking or noteworthy in this collection, although all spider-forms are interesting from whatever part of the world they come.

There is one curious point to be noted. Two species taken in the island of Juan Fernandez, 500 miles west of Valparaiso, are identical with examples which are indigenous to Northern Europe, namely *Teutana grossa* and *Dysdera crocota*. These spiders are, however, found almost all over the world, so that their presence in Juan Fernandez is not perhaps so astonishing, when we find them also in the Sandwich and Cape Verde Islands, separated by thousands of miles of ocean and continent.

List of Species.

THERAPHOSIDÆ.	
Paraphysa manicata, E. Simon.	Coquimbo, Chili.
Phryxotrichus roseus (Walck.)?	Corral.
Citharoscelus Kochii, Pocock.	Coquimbo, Chili.
SCYTODIDÆ.	
Sicarius thomisoides, Walck.	Coquimbo and Iquique, Chili
DYSDERIDÆ.	
Ariadna maxima (Nic.).	Juan Fernandez.
Dysdera crocota, C. Koch.	” ”
CLUBIONIDÆ.	
Sparassus bombilius, sp. n.	Amciven.]
Gayenna maculatipes, Keys.	Juan Fernandez.
DICTYNIDÆ.	
Amaurobius Platei, sp. n.	Tumbez, Peru.

Argiopidæ.	
Meta nigrohumeralis, sp. n.	Juan Fernandez.
Tmeticus Defoei, sp. n.	,, ,,
,, *Platei*, sp. n.	,, ,,
Theridiidæ.	
Teutana grossa, C. K.	,, ,,
Theridion tepidariorum, C. K.[1]	Cavan.
Pholcidæ.	
Pholcus americanus, Nic.	Chili.
Agelenidæ.	
Rubrius annulatus, sp. n.	Corral.
Lycosidæ.	
Lycosa implacida, Nic.	Coquimbo.
,, *fernandezi*, sp. n.	Juan Fernandez.
,, *australis*, E. Simon.	Tekenilla, Cape Horn.

Family Theraphosidæ.

Paraphysa manicata, *Sim.*, *Hist. Nat. Ar.* i. p. 166.

A single adult female was taken at Coquimbo by Dr. Plate in Sept. 1893.

Phryxotrichus roseus (*Walck.*)?

An adult male and female of this species were taken by Dr. Plate in Corral, Dec. 1894.

Citharoscelus Kochii, *Poc. Ann. Mag. Nat. Hist.* April 1899. (Pl. 2. figs. 13–15.)

A single female of this species was taken by Dr. Plate at Coquimbo.

An adult female *Eurypelma*, which I hesitate to assign to any species, as well as several immature forms, occurred in Dr. Plate's collection.

Family Scytodidæ.

Sicarius thomisoides, *Walck.*

Thomisoides terrosa, Nic., Gay, Hist. de Chile, vol. iii. p. 350, 1849.

Walckenaer forestalled Nicolet in publishing a description of this species and used that author's generic name as the specific. The genus and species belong undoubtedly to Walckenaer, who obviously saw Nicolet's work in print, though not published.

The type of the genus can scarcely be *terrosa*, Nic., for this was an *unpublished name*. To the single species which Walckenaer recognized, the name *thomisoides* was given when he gave the name *Sicarius* to the genus. *S. thomisoides*, Wlk., is therefore the type of the genus *Sicarius*. If we regard *Sicarius* as the proper generic title on the ground that, at the time of its publication, *Thomisoides* existed only in manuscript, or, if in type, as an unpublished name, as M. Simon has done in Hist. Nat. Ar. 2 ed. p. 271, we must also regard *thomisoides* as the proper specific title, which M. Simon has however not done in the place mentioned.

Several females and a male of this species were taken by Dr. Plate at Coquimbo and Iquique.

Family DYSDERIDÆ.

ARIADNA MAXIMA (*Nicolet*).

Dysdera maxima, Nic., Gay, Hist. de Chile, Zool. iii. p. 341, plate ii. fig. 6.

Two examples were taken by Dr. Plate in the island of Juan Fernandez.

DYSDERA CROCOTA, *C. K.*, *Die Arachniden*, Bd. v. p. 81.

Three adult males of this species were taken in Juan Fernandez by Dr. Plate.

Family CLUBIONIDÆ.

SPARASSUS BOMBILIUS, sp. n. (Pl. 2. figs. 1 & 2.)

♂. Total length 15 mm.; carapace 7×7; legs, i. 34—ii. 30—iii. 27—iv. 28.

Colour. Carapace mahogany-brown clothed with golden-grey hairs. Mandibles black, clothed with long golden-grey hairs. Fang-groove fringed with ferruginous-red hairs. Legs very dark mahogany, almost black, hirsute with stiff golden-grey hairs; abdomen clothed with rough golden-grey hairs, a transverse band across the shoulders black, continued indistinctly down the dorsal line, with a second narrower transverse dark band just before the middle, followed towards the spinners by a narrow central band having very short indistinct oblique lateral rays. Lateral area dark brown; sub-ventral area golden-grey, embracing the spinners; central ventral area black. Sternum deep brown, clothed with short golden-grey hairs. Palpi: femora and patellæ orange, tibiæ and tarsi deep brown or black.

Structure. Carapace almost circular, convex. Anterior row of eyes procurved, posterior row straight. Central anteriors slightly larger than laterals; central posteriors slightly smaller than posteriors; central quadrangle slightly broader than long. Tibial apophysis of palpus S-shaped, falciform, its apex directed outwards and slightly dilate, compressed, spiraliform. Palpal bulb surrounded by a stout circular spine, lying in a groove in the surface of the bulb.

A single adult male of this beautiful species was taken by Dr. Plate at Amciven.

GAYENNA MACULATIPES, *Keys.*, *Brasilianische Spinnen*, p. 141, pl. iv. 97 & 97 *a*.

Although the adult male example from Juan Fernandez is considerably larger than the type in Keyserling's collection, yet I am unable to find any difference in the structure.

An adult male and an immature female were taken by Dr. Plate in Juan Fernandez.

Family DICTYNIDÆ.

AMAUROBIUS PLATEI, sp. n. (Pl. 2. fig. 3.)

♂. Total length 12 mm.; carapace 5·5 × 3·5; leg i. 21.

Colour. Carapace pale orange-yellow, suffused with sooty-black on the margins of the caput. Mandibles deep mahogany-brown. Legs pale yellow, deepening to mahogany-brown towards the extremities. Legs i—femora mahogany-brown, with two indistinct dark transverse spots beneath; patella, tibia, protarsus, and tarsus deep mahogany-brown. Legs ii—femora pale yellow, with two transverse spots beneath, the rest as in i. Legs iii. and iv. paler; tibiæ and protarsi indistinctly annulate with sooty-brown. Abdomen black, with pale anterior dorsal area, containing four ill-defined white spots, followed to the spinners by a series (3 or 4) of narrow white Λ-shaped bars. Apex of abdomen deep black. Sternum pale orange-yellow.

Structure. For figure of palpus see Plate 2. fig. 3.

A single adult male was taken by Dr. Plate at Tumbez.

Family ARGIOPIDÆ.

META NIGROHUMERALIS, sp. n. (Pl. 2. figs. 4 & 5.)

♀. Total length 15 mm.

Colour. Carapace pale orange-yellow; the caput, central stria, and a submarginal line rich brown. Mandibles rich mottled brown. Legs pale orange-yellow; femora suffused with brown towards the apex; patellæ, tibiæ, and protarsi of i. and ii.

suffused and indistinctly annulated with brown; those of iii. and iv. more definitely annulate. Abdomen pale clay-white with deep black shoulder-spots—or a large black spot, bilobate and margined with pure white behind; a central brown band runs to the spinners, giving off lateral sooty-brown oblique lines, blending with the mottled brown and black lateral areas; ventral surface pale yellow-brown, margined on each side with a straight, narrow, broken white band. Sternum rich brown.

Structure. A figure of the vulva appears on the Plate (fig. 5).

Six adult females were found on the island of Juan Fernandez by Dr. Plate, but no males. This species bears a general resemblance to the European *Meta Menardi*, which is also found in North America, but is none the less quite distinct from it.

Tmeticus Defoei, sp. n. (Pl. 2. figs. 6 & 7.)

♀. Total length 7·5 mm.

Colour. Carapace, sternum, and legs rich orange-mahogany-brown. Abdomen black, with a pale yellow curved band on each side of the anterior dorsal area, enclosing a large black triangular patch; behind these longitudinal bands come two short transverse pale bands on each side. The lateral area has two longitudinal indistinct pale bands, and the ventral surface bears in the centre a dull pale blotch.

Structure. The mandible exhibits on the outer side the usual transverse striæ; and a figure of the vulva will be found on the Plate (fig. 7). The inferior margin of the fang-groove bears a row of five short cusps; the superior a row of seven longer teeth. The tibiæ of the legs bear a pair of short erect dorsal bristles.

Two adult females were taken by Dr. Plate on the island of Juan Fernandez.

Tmeticus Platei, sp. n. (Pl. 2. figs. 8 & 9.)

♀. Total length 8·5 mm.

Colour. Carapace, mandible, legs, and sternum dull orange-brown, more or less suffused with darker brown. The base and apex of the femora are suffused with darker brown. The tibiæ and protarsi have each an indistinct broad dark annulation towards the base, and another narrower one towards the apex. Abdomen olive-brown; dorsal area mottled with dull yellow-white blotches, the best defined being a series of five transverse Λ-shaped bars, their apices not confluent, extending from the middle to the spinners.

Structure. Mandibles very stout, with two rows of teeth, the inferior with 9 small conical cusps, the superior with 11 long stout teeth increasing in length, the longest being the fifth to the tenth. Outside the superior row of teeth lies an irregular row of stiff bristles. *Eyes.* Posterior row straight; eyes subequal, centrals slightly closer together, three fourths of a diameter apart; anterior row slightly recurved; centrals small, one fourth smaller than the laterals, half a diameter apart, over one diameter from the laterals: lateral eyes equal and in contact. Tibiæ of legs with two erect bristles above, one near the base, the other towards the apex. The mandibles bear a series of striæ on the outer side, and the coxæ of the palpi a few stiff bristles on the inner side.

A single adult female was taken on the island of Juan Fernandez by Dr. Plate.

Family THERIDIIDÆ.

TEUTANA GROSSA, *C. K.*

Theridion grossum, C. K., Die Arachniden, iv. p. 112.

Two adult females were taken on the island of Juan Fernandez by Dr. Plate.

THERIDION TEPIDARIORUM, *C. K.*, *Die Arachniden*, viii. p. 75.

A single adult female was taken at Cavan by Dr. Plate.

Family PHOLCIDÆ.

PHOLCUS AMERICANUS, *Nic.*

Two examples, which probably belong to this species, occurred in Dr. Plate's collection from Chili.

Family AGELENIDÆ.

RUBRIUS ANNULATUS, sp. n. (Pl. 2. fig. 10.)

♀. Total length 15 mm.

Colour. Carapace, sternum, and legs pale orange-yellow, mandibles black, maxillæ and labium deep brown. The sides and anterior margin of the caput are deep brown, besides a narrow central and two narrow lateral brown bands converging at the central stria. An irregular brown band runs midway between the central stria and the margin, consisting in reality of a series of blotches on the lateral striæ which are confluent. The margin of the sternum is suffused with dark brown. The femora of the legs bear three indistinct dusky annulations; the patellæ are dusky along their sides, while the tibiæ have two deep brown annulations on the upperside, obsolete below. The protarsi also exhibit two dark annulations. The abdomen, which has somewhat lost its colour, is dull white mottled with dark grey.

Structure. Carapace long, narrow; caput raised, convex, with three rows of stiff hairs along the three brown bands. Posterior row of eyes slightly procurved, eyes equal, centrals rather closer, one and an eighth diameter apart. Anterior row straight, centrals slightly smaller than the laterals, three fourths a diameter apart, the same distance from the laterals. Clypeus equal to a diameter of the anterior centrals. Mandibles stout, triangular, conical, gibbous above (as in *Cœlotes*). The margins of the fang-groove bear, each, 5 teeth, and the upper margin bears also a fringe of long incurving hairs. Legs spinose, femora with five or six spines above, tibiæ with three pairs beneath and one on each side, toward the apex, and often one towards the base. Protarsi with three or four pairs of stout, long spines beneath. Anterior tarsi with a double series of stiff bristles beneath; posterior with some spines towards the apex, amongst the bristles. Tarsal claws three.

I refer this spider to the genus *Rubrius*, E. Simon, although the character assigned to it, with several other genera, "chelarum margo inferior dentibus, 3 or 4 armatus," does not strictly apply. The species is undoubtedly closely allied to *R. subfasciatus*, Sim., Mission Sci. du Cap Horn, p. 14 (1887), but still distinct from it. The central anterior eyes are not very much smaller than the laterals, certainly not "plus duplo" as M. Simon says of *subfasciatus*.

A single adult female was taken by Dr. Plate at Corral.

Family Lycosidæ.

Lycosa implacida, *Nic.*

Gay, Hist. de Chile, Zool. iii. p. 358, pl. ii. fig. 10.

A single specimen (♀ adult) from Coquimbo, Chili.

Lycosa fernandezi, sp. n. (Pl. 2. figs. 11 & 12.)

♂. Total length 16 mm.; carapace 8 × 6; legs, i. 26—ii. 23·5—iii. 22·5—iv. 29·5

♀. Total length 25 mm.; carapace 10 × 7; legs, i. 27—ii. 25—iii. 24—iv. 33.

♂. *Colour.* Carapace mahogany-brown, clothed with fine golden-brown pubescence. Legs clothed with golden-brown pubescence. Anterior tibiæ and tarsi sooty black. Abdomen: shoulders black; anterior half with a central dorsal brown bar, its three angles picked out with black, followed towards the spinners by two or more small triangular black marks; on each side is a row of three or more black spots, contrasting with some white ones lying adjacent. Ventral surface unicolorous pale golden grey.

♀. *Colour* similar to that of the male, except that the golden pubescence has a deeper yellow-olive tinge. Abdomen entirely clothed on the upper side with golden brown pubescence, with a central dorsal suffusion of rust-red. Shoulders slightly tinged with brown, anterior dorsal mark very obscure, followed towards the spinners by two or three very obscure pale Λ-shaped marks.

♂. Structure. Palpus & organs. See Plate 2. fig. 11.
♀. ,, Vulva. See Plate 2. fig. 12.

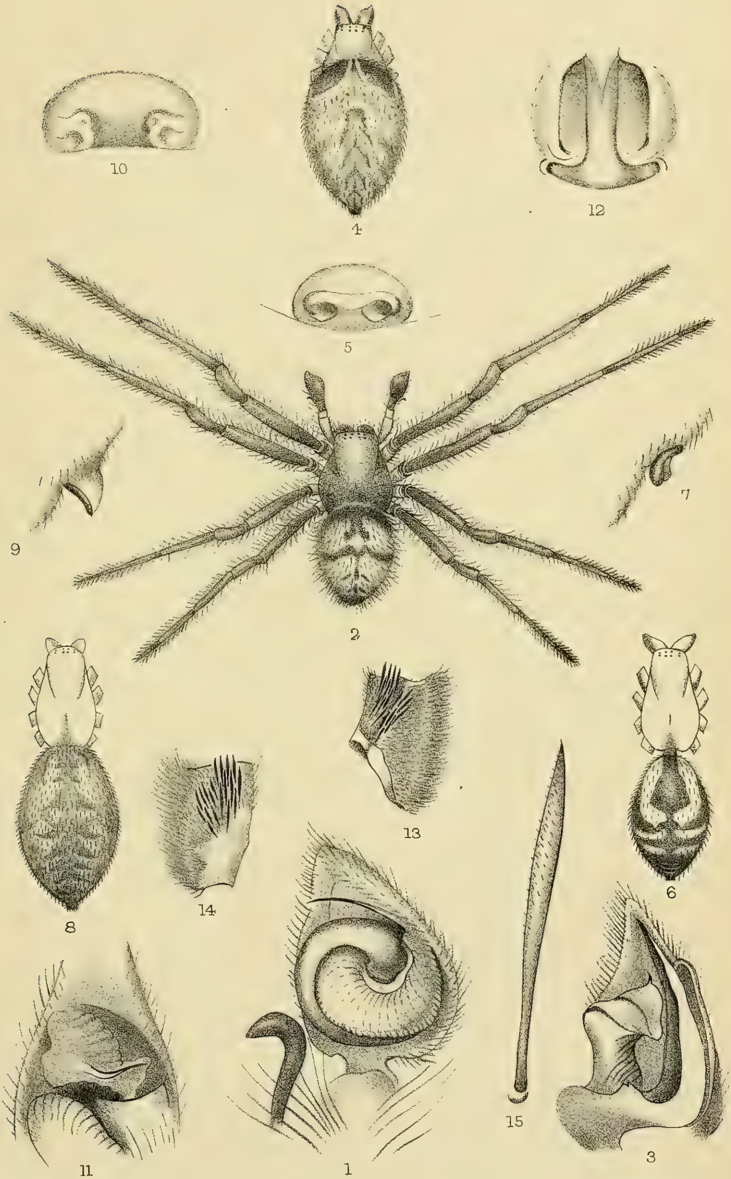
Four females and one male of this species, belonging to the *Trochosa* group, were taken by Dr. Plate in the island of Juan Fernandez.

LYCOSA AUSTRALIS, *E. Simon*, *Bull. Soc. Zool. Fr.* 1884, p. 3.

A single adult male, most probably belonging to this species, was taken at Tellenika on the False Cape Horn. M. Simon's type was taken on the Ile Hoste.

EXPLANATION OF PLATE 2.

Fig. 1. *Sparassus bombilius*, sp. n. Adult male. Right palpus from beneath.
2. ,, ,, ,, ,, Full figure.
3. *Amaurobius Platei*, sp. n. Right palpus.
4. *Meta nigrohumeralis*, sp. n. Adult female. Full figure.
5. ,, ,, Vulva.
6. *Tmeticus Defoei*, sp. n. Adult female. Full figure.
7. ,, ,, ,, ,, Vulva.
8. ,, *Platei*, sp. n. Adult female. Full figure.
9. ,, ,, ,, ,, Vulva.
10. *Rubrius annulatus.* Adult female. Vulva.
11. *Lycosa fernandezi.* Adult male. Palpal bulb.
12. ,, ,, Adult female. Vulva.
13. *Citharoscelus Kochii.* Female. Coxa of leg i., inside, showing stridulating spines.
14. ,, ,, ,, Coxa of pedipalp, outside, showing stridulating spines.
15. ,, ,, ,, A single stridulating spine, enlarged.



F. O. Pickard-Cambridge del. et lith. West, Newman imp

SPIDERS FROM CHILI & PERU.

On the Zoology and Botany of the Altai Mountains.

By H. J. Elwes, F.R.S., F.L.S.

[Read 15th December, 1898.]

It would be impossible, within the limits at my disposal, to give more than a brief sketch of the results of the journey which I undertook during the summer of 1898; but as the Altai Mountains are almost unknown to English naturalists, and as I am not aware that any Englishman has previously visited or written anything about that country, I think it will be of interest to point out what a wonderful field for research exists, within three weeks' journey of England, and one which is practically less known to naturalists than many parts of Central Africa.

The country is so extensive, and the season for travelling so short, that I was only able to visit a portion of it. So far as I am aware, the only travellers who have written on the natural history of the country, are Pallas, whose great work is well-known, though now rather out of date; Ledebour and Bunge, who 60 years ago compiled an excellent account of the botany of the Altai; Helmersen, who has described the geology of the country; and Tchihatcheff, a well-known Russian traveller, who published an account of his travels in French in 1852. The few English travellers who have preceded me, so far as I know, are Major Cumberland and Mr. St. George Littledale, both of whom went there solely for sport; and Mr. Rew, who last year made a rapid ride *viâ* Kusnetsk, Kobdo, and Uliassutai to Irkutsk. Since the first half of this century I am not aware of any zoologist who has written, except in Russian, anything of much importance about the Altai; and though no doubt there are many valuable memoirs on various parts of the country in the Russian language, especially relating to the geology and mineralogy, the majority of travellers who have gone to Siberia recently have passed along the main high road to Irkutsk, leaving the Altai far to the south of them. My late friend Seebohm, who visited Siberia especially to study ornithology, confined his exploration to the lower valley of the Yenesei river; and one of the ideas which he expressed to me, and which made me specially anxious to visit Siberia, was that the Yenesei valley formed probably the most natural boundary between the Eastern and Western Palæarctic, or, as it is now more properly called, the Holarctic Region. This idea was not confirmed by my own observations, for I found many species of butterflies and some birds which were previously only known from Dauria and Amurland; and I think that if any boundary can be fixed, it must be sought west of the Altai Mountains.

By the Altai Mountains I understand the western extension of the great mountain-range between Semipalatinsk and Irkutsk, which is divided from the mountain-ranges of Turkestan by the Irtysch river, and from the Himalayas and the great mountain-ranges of Central Asia by the Gobi Desert and Mongolia. The southern part of this range, known as the Great Altai, is in Chinese territory and is at present very little known. I may add that the political boundary between Russia and China follows roughly, or is supposed to follow, what I daresay geographers thought was the southern watershed of the Obb and Yenesei rivers, but as a matter of fact the whole of the upper waters of the Yenesei are in Chinese territory. One of our objects was to visit this great mountain valley, containing the head-waters of the Yenesei, which is almost unknown to the Russians themselves, though Clements and one or two other travellers have passed through parts of it, and it is annually visited by a number of fur-hunters and gold-miners. The upper region of the Yenesei, from the sources of the Kemchik to Lake Kossogol, including the great valleys of the Beikem and Ulukem between the Tannu-ola mountains and the Russo-Chinese frontier, is almost uninhabited, and unknown except to those in search of fur and gold, though in a general way its outlines are reproduced on the map. On reaching St. Petersburg, I made every endeavour to get information as to the possibilities of visiting this country, and as to what had been done recently by Russian travellers. I was introduced to M. Beresowsky, who had accompanied Potanin in two of his journeys right through Mongolia to China, and had collected what information he could. The result of these enquiries, and what I was told by M. P. P. Semenov, Vice-president of the Russian Geographical Society, who was most friendly to me, tended to show that the greater part of these valleys were almost impassable in summer; because the mountains were covered with dense forests, and the valleys were very marshy, intersected with numerous streams and rivers which were difficult to cross with horses. I was also informed, and afterwards found it to be the case, that the higher regions of the Altai were liable to excessive rains and snow-storms in summer, making it a very difficult country for horses to traverse. Tchihatcheff (the only writer so far as I know who has crossed from the head-waters of the Tchuja to the head-waters of the Abakan, the principal western tributary of the Yenesei in Siberia) has stated that to cover a distance of about 200 miles cost him six weeks' hard travelling, and the loss of about half of the 150 horses with which he started. This will give an idea of the difficulties of an explorer in some parts of this country.

But to return to the question of what should properly be called the Altai Mountains. I would draw the line eastwards at the boundary of the Government district of the Altai, which is somewhat east of the water-parting between the tributaries of the Yenesei on the east and those of the Obb on the west. I do not include all those eastern mountains which are known by the names of Sayansk, &c., and stretch away as far as the south-west end of Lake Baikal, though they are from a physical point of view part of the Altai.

Until two years ago the journey to Siberia was one which had to be undertaken in the winter, for the roads are almost impassable when the snow is melting in spring. But now the railway enables one to do in comfort in ten days what formerly entailed three weeks or a month of hard sledging.

Although my special object was an investigation of the Lepidoptera, a subject at which I have been chiefly working of late years, I was also anxious to collect birds and plants as well; and if M. Beresowsky had not left us just when the real work of collecting began, I should have done much more in that direction. My companion, Mr. Fletcher, very kindly assisted me during the leisure time he could spare from the pursuit of the Wild Sheep, which was the special object of his journey; and I have in consequence been able to bring home a very fine and complete collection of Butterflies, including specimens of about 200 species. I also made a collection of Altai plants, but unfortunately, after they were packed and sent off, the horse that carried them went down in one of the numerous rivers the crossing of which is the principal difficulty of travelling in the Altai. When I subsequently unpacked them, they were almost entirely spoilt; but as Mr. Littledale had made a good collection the year before, which was presented to Kew, I am able, with the permission of the Director of the Royal Gardens, and the kind assistance of Mr. J. G. Baker, to exhibit specimens of a few of the most interesting.

The language is a difficulty not easily overcome by English travellers, for though Russian is of course spoken all over the Russian Dominions, yet the inhabitants of the frontier districts are Tartars, Mongols, and Kirghiz; and when all communications have to be made through two uneducated interpreters in languages which they do not understand perfectly themselves, it is not easy to get accurate or full information on any subject.

There is no difficulty in getting leave from the Russian authorities, with proper introductions, to visit any part of Western Siberia, and in fact I was seldom asked for a passport the whole time I was in the Altai. The Chinese in Mongolia are also very civil and friendly to travellers provided with passports; and the only difficulty which prevented us from extending our journey far into the Chinese dominions was the lack of time, and the unwillingness of the Russian subjects to run the risk of having their horses stolen by the Kirghiz, who are subject only to Chinese authority.

We left Moscow on the 18th of May, 1898, and, travelling by rail without stopping, reached the crossing of the Obb river in six days and nights. The whole of our route between the Ural Mountains and the Obb lay through an immense flat plain, parts of which are marshy and more or less clothed with birch woods, and wherever the soil is dry enough a considerable amount of cultivation is seen. Large quantities of wheat were stored at the railway-stations for export, but I believe the price is now insufficient to enable Siberian wheat to be profitably exported to England.

Spring had hardly set in when we reached the Obb river, though it had been quite hot at Moscow; and almost the only flowers which I noticed in the Steppe were a blue-and-yellow anemone (*Anemone patens*), closely allied to if not identical with *A. Pulsatilla*, and the brilliant yellow flowers of *Adonis vernalis*. On reaching the Obb river, we had to wait two or three days for a steamer to take us up to Barnaoul, which is the chief, indeed I may say the only, town in the whole of the Altai Government. From there we drove in two days across the Steppe to Biisk, which, although a place of 18,000 inhabitants, is really a large and very dirty village rather than a town. As this is the last place, however, of any importance towards the Chinese frontier, it is the centre of a large trade in wool, tea, and furs. A Dutch fur-trader whom we found there showed us a collection of furs he had made during the previous winter. Though in the early days of the Russian conquest valuable furs were in such abundance in this part of Siberia that all the taxes were paid in them, the better kinds have now become very scarce, and the only skins which we saw in great quantity were those of the Yellow Marmot of Mongolia, which are now exported in enormous quantities at a very low cost, and I believe are dyed in Europe to imitate the fur of the Mink. We must have passed 400 or 500 horse and camel loads of them on the road between Biisk and the frontier.

All up the valley of the Obb are large villages, some of them over a hundred years old, and sometimes two or three miles long, and the peasants seem for the most part prosperous and wealthy, according to a Russian peasant's ideas of wealth; but we were informed that the country was so far filled up to the foot of the mountains that there was no more room for emigrants on a large scale, except in the forest country to the eastward, and most of the emigrant trains that we saw on the railway were going farther to the East, into the districts of Krasnoyarsk and Irkutsk.

At Biisk, which we reached on the last day of May, there were signs of spring. The birch and poplar trees were just opening their buds, and here we obtained our first view of the outlying spurs of the Altai Mountains; the country between Barnaoul and Biisk, which from the map one would suppose to be mountainous, being grassy rolling downs of low elevation. After some delay in getting horses, we fairly entered the mountains on June 6th, and at once found an immense improvement from a naturalist's point of view in the appearance of the country. Many of our well-known old garden flowers such as peonies, erythroniums, rhododendrons, and anemones were in full bloom, while in some parts the ground was completely covered with the flowers of *Iris ruthenica*. Butterflies also began to appear; and though I did not get any worth mentioning until we reached Ongodai, which is four long days' drive through the mountains, I could see that the country was of far greater interest than anything we had hitherto passed through.

The Obb river divides just below Biisk into two great branches—

the Bija, which flows out of Lake Teletskoi, and the Katuna, which rises on the Chinese frontier in the great mountain called Bielucha, which is over 10,000 feet high.

Ongodai is about 180 miles from Biisk, and is the last place on the trade route to Kobdo in Mongolia where Russians are settled. It lies in the valley of the Ursul river—a broad valley of steppe-like character, whose waters flow into the Katuna, one of the two great sources of the Obb river. The character of the country thus far is much like that of Colorado. The slopes exposed to the south are arid, and covered with dwarf plants and dry grass, while the slopes facing north are wooded, in some places very thickly, with larch, while spruce grows in the flat, marshy bottoms of the valleys.

We entered the country of the Altai Tartars shortly before reaching Ongodai. They are mostly nomads, and from their appearance are probably nearly akin to (if not identical with) the tribes from whom the Ottoman Turks originally sprung. Though Tchihatcheff, who spoke Turkish, says he could not understand their language or make himself understood, yet I recognized the few Turkish words I know for common objects, and the appearance of some of the men is exactly like that of the Turks of Asia Minor. They have enormous herds of horses, one chief owning as many as six or eight thousand, and live in summer in movable 'yourts' or tents, covered with felt on wicker frames, like those of the Kirghiz, whilst in winter they live in pyramidal huts covered with larch bark, which resemble in form the lodges of the North-American Indians.

From Ongodai we had to carry all our baggage on horseback, for beyond this the road is impassable, even for country carts, and there was considerable delay in getting horses sufficient for our outfit, for the spring had been very severe, and most of the working horses had already left with merchandise for Kobdo. A day's journey beyond Ongodai, we crossed the valley of the Katuna in a deep rocky gorge, about 3000 feet above the sea, by a ferry of log canoes, whilst the horses were all made to swim over. After crossing the Katuna we passed over a mountain, about 5000 feet high, and descended again into the Katuna valley, close to its junction with the Tchuja river, which we followed for six days nearly to its source in a great open valley lying about 6000 feet above the sea, and known as the Upper Tchuja Steppe. In this Steppe was a sort of frontier market-place, called Kuch

Agatch, where the Chinese and Russian traders formerly met for purposes of barter, and a small Russian custom-house is maintained here, whose superintendent was the only Russian official we saw anywhere beyond Ongodai.

Large numbers of horses and camels and a few sheep and yaks are pastured in the Tchuja valley. The yaks that I saw appeared to be larger and of a finer breed than those I have seen in the Himalayas. The camels were all of the double-humped Asiatic variety.

Having reached Kuch Agatch, we got a fresh lot of horses and Tartars to go into the mountains lying south of the Tchuja Steppe, where we expected to find the great Wild Sheep (*Ovis ammon*, Linn.), some of whose heads I now exhibit. This is the finest and largest wild sheep in the world, although its horns are not equal in spread to those of *Ovis Poli* of the Pamir.

Another animal whose acquaintance I specially wished to make was the great Stag of the Altai, known in Asia as the Maral.

As Mr. Lydekker, when preparing his recently published work on the *Cervidæ*, had not sufficient material to enable him to decide as to the species of *Cervus* found in Siberia, I have, with the kind aid of the Duke of Bedford, brought here for exhibition several heads and horns which are of scientific value; for I believe hardly any from Siberia have hitherto been seen in England, and some of them would be well worth figuring. First, I show three heads of so-called *Cervus eustephanus* of Blanford; a species which was described by him from shed horns from the Thian-shan mountains, and is well figured by Mr. Lydekker * from a living specimen in the Duke of Bedford's menagerie, the original painting of which His Grace has lent me for exhibition. Though smaller than the Wapiti, it is a much larger animal than *Cervus maral* from North Persia, the Caucasus, and Asia Minor, which is rightly, I think, regarded by Mr. Lydekker as an Eastern race of *Cervus elaphus*. A head (fig. 1) which was brought by Regel from the Thian-shan mts., though not a large one, is typical in character of this species; whilst the other two (figs. 2 & 3), which I procured in the Altai, are not so typical, and, as I thought at first, had more resemblance to the horns of the European Red Deer. Mr. Blanford, however, has convinced me that they are nearer in character to those of *Cervus eustephanus*. This species has

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* 'Deer of all Lands,' 1898, pl. vi. p. 105.

now become scarce in a wild state in the Russian Altai owing to the number which are shot by the native and Russian hunters, who sell their horns, if killed while "in the velvet," at high prices to the Chinese. They are, however, kept alive in parks at several places in the Altai for the sake of their horns, which are annually cut for sale, and which sometimes realize as much as 100 roubles a pair at the rate of 10 roubles a pound.

Fig. 1.

Cervus asiaticus, var. *songarica*, Severtzoff.
= *Cervus eustephanus*, Blanford.
From the Kuldja district. (Regel.)

The killing of these deer has now been prohibited by the

Government in the Altai district, and we never saw the animal in a wild state, and though we picked up horns, shed many years previously, in the high treeless mountains south of the Tchuja valley (one of which I exhibit to-night to show what a large size they attain), I believe that they are now very scarce except in the heavily wooded country east of the Katuna. In the Yenesei and Abakan valleys this deer, or a nearly allied form of it, is much more numerous; and I saw some horns from the Yenesei valley in the St. Petersburg Museum which I thought had much more resemblance to those of *Cervus elaphus*, having a distinct cup or crown of 6 or 7 tines branching from the same point on the beam, as in large old specimens of the Red Deer,

Fig. 2.

Cervus asiaticus, var. *sibirica*, Severtzoff. From the Altai. (Elwes.)

quite unlike the horns of *Cervus eustephanus*, in which there is no cup-like formation on top, and in which, as in the Wapiti, the main beam is deflected backwards; the 4th tine, usually the largest, points forwards and all the upper points are nearly in the same plane.

Fig. 3.

Cervus asiaticus, var. *sibirica*, Severtz. Bought at Barnaoul. (Elwes.)

Severtzoff, in the Proceedings of the Moscow Society of Naturalists, vol. viii. p. 2 (1873) (translated from the Russian in

Ann. & Mag. Nat. Hist. 4th ser. 1876, vol. xviii. p. 386), was the first to call attention to the resemblance between the Stag of the Thian-shan, which he calls *Cervus maral*, and the Wapiti: he divides the Asiatic species into two forms, which he calls—"(a) *sibirica*," from the Altai, the Yenesei, and the wooded hills of the Sayansk and Transbaikal mountains, and "(b) *songarica*," from the Thian-shan. Mr. Blanford, describing *Cervus eustephanus* (Proc. Zool. Soc. 1875, pp. 637–640), has alluded to Severtzoff's memoir ('Turkestanski Jevotni,' p. 108), which being in Russian he could not follow, and therefore could not say whether the form described as var. *songarica* is identical with *eustephanus* or not. Now, however, that both he and Mr. Lydekker admit its identity, it seems to me that the name *soongarica* having priority should be used, though Mr. Lydekker styles this race *Cervus canadensis asiaticus*.

With regard to Severtzoff's var. *sibirica*, however, it is impossible at present to decide its exact relationship to the others. I am able to exhibit four pairs of horns which have been lately sent by Herr Hagenbeck of Hamburg to the Duke of Bedford, which were procured by Herr Dörries in the Chingan mountains and from the Sutschan river in Manchuria, which Mr. Lydekker, who has seen them, considers to belong to the race which he calls *Cervus canadensis Luehdorfi*. This race he regards as more nearly related to the Western Wapiti, from the Pacific coast, Washington, and Vancouver's Island, than to the Thian-shan or Altai race. He had seen no adult male or horns of this form when he published his work, 'The Deer of all Lands;' and though all these four pairs (evidently those of adult stags) are much smaller than any race of the Wapiti with which I am acquainted, they certainly to some extent show the horn character of the Wapiti, rather than that of the Red Deer (figs. 4 & 5). If it be admitted that they belong to a race of *Cervus canadensis*, we have this curious fact in geographical distribution, namely, that the race of the Western American coast more nearly resembles the Eastern Asiatic race than it does the Rocky Mountain race, which latter, on the other hand, has resemblance to the Altai and Thian-shan race, most widely separated from it in point of distance *.

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* Since this paper was read I have received from Herr Hagenbeck another head procured by Dörries in the mountains south of Lake Baikal, which probably belongs to the same race as the Altai Deer, fig. 6 (p. 36).

Another point which should be taken into consideration in deciding the specific relations of these Deer, is the peculiar call of the stags in the rutting time. The Red Deer in all its forms, both in Europe and Asia, utters at this season a deep hoarse roar, ending in three or four loud grunts; which may be imitated by the human voice with the aid of a conch-shell or glass bottle.

Fig. 4.

Cervus asiaticus, var. *Lühdorfi*, Bolau.
From the Sutschan river, Manchuria. (Dörries.)

On the other hand, the Wapiti in all its races (Asiatic and American) has a very different cry, which is described by hunters as a whistle. Although I have never listened to this cry myself, I have heard hunters in the Altai imitate it with the hollow stem of a plant, whilst in America a tin whistle is used for the same purpose. Radde who, in his well-known and valuable work on the natural history of Amur-land, regards the Stag of the East Sayansk mountains and Dahuria as a race of *Cervus elaphus*, mentions this peculiar cry and reduces it to musical notation *. Now though such a fact as this may be looked upon as trifling by some naturalists, I venture to think that, as in the case of the song of birds, the cry of an animal is a point of material value in deciding the question of specific alliance.

If, on examination, M. Büchner should consider that the horns from the Yenesei, of which I have spoken, belong to a race different from that of the Altai and Thian-shan, and are also different from that found on the Amur and in Manchuria, and if it should prove that this race, notwithstanding that its horns

Fig. 5.

Another example of *C. Lühdorfi*. From the same source as fig. 4.

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* Mr. J. E. Harting informs me that the notes indicated by Radde (*op. cit.*) accurately express the call of the Wapiti as heard by him repeatedly in the Regent's Park Zoological Gardens, and are quite unlike the call of the European Red Deer.

occasionally assume an elaphine character, is a race of *Cervus asiaticus*, then I think the synonymy and distribution of the Asiatic races will stand as follows, though I confess that no characters can be given by which these races can be exactly defined, and probably they will be found to intergrade.

Fig. 6.

Cervus asiaticus, var. *sibirica*?
From mountains south of Lake Baikal. (Dörries.)

CERVUS CANADENSIS ASIATICUS vel CERVUS ASIATICUS, *Severtzoff.*

(*a*) Var. *songarica*, Severtzoff, Turkest. Jevotn. p. 109 (1873).
Cervus eustephanus, Blanford, P. Z. S. 1875, p. 637.
C. canadensis asiaticus, Lydekker, Deer of all Lands, p. 104 (1898).
Hab. Thian-shan Mts. of Kuldja; South Altai.

(*b*) Var. *sibirica*, Severtzoff, l. c.
Cervus elaphus, var., Radde, Reisen im Süden von Ost-Sibirien, 2 vols. (1862–63).
Hab. Altai; ? Yenesei Valley, E. Sayansk, Transbaikalia; Dauria; ? Upper Amur.

(*c*) Var. *Luehdorfi.*—*Cervus Lühdorfi*, Bolau, Abhandl. Ver. Hamburg, vii. p 33 (1880).
C. canadensis Luehdorfi, Lydekker, *op. cit.* p. 102.
C. isubra, Noack, Humboldt, viii. p. 6, fig. 5 (1889).
Hab. North and East Manchuria, Sutschan river.

As Herr Büchner, of the St. Petersburg Museum (where alone can be found sufficient material on which to decide the question at issue), has declined at present to express an opinion on a subject which he considers should be monographically treated, it seems the more desirable to place on record the views above suggested.

The Ibex of the Altai, *Capra sibirica*, Pallas, the head and horns of which I exhibit, is nearly allied to the Himalayan Ibex, and is common in some parts of the mountains, though very difficult to get at in summer. The Elk was formerly more numerous in the northern districts, but has now become extremely rare; and the single head which I brought back resembles those which I have seen from European Russia, differing somewhat in the set of the horns from the Elk of Norway.

The Roe, *Capreolus pygargus*, Pallas, is very common in some parts of the Altai and Sayansk mountains, and is a very much larger and finer animal than the European Roe. I was at one time under the impression that the wide spread of the horns was a peculiarity of this species; but it would appear, from the nine heads which I have brought for exhibition—six from the Upper Yenesei valley, and three from the Altai—that this peculiarity is by no means constant, and that there is nothing but their size to distinguish them, so far as I see, from the European race.

The Musk Deer is also very abundant near the upper limit of forest growth, and is snared in quantities by the natives. We saw as many as 200 skins in one merchant's store.

Reindeer are said by Radde to occur in some parts of the eastern Sayansk range, where they are also kept in a domesticated state, but so far as I could ascertain they do not exist in any part of the Altai.

Birds were not so numerous as I expected, although Cranes and Ducks were plentiful in the marshes of the Kurai and Tchuja Steppes. I was astonished to find a Scoter breeding here, which proves to be the species described as *Oidemia Stejnegeri*, and which is an inhabitant of the N.W. American coasts and North Pacific. It has never been hitherto procured, as I am informed by M. Alpheraky (who is at present engaged on a monograph of the Anatidæ of the Russian Empire), farther west than the Upper Amur.

Game-birds were very scarce, though I observed Capercaillie, Ptarmigan, and Quail, and in the highest and barest parts of the mountains the magnificent *Tetraogallus altaicus* was not uncommon, though very hard to approach. The only one which I got within shot of was a hen bird with a brood of young ones, and she fluttered along the ground before me just as a ptarmigan would do in similar circumstances.

I also saw a single pair of *Perdix barbata*, Pallas, with newly hatched young, on July 18 in a marshy larch wood at about 6000 feet elevation—a most unlikely place, as I should have thought, in which to find such a bird. I do not think that the Eastern Capercaillie (*T. urogalloides*) is found in the Altai. The Capercaillie I saw were apparently the same as those of Europe, though in the Southern Ural there is a well-marked variety with a white breast, which may be specifically distinct.

No ornithologist, so far as I know, has yet worked out the birds of the Altai, and there are few other regions in Europe or Asia of which it can now be said that they are unknown to the members of the British Ornithologists' Union. One fact, however, may be mentioned, as it bears upon the question raised recently by Mr. Hartert as to the migration of the Siberian Nutcracker, which he considers to be a distinct variety from the European one. As we rowed down Lake Teletskoi on the 4th of August, we saw large flocks of Nutcrackers which were evidently migrating, and though their migration may not have extended beyond the Altai Mountains, yet from the great abundance of edible seed of *Pinus cembra*, which were just becoming ripe, I could not see any reason to account for this. In Europe the Nutcracker is a solitary and not a migratory bird, and yet the regular occurrence of Asiatic Nutcrackers in Eastern Europe shows that the Siberian one must be at any rate partially migratory. Those who wish to study the birds of this country should go early and stay late in the year, for the height of summer is not the time for collecting. I have no doubt, however, that one who would give up his whole time to it might get very valuable results; and I am certain, that even the plants, which have hitherto received a greater share of attention than any other branch of Natural History, are by no means worked out.

Next to the Wild Sheep, to whose pursuit I devoted ten days of my stay in the mountains, I gave most time to the Butterflies, which, though comparatively scarce until about the 5th of July, then began to appear in great profusion. I was particularly pleased to discover here a number of species hitherto known only from the Upper Amur and from Lapland, among them some most interesting species of *Œneis*, *Erebia*, *Argynnis*, and *Lycæna*. I found, however, hardly any of the peculiar types which occur in the various mountain-ranges of Turkestan southwards; and it seems, from a general review of the Butterflies of the Altai, that the European element is dominant, with a large admixture of species belonging to Eastern and Northern Siberia. I must say, however, that the majority of these are confined to the high bare mountains above timber-line. The collections made by Kindermann in 1851–52 (which have been described by Lederer) and by Ruckbeil in the south-western parts of the Altai (which are in Herr Tancré's collection) are of a much more typically European character, and do not contain a large number of the more interesting species which I obtained.

As I have already given some account of my collection of Lepidoptera from the Altai at a meeting of the Entomological Society, and propose to publish a full account of them in the 'Transactions' of that Society, I need only remark that the number of Butterflies known from the Altai district amounts to about 180, of which I took about 140 myself in two months. Of these about 40 are not found in Europe. 109 are also found in the Amur region. 92 were also taken in the Kentei mountains of East Mongolia, which is the only place in that country of whose butterflies we have a fair list. 78 were found by M. Alpheraky in the mountains of Kuldja, which in point of distance are much nearer than the Kentei mountains; and out of above 200 species included by Grum-Grishimailo in his list of

Butterflies from the Pamir region, only 51, or about one-quarter of the species, are also found in the Altai. As compared with any area of similar extent in Europe or Asia, this number of species is surprisingly large; and as Kindermann in two seasons only took about 90 species, and Ruckbeil about the same, as against the 140 which I myself collected, it shows that the South-western Altai, where they both worked, is not nearly so rich and has not nearly so much of an Oriental character as the South-eastern Altai, where most of my collection was made.

In the 20 years during which I have collected butterflies, I have never got nearly so many species in so short a time, and must attribute my success to the fact that when travelling on horseback I always had a net in my hand and never passed a likely spot without giving it a trial.

As for Moths, I was not able to do much myself. First, because at the high elevation at which most of our time was spent there were not many night-flying species, or at all events very few came to our lights. Secondly, because I was generally too tired to sit up at night to collect. But having received since I returned home the collection made by M. Beresowsky at Ongodai, and having gone through the list of Moths made by Kindermann, I do not think they are as numerous in proportion to the Butterflies as they are in the Alps or Himalayas.

Of the plants I cannot say much, because, although they have been pretty fairly worked out by Ledebour, yet a very intimate knowledge of the Flora of Turkestan and Eastern Siberia, as well as that of Europe, would be necessary to enable one to say how the distribution of plants coincides with that of birds and butterflies.

The Fauna and Flora are also materially influenced by the very peculiar climate of the Altai, which has great extremes of heat and cold, and is subject to heavy thunderstorms, which fall as snow and hail in the higher regions, almost daily throughout the summer. During the whole of the two months we were in the mountains, we only had seven or eight days quite free from rain or snow. These heavy storms seem mostly to come from the eastward, and from the high mountains, at the source of the Kemchik river, which is the westernmost tributary of the Yenesei. To show what sort of climate it is, I may mention that there were large beds of unmelted snow close to our camp, at about 7000 feet, all through July. On almost every clear night it froze, and on the 17th of July snow fell to the depth of 8 or 10 inches at this elevation, and though the hot sun and dry atmosphere very rapidly melted it, we were assured by the inhabitants that the summer was too short to make it worth their while to graze sheep there, and that as early as the middle of August snow might be expected to fall and lie in the higher mountains. Tchikatcheff, in his journey from the Tchuja Steppe to the Abakan, the principal northern tributary of the Yenesei, also met with heavy snowstorms in June and July.

When we left England we had the intention of passing through North-western Mongolia and returning either by the upper valley of the Yenesei river, which is almost entirely unexplored, or, if we found that impossible, of going eastwards by the shores of the great Lake Kossogol to Irkutsk. But as we found no people who could act as guides in either of these directions, we were obliged to give up anything like real exploration. There is, however, no difficulty in travelling from Kuch Agatch through Mongolia, *viâ* Kobdo, Uliassutai, and Lake Kossogol to Irkutsk. Mr. Rew informed me that the Wild Horse (*Equus Prejvalskii*) was to be found in the desert between Kobdo and Uliassutai, and I was in great hopes of procuring a specimen of this animal which, so far as I know, has not been seen by any Englishman. M. Grum-Grishimailo, the celebrated Russian traveller, who has spent eight years in exploring Central Asia, and who is the only European who has actually seen the Wild Horse in its own country, assured me that the animals spoken of by Mr. Rew must be the Wild Ass, as the nearest point to the Altai at which be found the Wild Horse was about 15 days' hard travelling south from Kobdo, near Guchen, and as that country is almost inaccessible in summer on account of the want of water, time would not allow us to visit it.

Though the geographical results of this journey are therefore unimportant, the extra time given to collecting in the Altai was of the greatest possible advantage, and though a great deal may be done whilst travelling on horseback, if you stop every time you see a new or apparently new species, yet fast travelling is incompatible with collecting.

Our return journey from the Mongolian frontier took us through a very different and most interesting part of the Altai. Leaving the Tchuja valley by the Kurai pass, we crossed the mountains to the north of it into a valley through which flows a tributary of the Bashkaus river, which, after its junction with the Tchulishman river, flows into the great Lake Teletskoi, a deep mountain-lake about 60 miles long, out of which flows the Bija river, the principal eastern source of the Obb.

Before quitting the Tchuja Steppe, however, I must make some remarks upon the character of the country we saw from the tops of the mountains at the sources of the Obb. These mountains are above 6500 feet, absolutely bare and treeless, though three or four species of willows are found along the streams up to about 7500 feet. They consist of steep, shaly mountains surrounded by great rolling downs of grass. From the tops of these mountains, at about 9000 feet, we could see the sources of the Irtysch and the Kemchik, which latter flows into the Yenesei, and of the Kobdo river, which loses itself in the Mongolian desert. Eighty or ninety miles to the southward we could see the high snow-peaks of the Southern or Mongolian Altai range, which have, according to the accounts of Russian travellers, dense forests on their sheltered slopes. I am informed that the Beaver occurs there, as it certainly does in the Sayansk mountains near the source of the Yenesei.

To give an idea of the Alpine flora of the South-eastern Altai, I may mention a few of the plants which were most conspicuous for their beauty near our camp on the Darkoti, or Tachety river as Tchikatcheff spells it, 30 miles south-west of Kuch Agatch, at about 7000 feet. I have never, either in the Alps of Europe, in the Sikkim Himalaya, in Colorado, California, or anywhere else, seen such a perfect natural garden of beautiful alpine flowers as I saw here in the middle of July. Among the most conspicuous were the lovely *Primula nivalis*, Pall., which strongly resembles *P. Parryi* of Colorado; *Dracocephalum grandiflorum*, which grew in sheets of cæruleau blue; *Polemonium pulchellum*; *Gentiana altaica*; *Pedicularis verticillata*, *P. foliosa*, *P. comosa*; *Allium sibiricum*, or *senescens*, the most ornamental of its genus; *Linum cæruleum*; *Iris tigridia*, Bunge; *Pyrethrum pulchellum*; a lovely blue *Corydalis* growing in wet places, which Mr. Baker cannot name, and which may be new; a beautiful *Aquilegia*, named *A. glandulosa* at Kew, but much finer than that plant as we know it in our gardens; several pretty species of *Astragalus*, *Lloydia serotina*; and many well-known Arctic and high Alpine plants, such as *Papaver alpinum*, *Draba ochroleuca*, and *Saxifraga oppositifolia*, which were found as high up as 8500 feet, where the flora and scenery reminded one strongly of the high fjeld of Norway, and *Dryas octopetala*, which covered the curious dry gravelly ridges on the hill-sides in many places.

Flying over these marshy alpine flower-gardens were some of the rarest and most beautiful butterflies of Siberia, the European Alps, and Lapland, many of them also found on the Alps of Colorado, such as *Parnassius Eversmanni* and *P. delius*, *Erebia lappona*, *E. ero*, *E. tyndarus*, and *E. maurisius*, *Œneis bore* and *Œ. sculda*, *Argynnis Kefersteini*, *A. freya*, and *A. frigga*, *Colias mongola*, *Lycæna orbitulus* and *L. pheretes*. Whilst on the higher and more rugged mountain-tops were herds of the great Wild Sheep and Ibex, Marmots, and Alpine Hares.

The Kirghiz, who were pasturing large herds of mares in this neighbourhood, on whose milk converted into kumiss they almost entirely live, had taken from the nest to train for falconry two young falcons which I believe to be *F. sacer*; but a rare species or variety known as *Falco altaicus*, allied to the Peregrine, also occurs in the country.

The only vegetables which we had during our stay at these altitudes were rhubarb (*R. Rhaponticum*) and wild onions; but the Tartars were also fond of the young stem of a species of *Heracleum*, which was too strong for my taste.

The larch, *Larix sibirica*, ascended here to a little over 7000 feet. I saw young trees at this elevation about 1½ diameter and 7 feet high, which showed 25 years' growth; and a very remarkable stunted old larch, 3 feet in diameter and not more than 20 feet high, which must have been many hundreds of years old. Away from these there was no fuel but willows and dry horse dung, the common fuel of Mongolia and Tibet.

The change in the scenery and character of vegetation, fauna, and insects was most marked on crossing the watershed between the Tchuja and Bashkaus valleys. It seemed as though in one day we had passed from Asia into Europe, for a number of plants, such as *Linnæa borealis*, *Saxifraga umbrosa*, and various *Ericaceæ*, familiar to me in the Alps, which I had not previously seen, were found there; whilst ferns, which are conspicuous by their absence in the dry Tchuja valley, had also become abundant. Instead of thin larch forests, about which you could everywhere ride on horseback, we found dense forests of *Pinus sylvestris*, *Pinus Cembra*, and spruce forests which exceed in their impassability anything I have ever seen, even in British Columbia.

When we reached the north end of Lake Teletskoi, we found the grass and herbaceous vegetation very high and rank, forming a most marked contrast to the dry stunted grasses of the Tchuja Steppe and the hills around it. Aconites, delphiniums, thistles, wild hops, and many other plants grew 6 or 8 feet high; but though many species of moths were seen, butterflies were much less numerous and interesting, most of them being common European species.

As there is no track passable for horses along the western shores of Lake Teletskoi, we had to traverse it in a boat, and it took two days of hard rowing. The western shore of this lake is so steep and rocky that in many places you cannot land for several miles, and we had great difficulty in hauling our boat ashore during a sudden storm which sprung up and threatened to swamp us. Along the whole western shore of this great lake there is not a single vestige of man's presence, and the forest is so dense, rocky, and impassable, that I do not think it would be possible for a man on foot to make more than four or five miles a day in summer, though these forests are no doubt more easily traversed in winter on snow-shoes by fur-hunters. The shores of Lake Teletskoi were formerly a favourite resort of the Elk, Deer, and Bear, but they are now much diminished since firearms have become common. There is something in the climate of this region which, as Helmersen remarks, must be very exceptional, for we were assured by the inhabitants, as he was, that ice rarely remains on the lake for more than a month at a time, whereas the Obb river is frozen up during three or four months every winter.

The inhabitants of the country round Lake Teletskoi, and probably of the Bija valley, are of an apparently different race to the Altai Tartars, and are called Teleutes; in physique they appear to be much poorer, and nothing like so healthy and vigorous. They cultivate a little spring rye and oats in the valleys, and are now mostly Christianised to a certain extent by Russian missionaries, whereas the Altai Tartars and Kirghiz are either mussulmans or worshippers of spirits. All these natives are very much addicted to drink, and the chief, or Saisan, through whom we procured horses and men for our different journeys, though nominally a Christian, was not free from this failing.

As to the remarkable absence of glaciers in the Altai, a few words seem desirable. At the sources of the Katuna, where the mountains are higher and steeper than they are in the South-eastern Altai, I believe glaciers are larger and more abundant; but the only place where we saw what could really be called a glacier was in a high mountain south of the Kurai Pass. Their scarcity is probably accounted for by the extremely dry climate and light winter snowfall of the higher mountains. Notwithstanding the extreme cold, the snowfall in the Upper Tchuja valley is so light that horses can procure food on the mountains all through the hardest winter, whereas in the low country around Lake Teletskoi and the Bija valley they have to be fed on hay.

When we reached the north end of Lake Teletskoi, we had four days' hard riding down the Bija valley before we reached a country over which carts could travel. This valley is remarkable for its magnificent forests of pine, *Pinus sylvestris*, which exceed anything I have ever seen before. In some places I counted as many as 20 or 30 trees to the acre, of an average girth near the ground of from 6 to 10 feet, and carrying their girth higher up than I have ever previously seen, so that at a height of 80 or 100 feet the tree would still be over a foot in diameter. The Russians, however, who, as described by a well-known German forester, are "everywhere and at all times true wasters and destroyers of forests," are making rapid inroads upon this magnificent timber, which is felled and floated down the Bija and Obb for supplying the towns and villages in the Steppe country northwards. Fire also is rapidly wasting many of the hill-sides, and when the pine has been burnt off, its place is usually taken by poplar and birch.

The climate of this Bija valley is evidently very much damper than that of the country to the southwards, and we had the greatest difficulty in getting our horses through some of the marshy forests. The horses in the Altai are, however, capable of going where even ponies in the Rocky Mountains could hardly scramble, and where the road is too steep and slippery to get a foothold, will clamber up through the thick brushwood with dense undergrowth and herbaceous plants higher than their heads on an incline of at least 30 degrees. To give an idea of their endurance, I may state that one day we rode the same horses from 9 A.M. till 9.30 P.M., without halting more than a few minutes, none of them being apparently the worse for it, and a sucking foal following its mother during the whole journey. The horse which I rode accomplished the last hour of the journey at a canter in the dark.

In conclusion I would strongly urge upon any one who may think of visiting the country, that a knowledge of the Russian language is almost indispensable; and considering the large amount of valuable material which is practically buried in Russian scientific journals, I am surprised that so few English naturalists have hitherto thought it worth their while to do what many young Army Officers, for military purposes, now do every year.

Some Observations on the Caudal Diplospondyly of Sharks.

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It is a well-known fact in Ichthyology that in Selachian fishes the vertebræ of the tail are twice as numerous as the caudal segments, delimited by the spinal nerves and the intermuscular septa.

The first clear reference to this remarkable phenomenon occurs, curiously enough, in Götte's memoir on the development of the Fire-bellied Toad (*Bombinator*), (**6.** p. 418, footnote). It has since been remarked upon by von Ihering (**9.** pp. 220–236), Hasse (**7.** p. 21), Balfour (**1.** p. 455), Schmidt (**15.** p. 756), Mayer (**13.** pp. 262–267), Gadow (**4.** pp. 194–196), and others.

To each myomere and neuromere there occur two centra, two pairs of crural plates, two pairs of intercrural plates, and four neural spines. The two centra are similar*, as also are the hæmal arches and the neural spines, but the crural plates are alternately imperforate and perforated by the ventral nerve-root, while a similar relation exists between the intercrural plates and

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* Except in *Galeus*, in which they are alternately slightly longer and shorter.

the dorsal nerve-roots. In some forms, such as *Scyllium*, the nerve-roots pass out, not through the plates, but between them; yet the alternation exists the same (see fig. 1, p. 50).

In Hasse's monograph on the vertebræ of Elasmobranchs, to which one naturally turns for information on such a point, the figures (**7**. pl. 34. fig. 14, *Scyllium catulus*, and fig. 22, *Scyllium canicula*) give an incorrect idea of the actual appearance of the vertebræ, for the differences between the calcified and uncalcified parts are exaggerated, while the margins of the cartilage plates, which are of far more morphological importance, are not shown at all. And, further, although Hasse was fully aware of the occurrence of diplospondyly in the tails of these animals (**7**. p. 21), he has indicated in these figures nerve-apertures on consecutive vertebræ. The error cannot be excused on the ground that the part of the vertebral column figured is anterior to that where diplospondyly obtains, for the presence of large hæmal arches proves the contrary. The figures given by Mayer (**13**. pl. 18. fig. 12, and pl. 19. fig. 1, *Scyllium stellare*) are considerably clearer than those of Hasse, but even they leave much to be desired in the delineation of the boundary lines between the neural plates and spines.

The portion of the vertebral column of *Scyllium catulus* (=*stellare*) depicted in fig. 1 is taken immediately below the second dorsal fin, and shows the diplospondylous condition in its most typical form. The hæmal arches (*h*) and the crural plates (*cr*) are fused on the centra (*c*), but the intercrural plates (*ic*), alternating with the crural plates, remain distinct. The hæmal spines (*hs*) are not separate from the hæmal arches, but the neural spines (*ns*) are small cartilages which fit with great regularity over the intervals between the crural and intercrural plates. The dorsal roots of the spinal nerves issue through the foramina (*d*) on the posterior margin of every alternate intercrural plate, while the foramina for the ventral roots (*v*) lie at the lower end of the posterior edge of the crural plates. The dorsal foramina of the right and left sides lie in the same transverse plane; and similarly with the ventral foramina.

This condition of diplospondyly obtains not only in the tail of *Scyllium catulus*, but, as I can testify from personal observation, also occurs in *Mustelus vulgaris*, *Galeus canis*, *Carcharias laticauda*, *Scyllium canicula*, *Cestracion Philippi*, *Acanthias vulgaris*, *Spinax niger*, and *Scymnus lichia*. Considerable confusion has been introduced into the literature of the subject by von Ihering's statement (**9**. p. 229 & p. 233) that *Scymnus* departs from the condition found in *Acanthias* and *Scyllium* by having no double vertebræ in the tail, or only one or two vertebræ with imperforate crural and intercrural plates; for Gadow (**4**. p. 195) has repeated the statement in his memoir on the vertebral column of fishes, without having observed that Mayer (**13**. p. 265) had corrected von Ihering on this point. The figure given by Mayer (**13**. pl. 18. fig. 9) shows that normal diplospondyly commences at the forty-third vertebra in *Scymnus lichia*. In a specimen of this species, which by the kindness of Mr. G. A. Boulenger I was allowed to examine at the Natural History Museum, I found that nine myomeres of the tail were diplospondylous. The first of these segments was situated immediately behind the cloaca, and the hæmal arches commenced at the same place. The relations were thus exactly those which occur in other Selachians.

The passage from the diplospondylous condition in the tail to the monospondylous condition in the trunk is not abrupt, but gradual; and the four or five vertebræ involved in the transition offer an irregularity which deserves more notice than has hitherto been accorded to it. Although three theories at least have been propounded to explain the origin of the caudal diplospondyly, it does not appear to have occurred to anyone to inquire minutely into the detailed structure of these transitional vertebræ; yet they hold, as it were, the key to the situation. The transition is invariably in the proximity of the cloaca, as von Ihering and Mayer (**9**. p. 228, and **13**. p. 261) have already pointed out. It occurs behind the last rib-bearing vertebra, and in front of the vertebra carrying the third or fourth complete hæmal arch (see fig. 2). As a rule it does not extend through more than four or five myomeres, but according to Mayer (**13**. p. 266) six body-segments are involved in *Mustelus*.

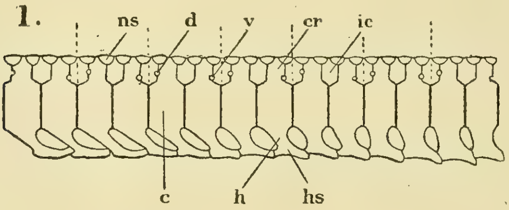
The transitional vertebræ do not stand in any constant relation with the dorsal fins, for they are anterior to the first dorsal fin in *Rhina* (**13**. pl. 18. fig. 1), below it in *Scyllium*, between the two dorsals in *Acanthias*, and below the second dorsal in *Scymnus*. Since, however, the dorsal fins are variable in position with respect to the cloaca in different genera, and the transitional vertebræ are definitely related to the position of the cloaca, it is but a logical conclusion that the vertebral transition shall not be related to the position of the dorsal fins. Since caudal diplospondyly occurs in forms like *Acanthias*, *Scymnus*, and *Rhina* which are destitute of the anal fin, the transitional region of the vertebral column cannot bear any relation to this appendage.

It is evidently to this transition region that Müller is referring, when he writes (**14.** p. 156):—"Bei *Zygæna* fand ich noch das merkwürdige, dass an einigen Wirbeln des mittlern Theils der Wirbelsäule sogar 3 Bogenstücke hinter einander auf einen Wirbel jederseits kommen, während die meisten Wirbel nur 2 Bogenpaare haben." The regularity of the neural plates over the centra in the tail-region was such that the duplicity of vertebræ passed without notice, but the irregularity in the transition region did not fail to catch the eye. Since Müller did not notice the relations of the vertebræ to the neuromeres and myomeres, the differences between the caudal and trunk vertebræ escaped him. According to Mayer (**13.** p. 263), the much misunderstood statement of Kölliker's with regard to *Heptanchus* (*vide postea*, p. 51 footnote) also refers to the few vertebræ in the transition region.

Gegenbaur (**5.** pl. 9. fig. 19) has figured a portion of the vertebral column of *Cestracion*, from the vertebra bearing the last rib to that with the fifth hæmal arch. The figure, however, shows no nerve foramina nor introduction of new intercrural plates, but perfect regularity such as would occur in the trunk region. Although, therefore, this is obviously the region of transition, the irregularities which must have existed are not shown.

The fullest information on the subject is that furnished by Mayer, whose illustrations (**13.** pls. 18 & 19) include the transitional vertebræ of *Scyllium*, *Mustelus*, *Centrophorus*, *Heptanchus*, *Scymnus*, *Acanthias*, and *Rhina*. He roughly describes (**13.** p. 266) the region in question in *Scyllium*, but does not discuss the detailed relations of the neural arches. He merely states that the arches are irregular, and that the bodies may carry three pairs of arches.

In the specimen of *Scyllium catulus* depicted in fig. 2, the irregularities commence immediately behind the last rib-bearing vertebra. The vertebra marked 2 has the crural plate (*cr*) exceptionally broad, and an additional neural spine (*ns*) is superposed upon it. This in itself is an exceptional occurrence, for the neural spines normally lie over the boundary-lines between the neural plates, and not directly over a plate. The third vertebra of the series differs from the second only in that its crural plate is still broader, and that the intercrural plate behind, which should lie over the hinder part of the centrum, has been pushed entirely off, and the third neural spine of this vertebra (*ns'*) has suffered a similar backward displacement. The centra 4 and 5 are the first to show the doubling. They are shorter than the preceding three, but are longer than the half of each of these. The second of the two centra (5) has over it a crural plate and the anterior half of the following intercrural, and above these are a half and a whole neural spine. The anterior centrum (4) has belonging to it a crural plate and the posterior half of the displaced intercrural in front, and a whole and a half neural spine. That only one half of the intercrural belongs to this vertebra is clear from the fact, that if in figure 2 the line be erased which separates the centra 4 and 5 and their corresponding crural plates, the now single vertebra will be a facsimile of those marked 2 and 3, except for the fact that there are two hæmal processes instead of one.



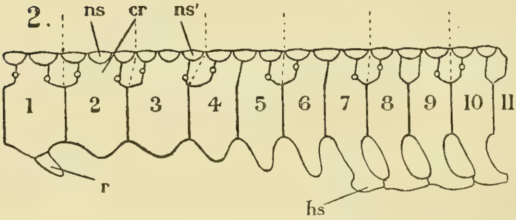


Fig. 1.—*Scyllium catulus*; caudal vertebræ, left side, natural size.

Fig. 2.—*Scyllium catulus*; transitional vertebræ, in the region of the cloaca, immediately below the first dorsal fin; left side, natural size.

c, centrum; *cr*, crural plate; *ic*, intercrural plate; *ns*, *ns'*, neural spines; *h*, hæmal arch; *hs*, hæmal spine; *r*, last rib; *d*, foramen for dorsal root of spinal nerve; *v*, foramen for ventral root.

The dotted lines indicate the hypothetical limits of the perfect vertebræ.

The next double vertebra (6·7) is a repetition of (4·5) except that the three neural spines occupy the full length of the two centra, and that the hæmal arch on centrum 7 is completed by a hæmal spine (*hs*). The double vertebra (8·9) shows a further departure. Both hæmal arches are complete; and between the two narrow crural plates an intercrural, unnotched on its anterior and posterior borders by nerve foramina, has been introduced. The middle of the three neural spines is thus again exceptionally placed, since it lies immediately over a plate, and not over a boundary line as it did in (4·5) and (6·7). The double vertebra (10·11) is the first of the normal diplospondylous series, and differs from (8·9) only in the greater breadth of the crural plates. A feature of special interest in vertebra (8·9) is that the intercalated intercrural has only appeared on the left side. As seen from the right side, this double vertebra is an exact counterpart of (6·7).

To summarize the above description:—The transition is effected by steps taken in the following order—the broadening of the crural plate and the introduction of an additional neural spine; the division of the centrum and crural plate, and the doubling of the hæmal process; the intercalation of an additional intercrural between the two contiguous crurals. The great advantage attained by this gradual transformation is obviously the avoidance of excessively large or excessively small cartilages, while yet securing a diminution, on the whole, of the antero-posterior length of the elements.

The most recent view on the subject of caudal diplospondyly in Selachians is that expressed by Dr. Gadow, who attributes (**4.** p. 194) the phenomenon to the "chorda centra" being independent of the "arcualia" and to the difference between the metamerism of the centra and that of the arches. He explains that in the middle of the trunk region of *Heptanchus* the centra are double their normal length, extend through two myomeres, and have four pairs of "dorsalia"*. After stating that it is the

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* It is not clear from Dr. Gadow's text whether he is here describing observations of his own, or is merely enlarging upon the unfortunate sentence of Kölliker's (**11.** p. 199) "bei *Heptanchus* im hintern und vordern Theil der Wirbelsäule die Zahl der Wirbel um das doppelte grösser ist als in der Mitte." But in either case, it should not escape notice that Hasse failed to confirm Kölliker's observation, and stated (**7.** p. 46) that this anatomist was probably misled by the deceptive appearance of "ein dunkler, doppelt contourirter

variable length of the chorda centra which causes the discrepancies, he proceeds:—"These apparent irregularities reach their climax in the tail of many Elasmobranchs, where exactly the reverse takes place to what occurs in the trunk, in this way, that the chorda centra are so numerous, or so short, that two of them fall to the share of one true segment. The number of dorsal cartilaginous pieces varies extremely." Now, as a matter of fact, the neural plates are arranged with the greatest regularity, as will be seen by a glance at fig. 1; namely, one plate united with each centrum and one plate intercalated, the median dorsal cartilages being regularly disposed over the intervals. In fact Mayer (whose paper is quoted by Gadow on p. 196) had already written (**13.** p. 266), "Nur die an der Übergangsstelle befindlichen Wirbel zeigen allerlei Unregelmässigkeiten in Lage und Anzahl jener Stücke." The only shark in which I have been able to detect any want of correspondence in the tail region between the neural plates and the centra is *Galeus*. Since, as a rule, the elements of the caudal vertebræ are as regularly disposed as are those of the trunk vertebræ, the "explanation" cannot be considered valid.

Dr. Gadow further observes (**4.** p. 195) that the "intercalation or wedging-in of these various cartilages can be followed from the simplest to the most complicated conditions in the Rajidæ." It is to be regretted that he does not give illustrations of these, for he acknowledges that Hasse's figures do not explain the facts. But it must here be pointed out that the Rays are less primitive than the Sharks; and that the fact of the phenomenon being

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Streifen, welcher der Mitte der Basen der Neur- und Haemapophysen entspricht und senkrecht verlaufend die überraschendste Aehnlichkeit mit einem Zwischenwirbelgewebe hat." And one year previously to this von Ihering (**9.** p. 222) had suggested that Kölliker's error arose from his counting the neural spines as arches. The figure, moreover, which Mayer has given of *Heptanchus* (**13.** pl. 18. fig. 10) shows the usual Selachian diplospondyly, commencing on the fifty-ninth vertebra. The deceptive bands on the centra mentioned by Hasse are clearly shown, but there is nothing abnormal in the regularity of the neural arches. In the accompanying text (**13.** p. 263) Mayer shows that the statement of Kölliker's is correct if read as referring only to the few transitional vertebræ between the trunk and tail regions. But none of these explanations can apply to Dr. Gadow's assertion (**4.** p. 194) that "each long centrum actually belongs to two true segments"—a statement which cannot refer to the alternation of the intercentral plates with those of the intermuscular septa, for that is normal in Sharks, and would not be worth mentioning.

inexplicable without having recourse to the former is a sign of weakness in the argument. And besides, Dr. Gadow is here disregarding his own word of caution expressed on page 193 of his treatise, "Indeed, mischief enough has been done by the selection of the Rajidæ for the elucidation of fundamental morphological questions."

Much may be said in favour of the contention of Mayer and Gadow (**13.** p. 266, and **4.** p. 195) to restrict the word "vertebra" or "spondylus" to a complete scleromere, equal in value and antero-posterior extent to a neuromere and myomere; although to agree in this is not necessarily to accept the conclusion of the latter writer that "diplospondylous" is a "term without any reasonable meaning." For, after all, these "vertebræ" of the tail of Sharks are so regular and complete that we can scarcely deny them the title. Each consists of a centrum of cartilage, partially calcified, with a conical depression in front and another behind, occupied by persistent notochord. Above each centrum, and united with it, is a pair of cartilaginous plates, and between every two consecutive "vertebræ" a pair of intercalary plates, while located over the intervals between these alternating plates are median dorsal cartilages, twice as numerous as the centra. That is to say, the *structure* of each "vertebra" of the tail is exactly the same (neglecting, of course, the distinctive features such as hæmal arches and absence of ribs) as that of a trunk vertebra, except that every alternate one has no nerve foramina, while all the trunk vertebræ are provided with them.

If, therefore, we deny the caudal "vertebræ" the right to rank as equal to those of the trunk region because of their failure to fall in with the metamerism of the muscular and nervous systems, we must yet admit for them a metamerism of their own, which is almost as perfect as that of the trunk vertebræ. It is certain that there is no such "discrepancy between chorda centra and arches," or "difference between the metamerism of the centra and that of the arches," as Dr. Gadow would have. The only discrepancy occurs in the transition region, where it could hardly be avoided; and even there it only affects four or five segments of the body.

Von Ihering conceived the idea (**9.** p. 235) that in the primitive Selachians the whole vertebral column was diplospondylous, and that the monospondylous condition is secondary, and has been introduced by a fusion of parts proceeding regularly from before backwards. According to this view, therefore, the fewer double vertebræ in the tail in existing forms of Selachians, the more specialized the fish. But Mayer, in disposing of the case of *Scymnus*, upon which von Ihering placed so much reliance, has shown (**13**. p. 265) that the idea is altogether untenable. He holds that the diplospondylous condition is secondary, and is due to the halving of the normal vertebræ. Hasse (**7**. p. 21), although lending active support to von Ihering's theory, at the same time regards every alternate "vertebra" of the tail as intercalated, and therefore not homologous with the others.

Embryology unfortunately throws no light upon the subject. Both Götte and von Ihering (**6**. p. 418, and **9**. pp. 222 & 235) were agreed that the ontogenetic segmentation of the caudal vertebræ was precluded by the disposition of the crural and intercrural plates; and Balfour (**1**. p. 455) satisfied himself by actual examination of embryos that the duplicity of the caudal vertebræ was not due to secondary segmentation, but was observable so soon as the vertebral column showed any signs of differentiation into vertebræ. The figure given by Klaatsch (**10**. p. 172, fig. 3) of the longitudinal section of the embryonic vertebral column of *Mustelus* fully confirms the conclusions of this embryologist.

Balfour was inclined to explain the want of correspondence between the metamerism of the caudal vertebræ and that of the nerves and muscles by the fact that the former are differentiated later than the latter. Since, however, he also showed (**1**. p. 453) that the segmentation of the continuous cartilaginous sheath of the notochord was determined by the muscle segments, and gave good reasons for the fact, the lateness of the differentiation of the vertebral segments cannot be taken as an *explanation* of diplospondyly. It merely leaves open the possibility of other influences coming into play and over-ruling the dominating metamerism of the muscles and nerves.

Caudal diplospondyly being so widely spread among existing Sharks, and the fact that there are no traces of the actual process of doubling during ontogenetic development, point to the conclusion that the condition is a very ancient one. With the object of ascertaining whether palæontology could assist in the solution of the problem, I availed myself of the kind assistance of Mr. A. S. Woodward in examining the specimens of fossil Sharks at the Natural History Museum. The results were disappointing; for, in the absence of the muscles, the only means of deciding the principal metamerism of the tail is by the nerve-foramina, and these could not be made out in any single instance. Yet, judging from the centra of the tail being markedly shorter, in proportion to their height, than those in the trunk region, it is by no means improbable that the diplospondylous condition of the tail is of considerable geological antiquity.

Embryology and palæontology both failing us in our efforts to divine the cause and origin of diplospondyly in Sharks, we are constrained to fall back upon the evidence afforded by the transitional vertebræ, and upon another important fact, that diplospondyly does not extend to the extreme posterior end of the vertebral column. The only reference to this fact that I have been able to discover in the scattered literature of the subject is the remark by Mayer (**13**. p. 267), "Somit entspricht an der Schwanzspitze wenigstens jedem Myotom ein Sclerotom." In the hinder three-fourths of the caudal fin of *Acanthias* the myomeres are as numerous as the centra. The change from the diplospondylous to the monospondylous condition occurs at about the twenty-fourth centrum from the end; but the relations between the vertebræ and the muscle-segments can only be made out for the anterior half of these; for in the hinder part there is scarcely any muscle at all between the skin and the vertebræ. The last ten or twelve vertebræ are imperforate, as already shown to be the case in *Scyllium* by von Ihering and Mayer (**9**. p. 228, and **13**. p. 269), and the little muscular tissue that is attached to these vertebræ is innervated by a backward extension of the nerves supplying the preceding myomeres.

Diplospondyly is thus confined to that part of the body lying between the cloaca and the greater part of the caudal fin; and the questions that most naturally present themselves are these—What advantage does diplospondyly confer on this part of the body, and in what respect would this part suffer if the monospondylous condition prevailed? The answer, it seems to me, can be given in a single word—Flexibility. Those who have watched dogfish swimming in an aquarium will know how important is the "tail," or post-cloacal region of the body, as an organ of locomotion, the paired fins playing but a small part in the actual progression of the body through the water. Yet, when the tail is lashed from side to side, the caudal fin at its extremity is seen not to partake of the general lateral curvature, or only in a minor degree. The caudal fin is chiefly concerned with obtaining a purchase upon the water, so as to constitute a relatively fixed point, about which the rest of the body can be moved by appropriate muscular contraction. Flexibility is thus not required in the caudal fin itself, but is of great advantage in the part of the body immediately preceding. The need for this extreme flexibility ceases in front of the cloaca, for here the body is largely occupied by the alimentary and other viscera, and constitutes, with the head, the most important part of the body, compared with which the post-cloacal part is merely a subservient appendage. And, further, since the body is thicker in the trunk region, the proportion existing between the length and the breadth of a segment is much less than in the tail, and consequently one vertebra to each myomere gives the necessary amount of flexibility.

There are not, in Sharks, synovial articulations between the centra as in Snakes, where the flexibility of the vertebral column is considerable; neither are there zygapophysial articulations between the neural arches as in most Vertebrates. The only movements possible are those due to the slight yielding power of the fibrous tissue around the margins of the centra, and between the various cartilages of the neural arches. To double the yielding power of this separating fibrous tissue would be to weaken the connection between the several vertebræ, and to introduce the possibility of lateral displacement; but by doubling the number of vertebræ in any region, twice the amount of fibrous tissue is introduced, without the above-mentioned disadvantage.

This response by the skeletogenous tissue to the requirements of flexibility of the particular part of the body, is possibly referred to in the following sentence from Gadow (4. p. 192):—"It is obvious that the chondrified chordal sheath is affected by the 'centra of motion,' which establish themselves according to the way in which the fish 'wriggles'."

That the vertebræ must be integral multiples of the segments of the body is evident from the relations which exist between the muscles and the vertebræ. Although a secondary feature (Balfour, 1. p. 453, and Gadow, 4. p. 192), it is a fact, that in the development of Elasmobranch fishes the chondrified sheath of the notochord is uniform and unsegmented at a time when the metamerism of the muscular and nervous system is perfect. As a rule the segmentation of this sheath is determined by the myomeres, in the manner explained by Balfour (**1**. p. 453), so that the vertebræ are as numerous as the myomeres; but there is nothing to prevent the vertebral segments being twice, or even three times, as many as the primary segments. To have fractional parts, however, is obviously impossible. Even allowing that the transition between the trunk and tail regions is beautifully gradual, yet, as will be seen by a glance at figure 2, the last monospondylous skeletal segment (3) is followed immediately by one with two centra and two crural plates (4·5).

The most logical conclusions, therefore, from the facts at command, are, that the condition of diplospondyly in the tail of Sharks is secondary, but of ancient date; and, further, that it is purely adaptive, being calculated to maintain a due proportion between length of centrum and width of body, without diminishing the length of the muscle-segments. In the region of the body from the cloaca to the caudal fin, the demand for increased flexibility is prepotent over the normal tendency of the chondrified chordal sheath to segment in such a way that the centra are as numerous as the myotomes.

This, of course, is not an *explanation* of diplospondyly, it is merely a suggestion for its *raison d'être*. That the diminution in the length of the tail which would be entailed by a shortening of the myomeres, and consequent restoration by this means of the balance between the length of the centra and the width of the body, would be a disadvantage, is also a pure assumption, Indeed, the study of Teleostean fishes shows that a shortening of the tail by the abolition of the terminal vertebræ may, and does occur; and this without any compensating increase in the skeletal parts, for the caudal segments of Teleosteans are monospondylous. But, in this connection, *Amia* comes to our assistance; for here, in spite of a homocercal tail and presumably abbreviated vertebral column, the segments of the caudal axis occur two to each myomere and neuromere (**9**. p. 231). And, as in Selachians, the last segments of the body, namely those in the hinder part of the caudal fin, are monospondylous (Franque, **3**; Kölliker, **12**; Shufeldt, **16**; Hay, **8**; and others).

Whether, therefore, we accept the view of Franque (**3**. p. 10) that in *Amia* those vertebral bodies of the tail which are destitute of neural and hæmal arches have been intercalated between the true vertebræ; that of von Ihering (**9.** p. 235), that the condition is due to the secondary segmentation of vertebræ originally simple; that of Schmidt (**15.** p. 755), that two consegmental vertebræ occurred primitively throughout the body, and now persist only in the caudal region; or that of Baur (**2.** p. 942), and Hay (**8.** p. 5), that the pleurocentrum and hypocentrum together constitute a single vertebra equivalent to those of the trunk region, where the fusion of pleurocentra and hypocentra is assumed to have occurred,—the same general conclusion will apply as that above specified for Selachians, namely, that the universal tendency to develop single vertebral bodies is, in the region between the anus and the caudal fin, over-ruled by the demand for increased flexibility. Indeed, the conclusion might even be further extended to the Stegocephali, in which the embolomerous type of vertebra prevails in the caudal region only.

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Report on the Marine and Freshwater Crustacea from Franz-Josef Land, collected by Mr. William S. Bruce, of the Jackson-Harmsworth Expedition. By THOMAS SCOTT, F.L.S., Naturalist to the Fishery Board for Scotland.

[Read 15th December, 1898.]

(PLATES 3–9.)

THROUGH the kindness of Mr. W. S. Bruce I have had the privilege of examining the Crustacea which he collected in Franz-Josef Land during his sojourn there in 1896 and 1897.

It was with some hesitation that I undertook the examination of this interesting collection. Fortunately, however, a large number of the organisms contained in it were already more or less familiar to me, either as recent or fossil species, and therefore the examination, though arduous, was less so than it would otherwise have been. Prof. G. S. Brady and the Rev. T. R. R. Stebbing have kindly assisted me with the identification of certain doubtful species; while my son, Mr. Andrew Scott, gave me valuable help with the examination of the Copepoda, and by the preparation of a number of drawings necessary for the elucidation of some apparently new forms, and for the confirmation of others which, though already described, have not before been recorded from the Arctic seas.

It was necessary, in describing the results of my examination, to adopt some recognized method in classifying them, and the general arrangement which I have followed is that proposed by the Rev. T. R. R. Stebbing in his 'History of Crustacea,' * and exhibited in the synoptical table at page 49. In this table the Crustacea are divided into four Subclasses, viz.: the MALACOSTRACA, ENTOMOSTRACA, GIGANTOSTRACA, and THYROSTRACA (or Cirripedia). The collection of Crustacea made by Mr. Bruce has been found to contain representatives of the first, second, and last of these Subclasses; and I now proceed to indicate briefly the number of the species that belong to each of these three subdivisions.

(1) The MALACOSTRACA.

The Malacostraca, which comprise what are otherwise called the higher Crustacea, are still further subdivided into the two

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* Internat. Sci. Ser. vol. lxxiv. (London, 1893).

Orders—PODOPHTHALMA (or Stalk-eyed Crustacea) and EDRIOPHTHALMA (or Sessile-eyed Crustacea). The first was represented in Mr. Bruce's collection by seven species, five of which belong to the smaller Macrura and two to the Schizopoda: there were no representatives of the larger Brachyura in the collection. But if the Stalk-eyed Crustacea are few in number, the Sessile-eyed forms are fairly numerous: they comprise Cumacea, of which there are five species; Isopoda, represented by twelve; and Amphipoda, of which there are forty-six species.

(2) The ENTOMOSTRACA.

The Entomostraca are divided into three Orders, but the first of these, Brachiopoda, is not represented in the collection; there are, however, numerous examples of Ostracoda and Copepoda. Thirty-four species of the former and sixty-six of the latter, with one new variety, have been obtained, and are recorded in the sequel.

(3) The THYROSTRACA or CIRRIPEDIA.

The only Cirripedia found in the collection are two species of Barnacles, both of which are widely distributed in the northern seas.

Perhaps the preceding statements may be more clearly understood if put into tabular form, thus:—

TABLE showing the general classification and number of the species of Crustacea contained in Mr. Bruce's Collection of Crustacea from Franz-Josef Land.

Subclass.	Order.	Suborder.	Number of species.
MALACOSTRACA.	Podophthalma ("Stalk-eyed" Crustacea)	Macrura	5
		Schizopoda	2
	Edriophthalma ("Sessile-eyed" Crustacea)	Cumacea	5
		Isopoda	12
		Amphipoda	46
ENTOMOSTRACA.	Ostracoda	Podocopa	32
		Myodocopa	1
		Cladocopa	1
	Copepoda	Gnathostomata	65
		Pœcilostoma	1
		Siphonostoma	1
CIRRIPEDIA.	Thoracica	Operculata	2

It will be observed from this table and from the preceding remarks that the collection of Crustacea brought home by Mr. Bruce, though it does not contain any of the larger Brachyura, is particularly rich in the smaller forms; indeed, though twelve suborders are represented in the collection, by far the largest number of species belong to only three of these. The total number of species is 173, but 132 of them belong to the Amphipoda, Podocopa, and Gnathostomata. It may be also remarked that this collection of Crustacea exceeds in importance as well as in number of species any other previously brought from Franz-Josef Land, except perhaps in the number of the larger forms.

Of the species above enumerated, three, represented each by a single specimen, are reserved for further investigation—one being a very small Macruran of the family Hypolytidæ, and the other two minute Cumacea, probably new.

In the following detailed list the locality where each species was obtained in Franz-Josef Land is given, except in the case of a few that are comparatively common. Notes on the distribution of species are occasionally added, and especially of those that have been observed in the British seas. Descriptions of several apparently new species will also be found in the sequel. A list of works that have been specially consulted in the preparation of this report is added.

The majority of the specimens were collected in the vicinity of Cape Flora and Cape Gertrude, Northbrook Island; Elmwood, which is also frequently mentioned, is situated near to Cape Flora. Northbrook Island is somewhat V-shaped: one branch extends in a north-by-west direction, about 15 miles from Barents Cape; the other branch, which is nearly 40 miles in length, extends almost due west; and Cape Gertrude, Elmwood, and Cape Flora are all situated at the western extremity of this lower branch. Northbrook Island is one of the most southerly of the Franz-Josef Land group, and while the lower branch which terminates in Cape Flora is somewhat under the 80th degree of North latitude, the other reaches to some distance beyond that.

MALACOSTRACA.

MACRURA.

(Tribe Caridea.)

Genus SPIRONTOCARIS, *Spence Bate*, 1888.

SPIRONTOCARIS GAIMARDII (*Milne-Edwards*). (Pl. **3**. figs. 1, 2.)
1837. *Hippolyte Gaimardii*, Milne-Edwards (**26**), p. 378.

The Bruce collection contained a single adult female with ova; it was taken about two-thirds of a mile south-west of Elmwood, in 18 fathoms water, on June 7th, 1897. The length of this specimen was about 62 millim.; the armature of the rostrum consisted of seven teeth on the upper, and five on the lower edge, as shown in the figure (fig. 1).

(?) SPIRONTOCARIS PHIPPSII (*Kröyer*). (Pl. **3**. figs. 3, 4.)
1841. *Hippolyte Phippsii*, Kröyer (**42**), p. 575.

A single specimen of this species was dredged in 8 fathoms, off West Bay, Cape Flora, on July 24th, 1897. Kröyer states that in this species there are four teeth on the front part of the lower margin of the rostrum, but in this specimen there are seven teeth; the first three (counting from the apex of the rostrum) are each somewhat stouter than the next four and are moderately wide apart, the fourth, fifth, and sixth are close together, while between the sixth and seventh there is an interval about equal to that between the third and fourth as shown by the drawing (fig. 3). But though the Cape Flora specimen differs from the typical *S. phippsii* in this respect, it seems to agree with it otherwise; variation in the number of the teeth of the rostrum amongst the group of crustaceans to which this one belongs is not uncommon.

SPIRONTOCARIS POLARIS (*Sabine*).
1824. *Alpheus polaris*, Sabine (**65**), p. 238, pl. 2. figs. 5–8.

There were several specimens of this species in the Bruce collection, some of them being females with ova. Considerable variation was observed in the number of teeth on the upper and lower margins of the rostrum; on the upper margin the number varied from four to seven, and on the lower margin from one to three. All the specimens were taken in the vicinity of Elmwood at the western extremity of Northbrook Island, and mostly during June and July 1897. One was taken on floe-ice, but the others were dredged in depths ranging from 5 to 19 or 20 fathoms. The variation in the armature of the rostrum may b thus indicated:

$$(1)\,\frac{7}{3},\ (1)\,\frac{6}{1},\ (1)\,\frac{5}{3},\ (2)\,\frac{5}{2},\ (1)\,\frac{4}{3},\ \text{and}\ (1)\,\frac{4}{2};$$

the number within parentheses indicates the number of specimens, while the number above and the number below the line indicates the number of teeth on the upper and lower margins of the rostrum. One of the specimens in which the arrangement of the teeth of the rostrum is represented by $\frac{5}{2}$, measured 65 millim. in length.

Genus SCLEROCRANGON, *Sars*, 1882.

SCLEROCRANGON BOREAS (*Phipps*).

1774. *Cancer boreas*, Phipps (**61** *a*), p. 190, t. 12. fig. 1.

This was represented by one specimen, which was taken in ten fathoms, off West Glacier in Günther Sound, on September 9th, 1896.

SCHIZOPODA.

Genus THYSANOESSA, *Brandt*, 1851.

THYSANOESSA (?) NEGLECTA (*Kröyer*).

1842. *Thysanopoda neglecta*, Kröyer (**44**), pl. 7. figs. 3 *a–d*.

Three specimens of *Thysanoessa* were included in the collection from Franz-Josef Land: one was obtained in West Bay, Cape Flora, on September 9th, 1896, and two near East Glacier, Cape Flora, on August 1st, 1897. The specimens appeared to belong to *T. neglecta*, but were scarcely perfect enough to enable the species to be satisfactorily determined.

Genus MYSIS, *Latreille*, 1803.

MYSIS OCULATA (*Fabricius*).

1780. (?) *Cancer oculatus*, O. Fabricius (**28** *a*), n. 222, p. 245.

A considerable number of specimens of this *Mysis* were included n the Bruce collection. Various stages of development were represented, but the majority of the specimens were adult. They appear to have been all captured at the west end of Northbrook Island, in the vicinity of Cape Flora. Several were taken in September 1896, but the largest portion were collected between the 4th and 23rd of June, 1897; they were dredged in from two to three fathoms water off West Point, Cape Flora. A specimen of *Dajus mysidis* was observed on two of the adult *Mysis*.

CUMACEA.

Genus Diastylis, *Say*, 1818.

Diastylis Rathkii (*Kröyer*).

1841. *Cuma Rathkii*, Kröyer (**42**), pp. 513 & 531, t. v–vi. figs. 17–30.

This species is represented by a single specimen—a female—taken near East Glacier, Cape Flora, on August 1st, 1897.

Genus Lamprops, *Sars*, 1863.

Lamprops fuscata, *G. O. Sars*.

1865. *Lamprops fuscata*, G. O. Sars (**69**), p. 192.

L. fuscata was represented by a number of specimens, most of which were dredged in West Bay in from two to ten fathoms. This has been recorded from a few places in Greenland by Hansen and G. O. Sars.

Genus Petalosarsia, *Stebbing*, 1893.

Petalosarsia ? declivis (*G. O. Sars*).

1865. *Petalopus declivis*, G. O. Sars (**69**).

A single specimen that seems undoubtedly to belong to this species was obtained in some material dredged in ten fathoms about two-thirds of a mile south-west of Elmwood, Cape Flora, in January 1897. *Petalosarsia declivis*, though somewhat rare, appears to have a wide distribution; it has been recorded from Norway, as well as from the British seas. *Petalosarsia* has also been recorded from Spitzbergen.

ISOPODA.

The names and arrangement of the Isopoda are as far as possible in conformity with the second volume of Prof. G. O. Sars's new work on the Crustacea of Norway.

Genus Typhlotanais, *G. O. Sars*, 1880.

Typhlotanais finmarchicus, *G. O. Sars*. (Pl. **3**. figs. 5–7).

1880. *Typhlotanais finmarchicus*, G. O. Sars (**72**), p. 36.

Several specimens of this Isopod were included in the Bruce collection; they occurred chiefly amongst dredged material from West Bay, Cape Flora; a few were also taken amongst sand near East Glacier, in the vicinity of Cape Flora. Prof. Sars discovered the species "many years ago, rather plentifully in the Harbour of Vadsö at a depth of 30 fathoms." One of the largest of the specimens in the Bruce collection measured about 2·3 millimetres. Besides the other characters that distinguish this species, the meral joints of the last three pereiopoda are furnished with one (or two) minute but distinct spines near the end of the inside margin (see fig. 6).

Genus LEPTOGNATHIA, *G. O. Sars*, 1880.

LEPTOGNATHIA LONGIREMIS (*Lilljeborg*).

1865. *Tanais longiremis*, Lilljeborg (**49**), p. 23.

A specimen of this species was obtained in a gathering of Crustacea from the vicinity of Cape Flora. The dactylus of the chelæ was not so distinctly serrate on the superior aspect as Scottish examples. This Isopod "occurs along the whole Norwegian coast from Vadsö to Christiania;" I also have it from various parts of the Scottish coast.

Genus PSEUDOTANAIS, *G. O. Sars*, 1880.

PSEUDOTANAIS FORCIPATUS (*Lilljeborg*). (Pl. **3**. figs. 8, 9.)

1865. *Tanais forcipatus*, Lilljeborg (**49**), p. 16.

This species was represented in the collection by a single specimen dredged in Günther Sound at a depth of ten fathoms on September 9th, 1896. The form of the chelæ (fig. 8) readily distinguishes this from other species of *Pseudotanais*. *P. forcipatus* is also represented in the British fauna; it was moderately frequent in a gathering of small Crustacea collected in the Moray Firth in 1895.

Genus GNATHIA, *Leach*, 1814.

GNATHIA ELONGATA (*Kröyer*).

1842. *Anceus elongatus*, Kröyer (**44**), pl. 30. figs. 3 *a–g*.

A single specimen of a female *Gnathia*, apparently belonging to this species, was obtained in some dredged material collected in lat. 77° 55′ N., long. 53° 20′ E., on July 13th, 1897. The distribution of *G. elongata* seems to be chiefly arctic.

Genus JANIRA, *Leach*, 1814.

JANIRA TRICORNIS (*Kröyer*).

1842. *Henopomus tricornis*, Kröyer (**44**), pl. 30. figs. 2 *a–q*.

A somewhat imperfect specimen of *Janira tricornis* was taken in the vicinity of Cape Mary Harmsworth in from 53 to 93 fathoms on August 7th, 1897 (Cape Mary Harmsworth lies between 30 and 40 miles further north and nearly 100 miles further west than Cape Flora).

Genus MUNNA, *Kröyer*, 1839.

MUNNA FABRICII, *Kröyer*. (Pl. **3**. figs. 10, 11.)

1842. *Munna Fabricii*, Kröyer (**44**), pl. 31. figs. *a–q*.

A single specimen was dredged in 30 fathoms off East Glacier, Cape Flora, on July 21st, 1897. (Fig. 10 is a drawing of the superior antenna.)

MUNNA KRÖYERI, *Goodsir*. (Pl. **3**. figs. 12–14.)

1842. *Munna Kröyeri*, Goodsir (**33**), p. 365, pl. 6. fig. 2.

A few specimens of a *Munna*, apparently belonging to this species, occurred in gatherings of small Crustacea dredged in the vicinity of Cape Flora.—One specimen was taken with the dredge in 15 fathoms one mile off Flora Cottage, on September 10th, 1896; others were dredged at West Bay and off Cape Gertrude in July 1897, in from 5 to 30 fathoms.

Genus PLEUROGONIUM, *G. O. Sars*, 1871.

PLEUROGONIUM INERME, *G. O. Sars*.

1883. *Pleurogonium inerme*, G. O. Sars (**73**), p. 67, pl. 2. fig. 5.

Two female specimens of this species (with ova), and three others, probably males of the same species, were dredged off East Glacier, Cape Flora, in 30 fathoms. The three (?) males were narrower in general outline than the female, but resembled them otherwise.

PLEUROGONIUM SPINOSISSIMUM, *G. O. Sars*. (Pl. **3**. fig. 15.)

1865. *Pleurocantha spinosissimum*, G. O. Sars (**71**), p. 30.

Two specimens, undoubtedly belonging to this species, were taken at the same place and time as *P. inerme.* The drawing (fig. 15) represents the more perfect of the two specimens. The late Dr. Robertson of Cumbrae has recorded this species from the Firth of Clyde.

Genus MUNNOPSIS, *M. Sars*, 1860.

MUNNOPSIS TYPICA, *M. Sars.*

1860. *Munnopsis typica,* M. Sars (**67**), p. 84.

The Bruce collection contained several specimens of *Munnopsis typica* ; they were collected chiefly in the vicinity of Cape Flora—such as, a quarter of a mile west of the flagstaff, on July 2nd, 1897 (this specimen was taken in the surface tow-net) ; off East Glacier in 30 fathoms, on the 21st of July and again on August the 1st; and off West Point in 2 to 3 fathoms in July. A specimen was also taken at about two-thirds of a mile south-west of Elmwood on April 29th, 1897, in 18 fathoms. Some of the specimens were considerably damaged, but a few were very complete. Heller also records *Munnopsis typica* from Franz-Josef Land.

Genus DAJUS, *Kröyer*, 1846.

DAJUS MYSIDIS, *Kröyer.*

1846. *Dajus mysidis,* Kröyer (**47**), pl. 28. fig. 1 A–B.

Two specimens of this parasite were observed; they were adhering to specimens of *Mysis oculata,* being attached to the underside of the thorax between the posterior swimming-feet.

Genus PODASCON, *Giard & Bonnier*, 1895.

PODASCON STEBBINGI, *Giard & Bonnier.*

1895. *Podascon Stebbingi,* Giard & Bonnier (**29**), p. 462.

A few specimens of an Epicaride occurred amongst gatherings of small Crustacea dredged in West Bay, off West Point, and off East Glacier (all in the vicinity of Cape Flora). This Epicardie agrees very closely with a form recorded by Rev. Mr. Stebbing from the Arctic seas, and which Professors Giard and Bonnier describe under the above name in their memoir on Epicarides published in the 'Bulletin Scientifique de la France et de la Belgique,' tome xxv. (1895).

AMPHIPODA.

This suborder of the Edriophthalma was represented in the Bruce collection by a considerable number of species, and some of the species, such as *Anonyx nugax*, *Onesimus Edwardsii*, and *Gammarus locusta*, by many individual specimens. Prof. G. O. Sars's recent work on the Amphipoda of Norway is generally followed in the arrangement and names of the species.

HYPERIIDEA.

Genus HYPERIA, *Latreille*, 1825.

HYPERIA GALBA (*Montagu*).

1815. *Cancer gammarus galba*, Montagu (**53** *a*), p. 4, pl. 2. fig. 2.

A single specimen of *Hyperia galba* was taken in West Bay, Cape Flora, on July 5th, 1897. According to Prof. Sars, the distribution of this species extends from the Arctic seas to the coasts of Britain and France.

Genus PARATHEMISTO, *Boeck*, 1870.

PARATHEMISTO OBLIVIA (*Kröyer*).

1838. *Hyperia oblivia*, Kröyer (**41**), p. 70, pl. 4. fig. 19.

A number of specimens of this Amphipod were obtained on the sand near East Glacier, Cape Flora, on August 1st, 1897. (No specimen of *Euthemisto libellula* (Mandt), so frequent and widely distributed in the Arctic sea, was contained in this collection.)

GAMMARIDEA.

Genus ORCHOMENELLA, *G. O. Sars*, 1890.

ORCHOMENELLA MINUTA (*Kröyer*).

1846. *Anonyx minutus*, Kröyer (**47**), 2 R. 2 B, p. 23.

A single example of this species was captured in about one to two fathoms at West Bay, near Cape Flora, on August 20th, 1896, and another near the same place on June 6th, 1897.

Genus ANONYX, *Kröyer*, 1838.

ANONYX NUGAX (*Phipps*).

1774. *Cancer nugax*, Phipps (**61** *a*), p. 192, pl. 12. fig. 3.

A considerable number of specimens of all ages and sizes were contained in the Bruce collection; most of the specimens were collected in the neighbourhood of Cape Flora, especially about two-thirds of a mile south-west of Elmwood. Some were collected in January 1897, and others during April, May, June, and July. Several of the specimens were of large size: Prof. Sars states that 40 millim. is about the maximum length of Arctic specimens; one or two of the largest in the Bruce collection measured from 40 to 42·5 millim.

Anonyx nugax seems to be one of the more commonly distributed species in the Arctic seas. Prof. Sars (*loc. cit.*) gives Franz-Josef Land among the places mentioned in his note on the distribution of the species. I have obtained on two separate occasions in the Firth of Forth what is certainly the same species.

Genus HOPLONYX, *G. O. Sars*, 1890.

HOPLONYX SIMILIS, *G. O. Sars*. (Pl. **9**. figs. 11–13.)

1890. *Hoplonyx similis*, G. O. Sars (**75**), p. 93, pl. 33. fig. 1.

A single adult female specimen (with ova) of an Amphipod which I ascribe to this species was taken about two-thirds of a mile south-west of Elmwood, in 18 fathoms water, on May 22nd, 1897. At first I thought it might be a specimen of *Hoplonyx cicada* (Fabricius), as that is said to be a widely distributed species in the Arctic Seas, but a more careful examination showed that the form of the fourth coxal plates (fig. 11) and of the last epimeral plates (fig. 12) differed from those of that species, while they agreed very closely with those of *H. similis*, G. O. Sars. In this specimen the integument is ornamented with numerous circular depressions as exhibited by the figures.

Genus PSEUDALIBROTUS, *Della Valle*.

* PSEUDALIBROTUS LITTORALIS (*Kröyer*).

1845. *Anonyx littoralis*, Kröyer (**46**), 2 R. 1 B. p. 621.

This species was obtained by Mr. Bruce on several occasions,

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* Prof. Sars, in 'Crustacea of Norway,' vol. i. p. 102, expresses some doubt as to whether M.-Edwards's generic name *Alibrotus* is correctly applied to this northern form, but he does not propose any substitute for it. More recently, however, Della Valle instituted a new genus, *Pseudalibrotus*, for Kröyer's species, and I have adopted this name here.

and usually in comparatively shallow wateror on the shore; it appeared to be one of the more common of the Franz-Josef Land Amphipoda. The following are some of the localities where it was obtained:—West Bay, Cape Flora, in 2 to 3 fathoms, on the 22nd and 25th August, and off Flagstaff Point, Elmwood, on the 19th September, 1896. Fifty yards off West Point, Cape Flora, in 2 to 3 fathoms, on July 7th; and on sand near East Glacier, Cape Flora, on August 1st, 1897. A few days afterwards, viz. on the 7th of August, the same species was taken on the shore at Cape Mary Harmsworth. Prof. G. O. Sars (*loc. cit.*) also records the species from Franz-Josef Land.

Genus ONESIMUS, *Boeck*, 1870.

ONESIMUS EDWARDSII (*Kröyer*).

1846. *Anonyx Edwardsii,* Kröyer (**47**), 2 R. 2 B. p. 1.

This species was also represented by numerous specimens in the Bruce collection; it was taken at the surface of the water and at various depths down to 26 fathoms. In 1896 it was obtained at West Bay, Cape Flora, in 2 to 3 fathoms water, on the 22nd of August, and at about a mile off Flora Cottage in 15 fathoms on the 10th September. *Onesimus Edwardsii* was taken on several occasions during 1897; the first record of it for that year is on January 11th, when specimens were collected about two-thirds of a mile south-west of Elmwood, others were afterwards collected near the same locality during April, May, and June. The species also occurred in other places, but they were all in the neighbourhood of Cape Flora, near the western extremity of Northbrook Island. This is also one of the species recorded by Prof. Sars from Franz-Josef Land.

Genus AMPHILOCHUS, *Spence Bate*, 1862.

AMPHILOCHUS OCULATUS, *Hansen.*

1887. *Amphilochus oculatus,* Hansen (**36**), p. 89, pl. iii. figs. 2–2 *c*.

Only one or two specimens of this comparatively small species were observed in the Bruce collection; they occurred in a gathering of material dredged in 2 to 10 fathoms in West Bay, Cape Flora, on July 2nd, and off Cape Gertrude in 30 fathoms on July 21st, 1897.

Genus GITANA, *Boeck*, 1870.

GITANA SARSII, *Boeck.*

1870. *Gitana Sarsii*, Boeck (6), p. 52.

A single specimen of this species occurred in a gathering of Microcrustacea dredged off East Glacier, in 30 fathoms, July 21st, 1897.

Genus METOPA, *Boeck*, 1870.

METOPA PUSILLA, *G. O. Sars.*

1890. *Metopa pusilla*, G. O. Sars (75), p. 256, pl. 90. fig. 1.

One or two specimens of a *Metopa* apparently belonging to this species were obtained off East Glacier, at a depth of 30 fathoms, and off Cape Gertrude, on July 21st, 1897.

METOPA SINUATA, *G. O. Sars.*

1890. *Metopa sinuata*, G. O. Sars (75), p. 263, pl. 92. fig. 2.

This species was represented by a single specimen which was dredged off Cape Mary Harmsworth, in 53 to 93 fathoms, on August 7th, 1897.

METOPA NEGLECTA, *Hansen.*

1887. *Metopa neglecta*, Hansen (36), p. 96, pl. iii. figs. 9–9 *c*.

This species was obtained in the same gatherings with *M. pusilla* and was represented by only one or two specimens.

All these three species of *Metopa* have already been recorded from the Arctic seas, but not from Franz-Josef Land.

Genus PARŒDICEROS, *G. O. Sars*, 1890.

PARŒDICEROS LYNCEUS (*M. Sars*).

1858. *Œdiceros lynceus*, M. Sars (66 *a*), p. 143.

This species, which is widely distributed in the Arctic seas, occurred very sparingly in the Bruce collection. It was first taken September 10th, 1896, about a mile off Flora Cottage, in 15 fathoms, and it also occurred amongst some material dredged in West Bay, Cape Flora, in 2 to 10 fathoms, on July 2nd, 1897.

Genus MONOCULODES, *Stimpson*, 1853.

MONOCULODES BOREALIS, *Boeck.*

1870. *Monoculodes borealis*, Boeck (6), p. 88.

Two specimens of *M. borealis* occurred in the Bruce collection ;

they were obtained in West Bay, Cape Flora, in 2 to 3 fathoms, in July 1897. This species has been taken in the Firth of Clyde.

MONOCULODES LATIMANUS (*Goës*).

1866. *Œdiceros latimanus*, Goës (**32**), pl. ii. fig. 23.

A single specimen of an Amphipod apparently belonging to this species was obtained amongst some dredged material from West Bay, Cape Flora; it seemed to differ slightly from *M. latimanus* in the form of the rostrum, but it otherwise agreed very well with that species.

MONOCULODES SCHNEIDERI, *G. O. Sars.*

1895. *Monoculodes Schneideri*, G. O. Sars (**75**), p. 692, pl. vi. (Suppl.) fig. 1.

This pretty species was represented in the Bruce collection by a considerable number of specimens; they mostly occurred in the one gathering dredged in the vicinity of West Bay in 2 to 10 fathoms.

Genus MONOCULOPSIS, *G. O. Sars*, 1891.

MONOCULOPSIS LONGICORNIS (*Boeck*).

1870. *Monoculodes longicornis*, Boeck (**6**), p. 85.

A single specimen of *Monoculopsis* was obtained in the gathering containing *M. Schneideri* from West Bay. This species has a superficial resemblance to *Perioculodes longimanus*, but the gnathopods, and especially the first pair, differ considerably. I have this species also from Baffin's Bay.

Genus BATHYMEDON, *G. O. Sars*, 1891.

BATHYMEDON OBTUSIFRONS (*Hansen*).

1887. *Halimedon obtusifrons*, Hansen (**36**), p. 116, pl. v. fig. 1.

A single specimen of an Amphipod which I identify as *Bathymedon obtusifrons* (Hansen) was obtained in the same gathering as the two species last recorded.

Genus ACEROS, *Boeck*, 1860.

ACEROS PHYLLONYX (*M. Sars*).

1858. *Leucothoë phyllonyx*, M. Sars (**66** *a*), p. 148.

A specimen of this species was included in the Bruce collection, but was taken a considerable distance to the south of Franz-Josef Land. It was dredged in lat. 77° 53′ N., long. 53° 16′ E. (or almost midway between Novaya Zemlya and Northbrook Island), and at a depth of 130 fathoms. Heller records this species from Franz-Josef Land.

Genus ACANTHOSTEPHEIA, *Boeck*, 1870.

ACANTHOSTEPHEIA MALMGRENI (*Goës*).

1865. *Amphithonotus Malmgreni*, Goës (**32**), p. 10, fig. 17.

This species was represented by a single specimen dredged in the vicinity of West Bay, in from 2 to 10 fathoms, on July 2nd, 1897. Mr. Stebbing records *Acanthostepheia* from lat. 75° 14′ N., long. 44° 26′ E., as well as from other parts of Barents Sea; it has also been recorded from Stor Fjord and other parts of the Spitzbergen coast by Goës, and from West Greenland by Hansen. The peculiar conformation of the eyes in this species gives it a somewhat *outré* appearance.

Genus PARAMPHITHOË, *Bruzelius*, 1859.

PARAMPHITHOË PULCHELLA (*Kröyer*).

1846. *Amphithoë pulchella*, Kröyer (**47**), pl. 10. fig. 2.

Two specimens were captured with the dredge off West Bay, Cape Flora, at a depth of about 8 fathoms, on July 24th, 1897. *Paramphithoë pulchella*, though widely distributed, seems to be scarce in the Arctic seas; but appears to be more or less common on the west and north of Norway.

PARAMPHITHOË BICUSPIS (*Kröyer*).

1838. *Amphithoë bicuspis*, Kröyer (**41**), p. 273, pl. 2. fig. 10.

This species was obtained amongst some small Crustacea dredged in West Bay, in from 2 to 10 fathoms, on July 2nd, 1897. This species is widely distributed in the Arctic seas, and is also included in the British fauna.

PARAMPHITHOË MONOCUSPIS, *G. O. Sars*.

1892. *Paramphithoë monocuspis*, G. O. Sars (**75**), p. 351, pl. 123. fig. 2.

The most prominent difference between this and *P. bicuspis* is that suggested by the name—this species having only one dorsal cusp instead of two. The species otherwise are closely related; but as the difference referred to appears to be fairly constant, and as there are one or two points in which a disagreement between the two forms is observed, it is more satisfactory to regard this as a distinct species than simply as a variety. Moreover, both forms have an extensive distribution. *P. monocuspis* is represented in the collection of Franz-Josef Land Crustacea by two specimens, one of which was obtained off Bear Berg, in about 10 fathoms, on September 27th, 1896; and the other about one mile off Flora Cottage, in 15 fathoms, on the 10th of the same month. Prof. Sars records the species from Greenland and from Norway; and it is also a member of the British fauna.

Genus PARAPLEUSTES, *Buchholz*, 1874.

PARAPLEUSTES GLABER (*Boeck*).

1860. *Amphithopsis glaber*, Boeck (**4**), p. 662.

This species is represented by a single specimen captured off Bear Berg, in 10 fathoms, on September 27th, 1896. It has been recorded from various other Arctic localities, and south as far as Christiania Fjord and the Kattegat.

Genus ACANTHONOTOSOMA, *Boeck*, 1876.

ACANTHONOTOSOMA CRISTATUM (*Owen*).

1835. *Acanthonotus cristatus*, Owen (**61**), p. 90, pl. B. figs. 8–12.

This species is included in the collection of Crustacea from Franz-Josef Land, but was dredged somewhat to the south of that Archipelago in lat. 77° 53′ N., long. 53° 20′ E., at a depth of 130 fathoms, on July 11th, 1897. Goës records this from Spitzbergen, Hoek from Barents Sea, and Hansen from the Kara Sea; while Mr. Stebbing records the occurrence of a specimen from lat. 75° 14′ N., long. 44° 26′ E., from a depth of 130 fathoms. Goës's Spitzbergen Station (Heenloopen Strat) is somewhat farther north than that of Mr. Bruce.

Genus SYRRHOË, *Goës*, 1865.

SYRRHOË CRENULATA, *Goës*.

1865. *Syrrhoë crenulata*, Goës (**32**), p. 11, fig. 25.

This species was dredged in 15 fathoms, about one mile off

Flora Cottage, on September 10th, 1896, and off West Bay, Cape Flora, in 8 fathoms, on July 24th, 1897. *Syrrhoë crenulata* appears to be a somewhat scarce species in the Arctic seas, but seems to be more frequent off the coast of Norway.

Genus PARDALISCA, *Kröyer*, 1842.

PARDALISCA CUSPIDATA, *Kröyer*.

1842. *Pardalisca cuspidata*, Kröyer (**43**), p. 153.

This species was also taken off Flora Cottage on September 10th, 1896, along with the *Syrrhoë*. One specimen only was obtained. *Pardalisca cuspidata*, although apparently scarce in the Arctic seas, is, according to Sars, not uncommon off the coast of Finmark.

Genus EUSIRUS, *Kröyer*, 1845.

EUSIRUS CUSPIDATUS, *Kröyer*.

1845. *Eusirus cuspidatus*, Kröyer (**46**), p. 501.

A single specimen of *Eusirus cuspidatus* was captured about two-thirds of a mile south-west of Elmwood on May 21st, 1897. The distribution of the species seems to be almost restricted to the Arctic seas.

Genus RHACHOTROPIS, *S. Smith*, 1883.

RHACHOTROPIS ACULEATA (*Lepechin*).

1778. *Oniscus aculeatus*, Lepechin (**48**), p. 247, pl. 8. fig. 1.

This species was represented in the Bruce collection by several specimens, which were obtained as follows:—A few specimens, all more or less immature, were taken in about 10 fathoms off West Glacier, in Günther Sound, on September 9th, 1896; an adult species was captured two-thirds of a mile south-west of Elmwood on April 30th, 1897; other specimens, more or less immature, occurred off West Point, Cape Flora, in 2 to 3 fathoms, on June 22nd; on June 26th three immature specimens were obtained south-west of Elmwood, in 18 fathoms; and on July 13th one or two more, also immature, were obtained in 4 fathoms off East Glacier, Cape Flora. Heller records this species also from Franz-Josef Land.

Genus ROZINANTE, *T. R. R. Stebbing*, 1894.

ROZINANTE FRAGILIS (*Goës*).

1866. *Paramphithoë fragilis*, Goës (**32**), p. 524, pl. 39. fig. 16.

This Amphipod was described by Goës as a *Paramphithoë*, but it was afterwards referred by Boeck and others to *Tritropis*. As, however, this name was already in use, Prof. S. Smith, in 1883, altered it to *Rhachotropis*. Along with these changes in the name, the characters also of the genus had been modified and restricted, with the result that Goës's species was disinherited. Mr. Stebbing came to the rescue of this unfortunate Amphipod and instituted a new genus (*Rozinante*) for its reception, where it now seems to be at rest. The following are some of the localities where *Rozinante* was obtained by Mr. Bruce:—Off Flora Cottage, in 15 fathoms, September 10th, 1896; two-thirds of a mile south-west of Elmwood, in 20 fathoms, January 11th, 1897; off West Point, Cape Flora, in 2 to 3 fathoms, June 22nd; off Cape Gertrude, in 30 fathoms, July 17th; off West Bay, Cape Flora, in 8 fathoms, July 23rd and 24th; and off Cape Mary Harmsworth, in 53 to 93 fathoms, August 7th, 1897. Goës records it from Wijde Bay, on the north, and Stor Fjord on the east side of West Spitzbergen, and also from Greenland. Hansen records it also from Greenland, and Mr. Stebbing from the Kara Sea (lat. 71° 19′ N., long. 63° 34′ E.). Its distribution seems to be limited to the Arctic seas.

There seems to be considerable variation in the length of the cleft of the telson, in some instances it does not exceed one-sixth of the length, while in others it is as much as one-third.

Genus HALIRAGES, *Boeck*, 1870.

HALIRAGES FULVOCINCTUS (*M. Sars*).

1854. *Amphithoë fulvocincta*, M. Sars (**66**), p. 141.

This species was represented in the Bruce collection by a considerable number of specimens; they were collected at various localities during 1896 and 1897, but chiefly in the neighbourhood of Cape Flora, near the western extremity of Northbrook Island. The following is a brief summary of the places where *Halirages fulvocinctus* was obtained:—In West Bay, Cape Flora; south-west of Elmwood, Cape Flora; off Cape Flora itself; off Cape Gertrude; near East Glacier; off West Glacier, off Bear Berg; and off Wilczek Island. *H. fulvocinctus* appears to be a common Arctic species; it also extends "along the whole west and north coasts of Norway."

Genus CLEIPPIDES, *Boeck*, 1870.

CLEIPPIDES QUADRICUSPIS, *Heller*.

1878. *Cleippides quadricuspis*, Heller (**37**), pp. 25–40.

This species was described by Prof. Camil Heller from specimens captured during the Austrian North-Polar Expedition (1878). It was represented in the Bruce collection by a single adult specimen, which was dredged in 130 fathoms, in lat. 77° 53′ N., long. 53° 16′ E., on July 13th, 1897. In this specimen the dorsal cusps were very prominent, even more so than is shown in Heller's figure.

Genus CALLIOPIUS, *Lilljeborg*, 1865.

CALLIOPIUS LÆVIUSCULUS (*Kröyer*).

1838. *Amphithoë læviusculus*, Kröyer (**41**), p. 281, pl. 3. fig. 13.

A single specimen of this widely distributed species occurred among some Crustacea collected near West Point, Cape Flora, on July 5th; while a second was obtained in a gathering collected about two-thirds of a mile south-west of Elmwood on January 11th, 1897.

Genus AMPHITHOPSIS, *Boeck*, 1870.

AMPHITHOPSIS GLACIALIS, *Hansen*.

1887. *Amphithopsis glacialis*, Hansen (**36**), p. 137, pl. 5. figs. 6–6 *e*.

This species was taken off West Point, Cape Flora, in 2 to 3 fathoms, on the 20th of June; and also inshore at Cape Mary Harmsworth, on August 7th, 1897.

Genus ATYLUS, *Leach*, 1817.

ATYLUS CARINATUS (*Fabricius*).

1793. *Gammarus carinatus*, Fabricius (**28**), t. ii. p. 515.

The only localities where this species was obtained were off West Bay, Cape Flora, in 5 fathoms, on September 12th, 1896; and off West Point, Cape Flora, in 2 to 3 fathoms, on June 20th, 1897—one specimen being obtained at each place. *Atylus carinatus* has also been recorded for Franz-Josef Land by Miers.

Genus AMATHILLA, *Spence Bate*, 1863.

AMATHILLA HOMARI (*Fabricius*).

1779. *Astacus homari*, Fabricius (**27**), p. 247.

This species was obtained off West Point, Cape Flora, in 2 to 4 fathoms, on two different occasions, viz., on June 22nd and July 5th, 1897.

AMATHILLA PINGUIS (*Kröyer*). (Pl. ~~7~~ 9. figs. 14, 15.)

1838. *Gammarus pinguis*, Kröyer (**41**), p. 24, pl. 1. fig. 5.

This *Amathilla* was represented by several specimens captured in the neighbourhood of Cape Flora on different occasions during June and July, 1897. Prof. G. O. Sars states that this species ought, in his opinion, to be removed as the type of a separate genus, as it differs considerably in several points "from the typical *Amathilla*." In *Amathilla pinguis* the last epimeral plates of the metasome somewhat resemble those of *Apherusa Jurinei.*

Genus GAMMARACANTHUS, *Spence Bate*, 1862.

GAMMARACANTHUS LORICATUS (*Sabine*).

1824. *Gammarus loricatus*, Sabine (**65**), p. 131, pl. 1. fig. 7.

A single specimen of this fine species was captured about 50 yards off West Point, Cape Flora, in 2 to 3 fathoms, on June 22nd, 1897. *G. loricatus* appears, in its distribution, to be restricted to the Arctic seas, and is not even recorded from the coast of Finmark, a district that has furnished not a few Arctic forms to the fauna of Norway.

Genus GAMMARUS, *Fabricius*.

GAMMARUS LOCUSTA (*Linne*).

1767. *Cancer locusta*, Linné (**50**), p. 1055.

Numerous examples of *Gammarus locusta*, comprising all stages from embryos to adults, were included in the Bruce collection. Nearly all the specimens were from inshore, and formed part of every inshore gathering of invertebrates. Some of the specimens were of large size, while a considerable proportion of the adult females carried ova or embryos. Prof. Sars includes Franz-Josef Land in his notes on the Arctic distribution of *Gammarus locusta.*

Genus PHOTIS, *Kröyer*, 1842.

PHOTIS TENUICORNIS, *G. O. Sars*. (Pl. ~~7~~ 9. figs. 16, 17.)

1883. *Photis tenuicornis*, G. O. Sars (**73**), p. 110, pl. 6. fig. 4.

This species was represented by a very few specimens collected chiefly in the neighbourhood of Cape Flora, as, for example, off Flora Cottage, in 15 fathoms, on September 10th, 1896, and off West Glacier, Günther Sound, in 10 fathoms, on September 9th, 1896. In the male of this species a row of minute spines extends in a diagonal manner across the basal joint of the posterior gnathopoda (fig. 17).

Genus ISCHYROCERUS, *Kröyer*, 1838.

ISCHYROCERUS (?) ANGUIPES, *Kröyer*. (Pl. 7. fig. 18.)

1838. *Ischyrocerus anguipes*, Kröyer (**41**), p. 55, pl. 3. fig. 14.

A few specimens of an Amphipod probably belonging to this species were among the Crustacea in the Bruce collection. In the male specimens the propodos (fig. 18) differed from those of the fully developed male of *Ischyrocerus anguipes*, but this difference may be due to the specimens being scarcely mature. The following are the localities where the specimens were collected:—Off West Glacier, Günther Sound, in 10 fathoms, September 9th, 1896; and off West Point, Cape Flora, June 20th, 21st, and 22nd, 1897.

Genus DULICHIA, *Kröyer*, 1845.

DULICHIA SPINOSISSIMA, *Kröyer*.

1845. *Dulichia spinosissima*, Kröyer (**46**), p. 512, pl. 6. fig. 1.

This curious species was represented by a single specimen captured about two-thirds of a mile south-west of Elmwood, at a depth of 18 fathoms, on April 28th or 29th, 1897. It appears to be restricted to the Arctic seas.

CAPRELLIDEA.

Genus ÆGINA, *Kröyer*, 1843.

ÆGINA SPINOSISSIMA, *Stimpson*.

1853. *Ægina spinosissima*, Stimpson (**88**), p. 44.

Representatives of this species were obtained off Flora Cottage in 15 fathoms, September 10th, 1896; off West Bay, Cape

Flora, in 8 fathoms, on July 23rd or 24th, 1897; and off Cape Mary Harmsworth, in 53 to 93 fathoms, on August 7th, 1897. The largest specimen measured from rostrum to telson about 38 millimetres, and the antennules 32 millimetres, or a total length of 2⅘ inches.

Genus CAPRELLA, *Lamarck*, 1818.

CAPRELLA SEPTENTRIONALIS, *Kröyer*, forma ε. PARVA, *Mayer*.
1838. *Caprella septentrionalis*, Kröyer (**41**), p. 90.

This species was dredged in 130 fathoms in lat. 77° 53′ N., long. 53° 20′ E. One specimen only was obtained.

CAPRELLA MICROTUBERCULATA, *G. O. Sars*.
1865. *Caprella microtuberculata*, G. O. Sars (**69**).

This species was taken in 10 fathoms, off Bear Berg, on September 28th, 1896; and off Cape Mary Harmsworth, in 53 to 93 fathoms, August 7th, 1897.

CAPRELLA DUBIA, *Hansen*.
1887. *Caprella dubia*, Hansen (**36**), p. 217, pl. 4. figs. 8–8 *d*.

A specimen of this *Caprella* was dredged by Mr. Bruce, in 10 fathoms off Bear Berg, on September 28th, 1896. Dr. Hansen recorded this species in his work on the Crustacea of Greenland, and he at first described it as *Caprella microtuberculata*, G. O. Sars, var. *spinigera*; but in a postscript to the same work (p. 217) he considered that the form he had so described should rank as a species, for which he proposed the new name of *Caprella dubia*.

ENTOMOSTRACA.

OSTRACODA.

The Ostracoda contained in Mr. Bruce's collection number thirty-four species; the first four are freshwater forms, all the others are marine; the freshwater species are from ponds in the vicinity of Elmwood, at the western extremity of Northbrook Island. A pond near Cape Mary Harmsworth was also examined, but no Ostracoda were obtained in it. Three of the freshwater and one of the marine species appear to be undescribed; but all the others belong to more or less well-known forms, and are all represented in the British fauna either as recent or fossil. As to names and arrangement of the species recorded below, I have followed the Monograph of the marine and freshwater Ostracoda of the North Atlantic and North-western Europe by Prof. G. S. Brady and the Rev. Dr. A. M. Norman.

PODOCOPA.

(a. *Freshwater.*)

Genus CYCLOCYPRIS, *Brady & Norman*, 1889.

CYCLOCYPRIS GLOBOSA (*G. O. Sars*). (Pl. 4. fig. 1.)

1863. *Cypris globosa*, G. O. Sars (68), p. 27.

Single valves of an Ostracod apparently identical with *C. globosa* were obtained in the gathering from Elmwood Pond. The valve figured measures about 1·1 millimetre in longest diameter. (This may be the *Cypria lacustris* of Lilljeborg, but the convexity of the shell is rather too great to fit that species.)

Genus HERPETOCYPRIS, *Brady & Norman*, 1889.

HERPETOCYPRIS (?) DUBIA, sp. n. (Pl. 4. figs. 7–11.)

The shell seen from the side is subreniform; the greatest height, which is equal to fully half the length, is situated about one-third of the entire length from the anterior end; the upper margin is considerably elevated in front of the middle; the posterior slope is gentle and slightly curved, but anteriorly the slope is more abrupt; the anterior extremity is broadly rounded; the posterior end is also evenly and gently rounded, but is rather narrower than the front end; lower margin slightly sinuated. Seen from above, ovate, widest in the middle, greatest width equal to about half the length; sides evenly curved; extremities slightly acuminate. Shell surface smooth and yellowish in colour. Length 13 mm.

This Ostracod, seen from above, somewhat resembles *Cypris crassa*, O. F. Müller, and the side view is also suggestive of the same species; but when compared with the figures of that species in Brady and Norman's Monograph, the present form, viewed laterally, is seen to be more boldly arched. It may also be noted that, when viewed laterally, *H. dubia* somewhat resembles *Candona rostrata* seen in the same position; but in that species the dorsal view is different. It is just possible that *H. dubia* may represent a somewhat immature stage of the next species.

HERPETOCYPRIS ARCTICA, sp. n. (Pl. 4. figs. 2–6.)

Shell, seen from the side, subreniform, highest in front of the middle; greatest height equal to fully half the length, extremities broadly rounded; dorsal margin moderately arched, ventral slightly sinuated. Seen from above, ovate, tumid, greatest width situated behind the middle and nearly equal to half the length: posteriorly the sides converge in a broadly rounded curve and, where they meet, form an obtuse angle; they taper more gradually towards the anterior end, and the extremity there is slightly acuminate. Colour bluish green, ornamented with darker streaks and blotches. Length 1·9 mm.

This Ostracod, which was moderately frequent in a freshwater pond near Elmwood, Cape Flora, was collected July 30th, 1897.

Genus CANDONA, *Baird*, 1845.

CANDONA HARMSWORTHI, sp. n. (Pl. 3. figs. 16, 17.)

The shell, seen from the side, is somewhat subreniform; the dorsal margin is considerably elevated near the posterior end, where the anterior and posterior slopes meet and form an obtuse angle; the greatest height is equal to rather more than half the length; the front slope curves gently downwards to the evenly rounded anterior extremity; the posterior end is subtruncate and forms a slight curve from the obtuse dorsal angle downwards and backwards to where it meets the ventral margin; the ventral margin is distinctly incurved in front of the middle. The shell, seen from above, is ovate; the greatest width, which is situated behind the middle, is equal to rather more than two-fifths of the length; extremities slightly acuminate. Length 1 mm.

I have named this quite distinct species after Mr. Harmsworth, of the Jackson-Harmsworth Expedition.

Candona harmsworthi has a distant resemblance to *C. candida*, var. *claviformis*, when viewed laterally, but the dorsal view is dissimilar.

(b. *Marine Species.*)

Genus PONTOCYPRIS, *G. O. Sars*, 1865.

PONTOCYPRIS (?) HYPERBOREA, sp. n. (Pl. 4. figs. 12–15.)

Shell, seen from the side, subreniform, dorsal margin boldly arched, being almost semicircular, height equal to half the length;

ventral margin nearly straight; anterior end narrowly rounded, posterior subangular. Seen from above ovate, the sides evenly curved; ends slightly acuminate, or forming an acute angle; width scarcely equal to half the length. Seen from the end, somewhat triangular, with the underside (the base of the triangle) slightly oblique. Surface of the shell smooth, white, with scattered opaque circular markings. Length ·9 mm.

A single dead specimen was dredged in West Bay, Cape Flora, at a depth of 2 to 10 fathoms, on July 2nd, 1897. I only provisionally ascribe this Ostracod to *Pontocypris*, for without the animal it is hardly possible to determine the genus it may belong to.

Genus CYTHERE, *Müller*, 1781.

CYTHERE MARGINATA, *Norman*.

1862. *Cythere marginata*, Norman (**56**), p. 47, pl. 3. figs. 10–12.

Dredged one mile off Cape Flora, in 15 fathoms, September 10th, 1896. This has been recorded from Spitzbergen, Norway, and from various British localities.

CYTHERE LIMICOLA, *Norman*.

1865. *Cythere limicola*, Norman (**58**), p. 20, pl. 6. figs. 1–4.

Dredged off East Glacier, Cape Flora, in 30 fathoms, July 21st, 1897. This was a somewhat rare species in the Franz-Josef Land collection; it is also one of the less common of the British species. It has been recorded from Baffin's Bay by Dr. Brady, and from Norway by G. O. Sars.

CYTHERE GLOBULIFERA, *G. S. Brady*.

1868. *Cythere globulifera*, Brady (**12**), p. 406, pl. 31. fig. 42.

This species was also rare in the collection, one or two specimens only having been observed. Dr. Norman records it from Norway, and Prof. Brady from Spitzbergen. As a recent species it is rare in the British seas, but is less rare as a post-tertiary fossil. It was taken off East Glacier with the last.

CYTHERE CLUTHÆ, *Brady, Crosskey, & Robertson*.

1874. *Cythere cluthæ*, Brady, Crosskey, & Robertson (**16**), p. 153, pl. 13. figs. 16, 17.

This was also a rare species; it was taken off East Glacier, in 30 fathoms, on July 21st, 1897. *C. cluthæ* was first described from fossil specimens, but has since been obtained as a recent species in several British localities, as the Irish Sea (Malcolmson); Loch Fyne and Stromness Harbour (mihi). Prof. G. S. Brady records it from Cape Frazer, from specimens obtained in Capt. Feilden's dredgings during Nares's Arctic Expedition.

CYTHERE SEPTENTRIONALIS, *G. S. Brady.*

1866. *Cythere septentrionalis,* G. S. Brady (**11**), p. 375, pl. 60. figs. 4 *a–f.*

This fine species was dredged one mile off Cape Flora, in 15 fathoms, on September 10th, 1896, and off East Glacier, in 30 fathoms, July 21st, 1897. Prof. Brady described the species from specimens obtained in Dr. P. E. Sutherland's dredgings at Hunde Islands, Baffin's Bay, in 60–70 fathoms.

CYTHERE TUBERCULATA (*G. O. Sars*).

1865. *Cythereis tuberculata,* G. O. Sars (**71**), p. 37.

This was dredged in 15 fathoms about one mile off Cape Flora, September 10th, 1896; also off East Glacier and off Cape Gertrude, in 30 fathoms, July 21st, 1897. It is a common and widely distributed species.

CYTHERE EMARGINATA (*G. O. Sars*).

1865. *Cythereis emarginata,* G. O. Sars (**71**), p. 38.

Dredged off Cape Flora, September 10th, 1896; also off West Point, July 5th, 1897, and on the 21st of the same month off Cape Gertrude. *C. emarginata* has been obtained in Loch Fyne, but the specimens had probably washed out from a submarine post-tertiary deposit; it has been obtained recent at Shetland.

CYTHERE COSTATA, *G. S. Brady.*

1866. *Cythere costata,* G. S. Brady (**11**), p. 375, pl. 60. figs. 50 *a–f.*

This was dredged off East Glacier, Cape Flora, in 30 fathoms, July 21st, 1897; it did not appear to be very common.

CYTHERE MIRABILIS, *G. S. Brady.*

1868. *Cythere mirabilis,* G. S. Brady (**12**), p. 415, pl. 29. figs. 7, 8.

This species was very rare in the Franz-Josef Land collections; it was dredged with the last off East Glacier. Prof. Brady records *C. mirabilis* from Spitzbergen.

CYTHERE DUNELMENSIS (*Norman*).

1865. *Cythereis dunelmensis,* Norman (**58**), p. 22, pl. 7. figs. 1–4.

Dredged in 15 fathoms, one mile off Cape Flora, September 10th, 1896, but very rare in the Franz-Josef Land collection.

Genus CYTHERIDEA, *Bosquet*, 1852.

CYTHERIDEA PAPILLOSA, *Bosquet*.

1852. *Cytheridea papillosa*, Bosquet (**8**), p. 42, pl. 2. figs. 5 *a–d*.

This was one of the more common species of Ostracoda in the Collection, and was obtained at several places; it was dredged off East Glacier, September 10th, 1896; at West Bay, Cape Flora, in 2 to 10 fathoms, July 2nd, 1897, and off Cape Gertrude, in 30 fathoms, on the 21st of the same month. It seems to be a common Arctic, as it is a common British species.

CYTHERIDEA PUNCTILLATA, *G. S. Brady*.

1865. *Cytheridea punctillata*, G. S. Brady (**9**), p. 189, pl. 9. figs. 9–11.

Several specimens of this Ostracod were obtained in a gathering dredged off Cape Flora, September 1896, and in another dredged off East Glacier, July 1897.

CYTHERIDEA SORBYANA, *Jones*.

1856. *Cytheridea sorbyana*, Jones (**39**), p. 44, pl. 4. figs. 6 *a–e*.

A considerable number of examples of *Cytheridea Sorbyana* were obtained in the Franz-Josef Land collection; they occurred mostly in some material dredged off Cape Flora, September 10th, 1896. All these three *Cytherideas* have been recorded for Spitzbergen by Prof. G. S. Brady.

Genus EUCYTHERE, *Brady*, 1868.

EUCYTHERE DECLIVIS (*Norman*).

1864. *Cythere declivis*, Norman (**57**), p. 192.

This Ostracod occurred very sparingly in the Collection; it was dredged off Cape Gertrude and off East Glacier in July 1897.

Genus XESTOLEBERIS, *G. O. Sars*, 1865.

XESTOLEBERIS DEPRESSA, *G. O. Sars*.

1865. *Xestoleberis depressa*, G. O. Sars (**71**), p. 68.

This was dredged off Cape Flora, in 15 fathoms, September 1896; at West Bay, Cape Flora, in 2 to 10 fathoms, and off West Point, in 2 to 4 fathoms, on July 5th, 1897; very few specimens were observed.

Genus CYTHERURA, *G. O. Sars*, 1865.

CYTHERURA UNDATA, *G. O. Sars*.

1865. *Cytherura undata*, G. O. Sars (**71**), p. 75.

Only a few specimens of this species were observed in the

Collection; they occurred in two gatherings—one dredged off West Point, the other off East Glacier. This has been recorded from Spitzbergen and other Arctic localities; it is also frequent as a British species.

CYTHERURA FULVA, *Brady & Robertson.*

1874. *Cytherura fulva*, Brady & Robertson (**21**), p. 116, pl. 4. figs. 1–5.

This was dredged off East Glacier, Cape Flora, at a depth of 30 fathoms, July 21st, 1897, but very few specimens were observed. This is a widely distributed species in the British seas; but it does not appear to have been recorded from the Arctic seas.

CYTHERURA CLATHRATA, *G. O. Sars.*

1865. *Cytherura clathrata,* G. O. Sars (**71**), p. 77.

This distinct and pretty species was dredged off East Glacier with the previous species, and, like it, was also rare, very few specimens being observed.

Genus CYTHEROPTERON, *G. O. Sars*, 1865.

CYTHEROPTERON LATISSIMUM (*Norman*).

1865. *Cythere latissima,* Norman (**58**), p. 19, pl. 6. figs. 5–8.

One or two specimens only of this species were observed in the Collection; they occurred in some material dredged off West Point, Cape Flora, in 2 to 4 fathoms, in July 1897.

CYTHEROPTERON PYRAMIDALE, *G. S. Brady.*

1868. *Cytheropteron pyramidale,* G. S. Brady (**12**), p. 34, pl. 5. figs. 11–14.

This was scarcely so rare as the last species; a few specimens were dredged off Cape Flora on September 9th, 1896, and off Cape Gertrude and East Glacier, in 30 fathoms, in July 1897.

CYTHEROPTERON SUBCIRCINATUM, *G. O. Sars.*

1868. *Cytheropteron subcircinatum,* G. O. Sars (**71**), p. 81.

A considerable number of specimens of this Ostracod were dredged off East Glacier, Cape Flora, July 21st, 1897; this species does not appear to have previously been observed out of Norway. Prof. Brady agrees with my identification of the species.

CYTHEROPTERON PUNCTATUM, *G. S. Brady.*

1868. *Cytheropteron punctatum,* G. S. Brady (**12**), p. 449, pl. 34. figs. 45–48.

This is a rare species in the Collection; it was obtained off

East Glacier, along with the last, and is also a new record for Arctic seas.

CYTHEROPTERON ANGULATUM, *Brady & Robertson.*

1872. *Cytheropteron angulatum,* Brady & Robertson (**19**), p. 62, pl. 2. figs. 7, 8.

This also was very rare; it was taken off East Glacier along with *C. punctatum* and *C. subcircinatum.* In view of these additions to the Arctic Ostracod fauna (for this also is now for the first time recorded for the arctic seas), it may be of interest to quote a remark made by the authors of the Monograph of the Marine and Freshwater Ostracoda of the North Atlantic and North-Western Europe concerning *C. angulatum,* which is as follows:—"From its abundance in the glacial clays of Scotland it may be expected that this species (*C. angulatum*) will hereafter prove be a recent Arctic form." It has been obtained as a recent species at quite a number of places around the Scottish coasts, as well as in Roundstone Bay, Ireland.

Genus PSEUDOCYTHERE, *G. O. Sars,* 1865.

PSEUDOCYTHERE CAUDATA, *G. O. Sars.*

1865. *Pseudocythere caudata,* G. O. Sars (**71**), p. 88.

Only one or two specimens of this curious species were obtained; it was dredged off East Glacier, where so many other rare things were captured. It is of interest to note that *Pseudocythere caudata* is recorded by Prof. G. S. Brady from the vicinity of Kerguelen Island, situated about 50° South latitude and 70° East longitude.

Genus SCLEROCHILUS, *G. O. Sars,* 1865.

SCLEROCHILUS CONTORTUS (*Norman*).

1862. *Cythere contorta,* Norman (**56**), p. 48, pl. 2. fig. 15.

This was dredged off Cape Flora, September 10th, 1896, and off Cape Gertrude and East Glacier in July 1897. *S. contortus* has already been recorded from the Arctic seas; it is also one of the British species. It was moderately rare in the Franz-Josef Land collection.

Genus PARADOXOSTOMA, *Fischer,* 1855.

PARADOXOSTOMA VARIABILE (*Baird*).

1835. *Cythere variabilis,* Baird (**1**), p. 98, pl. 3. figs. 7 *a–b.*

Several specimens were obtained in some material dredged off

West Point and in West Bay, Cape Flora, in July 1897, at a depth of from 2 to 10 fathoms. This is recorded from Spitzbergen and Greenland, and is also one of the more generally distributed species in Norway, as well as round the British Islands.

PARADOXOSTOMA FLEXUOSUM, *G. S. Brady.*
1866. *Bythocythere ? flexuosa,* G. S. Brady (**11**), p. 211.

A few specimens of *Paradoxostoma flexuosum* were dredged off East Glacier in July 1897. It has been previously recorded from Davis Strait (lat. 69° 31′ N., long. 56° 1′ W.) by A. M. Norman, and is widely distributed southward to the Bay of Biscay.

MYODOCOPA.

Genus PHILOMEDES, *Lilljeborg*, 1853.

PHILOMEDES BRENDA (*Baird*).
1850. *Cypridina brenda,* Baird (**3**), p. 181, pl. 23. figs. 1 *a–g.*

A number of specimens of this Ostracod were dredged in 15 fathoms, one mile off Flora Cottage, on September 10th, 1896, and off West Glacier, Günther Sound, in 10 fathoms, on September 9th, 1897. Dr. Norman records *Philomedes brenda* from Holsteinbourg Harbour, Greenland; it has also been observed in different Norwegian localities as well as in Sweden. In Britain the only places where it has been obtained are off Noss, in Shetland, the Dogger Bank off the coast of Durham, and in the Clyde in the deep water to the east of Arran.

CLADOCOPA.

Genus POLYCOPE, *G. O. Sars*, 1865.

POLYCOPE ORBICULARIS, *G. O. Sars.*
1865. *Polycope orbicularis,* G. O. Sars (**71**), p. 122.

This species was dredged off Flora Cottage in September 1896, and off East Glacier and Cape Gertrude in July 1897. *Polycope orbicularis,* though recorded from various parts of the British and Norwegian coasts, does not appear to have been previously observed so far within the Arctic circle; its occurrence there is, however, not surprising, seeing that it is moderately common as a post-tertiary fossil, at least in the shell-bearing "Glacial clays" of Scotland.

COPEPODA.

Copepoda were fairly numerous in Mr. Bruce's collection of Franz-Josef Land Crustacea. They represent a considerable number of species, and two of them are freshwater forms. Several of the species have been long known as denizens of the Arctic seas; but, on the other hand, this is the first time that a large proportion of them have been recorded from such high latitudes. Nearly all the Franz-Josef Land Copepoda belong to described species, only a very few being new to science. Another interesting point in regard to these Arctic Copepods is, that while the majority of the pelagic forms—that is such as are usually captured by tow-net—are of large size and belong to few species, the majority of those taken with the dredge are small and the species numerous. It may be remarked further that in recording the species of Copepoda obtained in the Franz-Josef Land collection, those belonging to the Calanidæ are placed first, then follow the Centropagidæ, the Mesophriadæ, the Cyclopidæ, the Harpacticidæ, and the Oncæadæ. The families Centropagidæ, Mesophriadæ, and Oncæadæ are each represented by a single species, the Calanidæ and the Cyclopidæ by four species each, and the Harpacticidæ by 36 species, or 47 in all.

Family CALANIDÆ.

Genus CALANUS, *Leach*, 1819.

CALANUS FINMARCHICUS (*Gunner*).

1765. *Monoculus finmarchicus*, Gunner (**35**), p. 175, figs. 20–23.

This species was fairly well represented in the Franz-Josef Land collection; it occurred chiefly in tow-net collections from the vicinity of Cape Flora, Northbrook Island, as, for example, at West Bay; off east end of Cape Gertrude; two-thirds of a mile south-west of Elmwood; off West Glacier, and also near East Glacier.

CALANUS HYPERBOREUS, *Kröyer*.

1838. *Calanus hyperboreus*, Kröyer (**41**), p. 82, pl. 4. figs. 23 *a–d*.

This is quite distinct from *Calanus finmarchicus*, both in the junior and adult forms. *Calanus hyperboreus* was of rather more frequent occurrence than *C. finmarchicus*, and appeared to be more generally distributed; but most of the specimens were collected in the neighbourhood of Cape Flora. Some of the adult females of this species were comparatively of large size; one that was measured was fully 8 millimetres (nearly one-third of an inch) in length from the forehead to the end of the caudal furca.

Genus PSEUDOCALANUS, *Boeck*, 1872.

PSEUDOCALANUS ELONGATUS (*Boeck*).

1864. *Clausia elongata*, Boeck (**5**), p. 10.

This species was observed in several tow-net gatherings and was moderately frequent in a few of them. Both male and female specimens were observed. They occurred chiefly in gatherings from the neighbourhood of Cape Flora.

Genus EUCHÆTA, *Philippi*, 1843.

EUCHÆTA NORVEGICA, *Boeck*.

1872. *Euchæta norvegica*, Boeck (**7**), p. 40.

A single, scarcely mature specimen of this *Euchæta* was captured with the tow-net about one and a half miles south-west of Elmwood on June 9th, 1897.

Family CENTROPAGIDÆ.

Genus METRIDIA, *Boeck*, 1865.

METRIDIA LONGA (*Lubbock*). (Pl. 4. figs. 16, 17.)

1854. *Calanus longus*, Lubbock (**51**), p. 127, pl. 5. fig. 10.

This species was rather common in tow-gatherings collected in the neighbourhood of Cape Flora, as, for example, off Elmwood, near East Glacier, &c. A considerable proportion of the specimens were immature. It is difficult to distinguish immature specimens of *Metridia longa* from those of *Metridia hibernica*; the adults of *M. longa* may be recognized by their larger size; but satisfactory identification can only be arrived at by the careful examination of structural details in mature specimens. *Metridia longa* has been recorded from the Faröe Channel. Some time ago I had the privilege of examining a series of tow-net gatherings collected between the Shetland Islands and Faröe, but the only *Metridia* obtained in these gatherings was *M. hibernica* (Brady & Robertson). [*Metridia longa* (Lubbock, 1854) is identified as *Metridia armata*, Boeck (1865), but not *Metridia armata*, Brady (1878): the latter is recognized as a distinct species by Giesbrecht under the name of *Metridia hibernica* (Brady & Robertson, 1873).]

Family MISOPHRIADÆ.

Genus MISOPHRIA, *Boeck*, 1864.

MISOPHRIA PALLIDA, *Boeck*.

1864. *Misophria pallida*, Boeck (5), p. 24.

One or two specimens of this species were obtained in a gathering of micro-crustacea dredged at West Bay, Cape Flora, in 2 to 10 fathoms on July 2nd, 1897. *Misophria pallida* has been recorded from Norway, and it appears to be generally distributed around the British coast, but to be nowhere very common. In Scotland it has been obtained in the Firth of Forth, in Moray Firth, and in the Firth of Clyde.

Family CYCLOPIDÆ.

Genus OITHONA, *Baird*, 1843.

OITHONA SIMILIS, *Claus*. (Pl. 4. figs. 18, 19.)

1866. *Oïthona similis*, Claus (24).

This species was obtained in tow-net gatherings collected two-thirds of a mile south-west of Elmwood on May 22nd, 1897, but was comparatively scarce; and it was taken with the tow-net in the same neighbourhood during the following month. This is certainly the *Oithona similis*, Claus, as described and figured by Dr. Giesbrecht in 'Pelagischen Copepoden des Golfes von Neapel.' The same author refers doubtfully to this species the *Oithona helgolandica*, Claus (1863), and the *Oithona spinifrons*, Boeck (1864); and with respect to *Oithona spinifrons*, Boeck, Prof. Brady, in his 'Monograph of the British Copepoda,' vol. i. published 20 years ago, states that he is "not at all satisfied that this is not synonymous with *O. helgolandica*, Claus." As there appears to be a consensus of opinion that all three species are synonymous, it would be better if the earlier name—*O. helgolandica*—of Claus were adopted. *Oithona spinirostris*, Claus (1863), is regarded by Dr. Giesbrecht as synonymous with *O. plumifera*, Baird (1843).

Genus CYCLOPINA, *Claus*, 1863.

CYCLOPINA GRACILIS, *Claus*.

1863. *Cyclopina gracilis*, Claus (**23**), p. 104, pl. 10. figs. 9–15.

A few specimens of this small but distinct species were obtained in some material dredged off East Glacier, Cape Flora, on July 21st, 1897. *Cyclopina gracilis* has a wide distribution in the British seas, but is not very common.

Genus THORELLIA, *Boeck*, 1864.

THORELLIA BRUNNEA, *Boeck*.

1864. *Thorellia brunnea*, Boeck (**5**), p. 26.

Thorellia brunnea was more or less frequent in several gatherings of micro-crustacea collected by means of the dredge, as, for example, in gatherings from West Bay, off East Glacier, and south-west of Elmwood—this last was an inshore gathering in quite shallow water.

Genus CYCLOPS, *O. F. Müller*, 1776.

CYCLOPS BRUCEI, sp. n. (Pl. **6**. figs. 1–6.)

This appears to be a new species, of which the following is a description:—Length of adult female 1·1 mm. (about $\frac{1}{23}$ of an inch). Antennules (fig. 2) moderately short and stout, 12-jointed and sparingly setiferous; the third and fifth joints are the shortest, the eighth, ninth, and last are rather longer than any of the others except the first. Both branches of the swimming-feet are short and stout and 3-jointed: in the first pair (fig. 3) the inner branches are armed with a strong terminal claw-like spine; the fourth pair (fig. 4) are less powerfully armed; the fifth pair (fig. 5) are small, the secondary joint is cylindrical in form, and the length rather more than twice the breadth, the truncate end bears interiorly a moderately short spine, and exteriorly a long seta that is at least four times the length of the joint from which it springs; the seta that springs from the exterior produced part of the basal joint is also elongate. The caudal furca (fig. 6) are nearly three times as long as the last abdominal segment; the small spiniform seta usually observed on the outer margins of the furca in *Cyclops* is situated at about a third of their length from the distal end; there is also a minute notch near their base.

The species is named in compliment to Mr. Bruce, the Naturalist of the Jackson-Harmsworth Expedition.

In some respects *Cyclops Brucei* resembles *Cyclops bisetosus*, Rehberg, but in that species the antennules are 17-jointed; the armature of the swimming-feet also differs somewhat, and especially as regards the first pair.

Hab. Pond near Elmwood, Cape Flora; not uncommon.

Family HARPACTICIDÆ.

Genus BRADYA, *Boeck*, 1872.

BRADYA TYPICA, *Boeck*.

1872. *Bradya typica*, Boeck (7), p. 42.

This species was somewhat rare in the Franz-Josef Land collections; it was only observed in a gathering made off East Glacier, Cape Flora, in about 30 fathoms, on July 21st, 1897. Though *Bradya typica* appears to be widely distributed, it is not a common species anywhere.

BRADYA MINOR, *T. & A. Scott*.

1896. *Bradya minor*, T. & A. Scott (**84**), p. 425, pl. 35. figs. 5, 9, 13, 21, 24, 31, 35, 42; pl. 36. figs. 5 & 9.

This was one of several species described in the 'Transactions of the Linnean Society of London,' vol. vi., 2nd ser., p. 425; it is distinguished from its near allies by its small size, brownish colour, and an "eye-like dusky pigment-spot at the base of the antennules." *Bradya minor* occurred along with *B. typica* in the gathering collected off East Glacier, Cape Flora, on July 21st, 1897. Its distribution in the British Islands includes the Firths of Forth and Clyde and Liverpool Bay.

Genus ECTINOSOMA, *Boeck*, 1864.

ECTINOSOMA SARSI, *Boeck*.

1872. *Ectinosoma Sarsi*, Boeck (7), p. 45.

This species was dredged off East Glacier in company with the two species of *Bradya* already referred to, and also at West Bay, Cape Flora, in from 2 to 10 fathoms on July 2nd, 1897. This is one of the larger and more common species of *Ectinosoma* in the British Copepod fauna.

ECTINOSOMA PROPINQUUM, *T. & A. Scott.*

1896. *Ectinosoma propinquum*, T. & A. Scott (**84**), p. 428, pl. 36. figs. 19, 27, 46, *et seq.*

Two specimens of an *Ectinosoma* differing little from the characters of *E. propinquum* were obtained in a gathering from West Point, Cape Flora, at a depth of 2 to 4 fathoms, collected on 5th July, 1897. This species is one of the larger of the *Ectinosomata*, being not much less in size than *Ectinosoma Sarsi*; it possesses a distinctly hooked labium, the fifth pair of thoracic feet are of moderate size and resemble somewhat those of *E. Sarsi.*

ECTINOSOMA CURTICORNE, *Boeck.*

1864. *Ectinosoma curticorne*, Boeck (**5**).

Dredged off East Glacier, Cape Flora, July 21st, 1897; rare. Like *Bradya minor*, this *Ectinosoma* is of a brownish colour. It has been observed in the stomachs of young flat-fish (*Pleuronectes limanda*) caught in Liverpool Bay.

ECTINOSOMA PYGMÆUM, *T. & A. Scott.*

1896. *Ectinosoma pygmæum*, T. & A. Scott (**84**), p. 433, pl. 36. figs. 15, 41; pl. 37. figs. 5, 20, 39, 43; pl. 38. figs. 4, 26, 31, 55.

This was also dredged off East Glacier, Cape Flora, in 30 fathoms, July 21st, 1898. *E. pygmæum* is very small: it is even shorter, but somewhat stouter than *E. atlanticum*. Distribution: Firth of Forth, Scotland; vicinity of Port Erin, Isle of Man.

ECTINOSOMA MELANICEPS, *Boeck.*

1864. *Ectinosoma melaniceps*, Boeck (**5**), p. 30.

The colour of the head in this species is, as the name implies, distinctly different from the rest of the body, so that the species may be distinguished by this character alone. *E. melaniceps* occurred rather more frequently than others of the same genus. It was dredged at about 50 yards off West Point, Cape Flora, in 2 to 3 fathoms, June 18th, 1897; at West Bay, in 2 to 10 fathoms, July 2nd, 1897; and off East Glacier, in 30 fathoms, July 21st, 1897. It is also of frequent occurrence around the shores of the British Islands.

ECTINOSOMA NORMANI, *T. & A. Scott.*

1896. *Ectinosoma Normani*, T. & A. Scott (**84**), p. 435, pl. 36. figs. 21, 29, &c.

This was dredged off East Glacier, Cape Flora, July 21st,

1897. *E. normani* was one of the rarer species in the Franz-Josef Land collections. Its distribution includes the Firths of Forth and Clyde, Scotland; and Barrow Channel, near Barrow-in-Furness, England.

ECTINOSOMA ATLANTICUM (*Brady & Robertson*).

1873. *Microsetella atlantica*, Brady & Robertson (20), p. 130, pl. 9. figs. 11–16.

The small size and slender form of this species make it easily overlooked. It was very scarce in the Franz-Josef Land collections, having only been observed in a gathering off East Glacier made in July 1897. This species has a wide distribution, and is not unfrequent in the British seas.

Genus ZOSIME, *Boeck*, 1872.

ZOSIME TYPICA, *Boeck*.

1872. *Zosime typica*, Boeck (7), p. 14.

This was obtained at Cape Gertrude and also off East Glacier, Cape Flora, but was apparently not very common. It is also a British species.

Genus ROBERTSONIA, *Brady*, 1880.

ROBERTSONIA TENUIS (*Brady & Robertson*).

1873. *Ectinosoma tenue*, Brady & Robertson (22), p. 196.

This species was dredged at West Bay, Cape Flora, in from 2 to 10 fathoms, July 2nd, 1897. *Robertsonia* somewhat resembles *Ectinosoma*, and was at first ascribed to that genus. It has been obtained at various places around the British coasts.

Genus AMYMONE, *Claus*, 1863.

AMYMONE SPHÆRICA, *Claus*.

1863. *Amymone sphærica*, Claus (23), p. 114, pl. 20. figs. 1–9.

The Copepod so named is one of a very curious group of crustaceans, and quite unlike the usual Copepod forms. It appeared to be very rare in the Franz-Josef Land collections. The only gathering in which this species was obtained was dredged off Flagstaff Point, Elmwood, by D. W. Wilton, 20th September, 1896. This is also a British species.

Genus STENHELIA, *Boeck*, 1864.

STENHELIA REFLEXA, *T. Scott.*

1895. *Stenhelia reflexa*, T. Scott (80), p. 166, pl. 3. figs. 1–9.

This was dredged off East Glacier, Cape Flora, on July 21st, 1897. *Stenhelia reflexa* is described and figured in Part iii. of the 13th Annual Report of the Fishery Board for Scotland (1895), from specimens obtained in the Firth of Forth.

Genus AMEIRA, *Boeck*, 1864.

AMEIRA LONGIPES, *Boeck.*

1864. *Ameira longipes*, Boeck (5), p. 49.

This was obtained in a gathering dredged at West Bay, Cape Flora, on July 5th, 1897; it was also obtained off East Glacier on the 21st of the same month, but it appeared to be somewhat rare in these gatherings. It is not a very rare species in the British seas.

AMEIRA EXIGUA, *T. Scott.*

1894. *Ameira exigua*, T. Scott (79), p. 243, pl. 6. figs. 15–23.

This is a much smaller species than the last, and it was also of rare occurrence. It was obtained sparingly in the gathering dredged off East Glacier on July 21st, 1897. This species is described and figured in Part iii. of the 12th Annual Report of the Fishery Board for Scotland (1894).

AMEIRA LONGIREMIS, *T. Scott.*

1894. *Ameira longiremis*, T. Scott (79), p. 241, pl. 5. figs. 29–32, pl. 6. figs. 1–5.

This *Ameira* was also dredged off East Glacier; this was the only gathering in which it was observed. The species is described and figured in Part iii. of the same Fishery Board's Report in which *Ameira exigua* and *Ameira reflexa* are described.

AMEIRA REFLEXA, *T. Scott.*

1894. *Ameira reflexa*, T. Scott (79), p. 240, pl. 5. figs. 20–28.

Ameira reflexa was obtained in the same gathering with the last species, and appeared to be rare.

Genus JONESIELLA, *Brady*, 1890.

JONESIELLA SPINULOSA (*Brady & Robertson*).

1875. *Zosima spinulosa*, Brady & Robertson (22), p. 196.

This *Jonesiella* was rather more frequent than some of the other species; it was dredged off East Glacier, off Cape Gertrude in 30 fathoms, and in 8 fathoms off Cape Flora, in July 1897. This is not an uncommon species in the British seas.

Genus DELAVALIA, *Brady*, 1868.

DELAVALIA ROBUSTA, *Brady & Robertson.*

1875. *Delavalia robusta,* Brady & Robertson (**22**), p. 196.

This species was dredged off East Glacier in 30 fathoms and in 2 to 4 fathoms off West Point, Cape Flora, in July 1897. Several specimens were obtained.

DELAVALIA MIMICA, *T. Scott.*

1897. *Delavalia mimica,* T. Scott (**82**), p. 150, pl. 1. figs. 1–9.

A number of specimens of this distinct species were obtained in gatherings dredged off West Point, July 5th, and off East Glacier, July 21st, 1897. The species is described and figured Part iii. of the 15th Annual Report of the Fishery Board for Scotland (1897), from specimens obtained in the Firth of Clyde; it has also been observed in the Firth of Forth.

DELAVALIA REFLEXA, *Brady & Robertson.*

1875. *Delavalia reflexa,* Brady & Robertson (**22**), p. 196.

A few specimens of *Delavalia reflexa* were obtained in a gathering collected off East Glacier. In this species the inner branches of the first pair of swimming-feet want the stout spiniform terminal seta that distinguishes *D. robusta*; in *D. reflexa* the terminal setæ are slender.

DELAVALIA ARCTICA, sp. n. (Pl. **5**. fig. 14; Pl. **6**. figs. 7–11.)

The female specimen represented by the figure (fig. 7, Pl. **6**) measured fully 1 mm. ($\frac{1}{22}$ of an inch) in length from the end of the rostrum to the extremity of the caudal furca. The species somewhat resembles *Delavalia palustris*, Brady, in general outline. The antennules (anterior antennæ) are 8-jointed (fig. 8, Pl. **6**); the proportional lengths of the joints are indicated approximately by the formula:

Proportional lengths of the joints	20	12	11	8	7	8	6	8
Numbers of the joints	1	2	3	4	5	6	7	8

The mouth-organs are somewhat similar to those of *Delavalia giesbrechti*, T. Scott, except that the second foot-jaws are comparatively robust; the first joint bears one slender and two stout spiniform setæ at the extremity of the inner margin; the terminal claws are feeble (Pl. 5. fig. 14). The first pair of swimming-feet resemble those of *Delavalia palustris*, but both branches are more elongate and the lengths of the joints are proportionally slightly different; they differ also in their armature, as shown by the figure (fig. 9, Pl. 6). The other swimming-feet are also moderately elongate and slender; the joints of the inner branches, as shown by the figure of the fourth pair (fig. 10, Pl. 6), have their inner distal angles more or less produced downwards into spine-like processes as in *Delavalia robusta*, Brady & Robertson. The fifth pair also somewhat resemble those of that species, but the secondary joint is proportionally broader and of a somewhat different form; and there is a peculiarity in the hinge arrangement of the joint by which it can be extended at nearly right angles to the body (fig. 11, Pl. 6). The caudal furca are about as long as the combined lengths of the last two abdominal segments.

Hab. Cape Gertrude (Cape Flora), Northbrook Island; rather rare.

Remarks. This species partakes of the characters of *Delavalia palustris* on the one hand and of *Delavalia robusta* on the other; but it differs from the first by the form of the fifth pair of thoracic feet and from the second in the structure of the first pair. A difference may also be observed in the proportional lengths of the joints of the antennules, as well as in the more robust form of the posterior foot-jaws.

Genus MARAENOBIOTUS, *Mrazek*, 1893.

MARAENOBIOTUS VEJDOVSKYI, *Mrazek*. (Pl. 6. figs. 12–17.)

1893. *Maraenobiotus Vejdovskyi*, Mrazek (54), p. 103, pl. 4. figs. 17–32, pl. 5. figs. 33–37.

This is a freshwater species; it was first discovered by Mrazek in Bohemia, and it has also occurred in one or two places in Scotland. It is a slender Copepod, and in this respect resembles certain species of *Moraria*—a genus with which it is closely related. One of the principal characters that distinguishes *Maraenobiotus* from *Moraria* is the very rudimentary form of the mandible-palp (fig. 14); whereas in *Moraria* the mandible-palp, though small, is normal in structure. The Franz-Josef Land specimens resemble those found in Scotland in almost every detail of structure: the chief difference observed is in the form of the secondary joints of the fifth thoracic feet; in the Franz-

Josef Land specimens this joint is subquadrangular, with straight margins, as shown in fig. 17. The species is very small—the average length of the specimens is about ·56 mm. to ·6 mm. ($\frac{1}{45}$ to $\frac{1}{42}$ of an inch). The species was moderately frequent in freshwater pools near Elmwood, Cape Flora. A few of the females carried ova, but a considerable proportion of the specimens were more or less immature.

After the above remarks on *Maraenobiotus* had been prepared, I received from the author, Dr. Jules Richard, an interesting contribution to the literature of the Arctic freshwater fauna, being a report on the Entomostraca obtained in the freshwaters explored during the recent voyage to the Arctic seas of the steam yacht 'Princesse Alice.' The places visited comprised Lofoten, Spitzbergen, Iles Beeren, Hope, de Barents, and Faröe. In this memoir Dr. Richard describes under the name of *Mesochra Brucei* an harpactid which appears to resemble the Franz-Josef Land form referred to above; it may not, however, be the same species.

With regard to the specimens from Franz-Josef Land, the rudimentary form of the mandible-palp, together with the structure of the first and fifth pairs of thoracic feet, identify them with Mrazek's *Maraenobiotus*; there may be slight differences in the armature of the swimming-feet, but such differences are unimportant in view of the close similarity otherwise.

Genus CANTHOCAMPTUS, *Westwood*, 1836.

(?) CANTHOCAMPTUS PARVUS, *T. & A. Scott*. (Pl. 6. figs. 18–24.)

1896. (?) *Canthocamptus parvus, T.&A. Scott* (85), p. 6, pl. 2. figs. 14–22.

This species, which is represented in the Franz-Josef Land collection by several specimens, was dredged off East Glacier, Cape Flora, in 30 fathoms, July 21st, 1897. (?) *Canthocamptus parvus* is a small species that was first described from specimens obtained in the Firth of Forth near Aberlady. The Franz-Josef Land specimens are somewhat larger than those from the Firth of Forth; there are also one or two other differences, but they are comparatively unimportant. The following is a brief description of the Arctic specimens:—

The antennules in the female are short and six-jointed (fig. 19). The antennæ have the secondary branches small and two-jointed (fig. 20). The mandible-palp is moderately well developed and bears a one-jointed branch which is subapical (fig. 21). A moderately long plumose seta springs from the basal joint of the palp a short distance below the one-jointed branch. The posterior foot-jaws are moderately stout, and are each furnished with an elongate and slender terminal claw. The first pair of swimming-feet somewhat resemble those of *Dactylopus longirostris,* Claus, but are rather more slender (fig. 22); a small seta springs from about the middle of the inner margin of the first joint of the inner branches, while the outer margin is fringed with minute hairs; the inner branches are also armed with a moderately stout terminal spine and an elongate slender seta; the outer branches, which are rather more than half the length of the inner, are composed of three subequal joints. The inner branches of the second, third, and fourth pairs are two-jointed; in the fourth pair (fig. 23) the two-jointed inner branches are short, but the outer, which are three-jointed, are elongate. The fifth pair (fig. 24) are somewhat similar to those of *Dactylopus minutus,* Claus. The caudal furca are very short.

Remarks. This species resembles very closely one of the smaller species of *Dactylopus* both in its general outline and in its six-jointed antennules; but it is precluded from that genus by the structure of the mandible-palp and by the inner branches of the second, third, and fourth pairs of swimming-feet being only two-jointed, and in these respects it agrees more closely with *Canthocamptus* than with any other described genus. In the original description of the species, reference is made to one or two points in which the species does not agree with *Canthocamptus,* and which may by-and-by render its removal from that genus necessary. I am inclined, however, for the present to leave it as described. The length of the specimen figured (fig. 18) is ·48 mm. ($\frac{1}{52}$ of an inch). The Firth of Forth is the only British habitat of the species known to me.

Genus LAOPHONTE, *Philippi*, 1840.

LAOPHONTE HORRIDA, *Norman.*

1876. *Laophonte horrida,* Norman (60), p. 206.

This well-marked form was dredged off East Glacier in 30 fathoms, and also off West Point in 2 to 3 fathoms; both localities being in the vicinity of Cape Flora, Northbrook Island. It was dredged at West Point on June 4th and on July 2nd and

21st, 1897. *Laophonte horrida* is recorded from the Arctic seas by Buchholz, in his Report on the German North-Polar Expedition of 1869–70, but he, under some misapprehension, referred this Copepod to Müller's *Cyclops minuticornis*. The species appears to be generally distributed round the British coasts.

LAOPHONTE CURTICAUDA, *Boeck*.

1864. *Laophonte curticauda,* Boeck (**5**), p. 55.

This species was somewhat rare in the Franz-Josef Land collection; a few specimens were obtained in some material dredged off Cape Gertrude. *L. curticauda* is also a British species.

LAOPHONTE DEPRESSA, *T. Scott*.

1894. *Laophonte depressa,* T. Scott (**79**), p. 245, pl. 6. figs. 24–31, pl. 7. figs. 1–3.

This species was described and figured in Part iii. of the Twelfth Annual Report of the Fishery Board for Scotland (1894), from specimens found in the Firth of Forth. The Franz-Josef Land gathering in which it occurred was dredged off East Glacier, Cape Flora, July 21st, 1897.

LAOPHONTE LONGICAUDATA, *Boeck*.

1864. *Laophonte longicaudata,* Boeck (**5**), p. 55.

This also was dredged off East Glacier, Cape Flora, and appeared to be somewhat rare. It has been long known as a British species. The outer branches of the first pair of swimming-feet in all the Franz-Josef Land specimens appear to be two-jointed, the first joint being short and the other about twice as long as the first.

LAOPHONTE INTERMEDIA, *T. Scott*.

1895. *Laophonte intermedia,* T. Scott (**80**), p. 168, pl. 3. figs. 10–20.

This distinct species was obtained in West Bay on July 27th, 1897, it occurred in a tow-net gathering. *L. intermedia* was described and figured in Part iii. of the Thirteenth Annual Report of the Fishery Board for Scotland (1895), from specimens found in the Firth of Forth.

LAOPHONTE SIMILIS, *Claus*.

1866. *Laophonte similis,* Claus (**24**), p. 23, pl. 5. figs. 13, 14.

One or two specimens of a Copepod which I have ascribed to *Laophonte similis* occurred in some dredged material from West Bay, Cape Flora, collected in July 1897.

LAOPHONTE PERPLEXA, sp. n. (Pl. 7. figs. 1–7.)

Several specimens of a *Laophonte* that appear to be undescribed were obtained in a gathering of small Crustacea collected off East Glacier, Cape Flora, in 30 fathoms, on July 21st, 1897. Its characters are somewhat intermediate between those of *Laophonte curticauda* and *Laophonte similis.* It is rather smaller than either of these species, being only about ·63 mm. ($\frac{1}{40}$ of an inch) in length. The body is in general appearance like that of *L. curticauda.* The rostrum is short, and the antennules are seven-jointed; the fourth and fifth joints of the antennules are shorter than the others, as shown by the formula, which indicates approximately the proportional lengths of all the joints:—

Proportional lengths of the joints	14 .	20 .	16 .	5 .	3 .	7 .	11.
Numbers of the joints...................................	1	2	3	4	5	6	7

The posterior foot-jaws (fig. 3) resemble very closely those of *L. similis* except that the terminal claw is somewhat stronger. The first pair of swimming-feet (fig. 4) are intermediate in structure between those of *L. similis* and *L. thoracica*; the outer branches are short and two-jointed, the last joint being about twice the length of the first, the terminal claws of the inner branches are moderately stout. The fourth pair (fig. 5) have the outer branches elongate and slender, and the inner branches short and composed of two subequal joints. The fifth pair (fig. 6) are nearly like those of *L. curticauda*, but the secondary joints are proportionally rather smaller, and the armature of both joints is somewhat different. The caudal furca (fig. 7) resemble those of *L. similis*, being rather longer than the last abdominal segment.

Remarks. The *Laophonte* referred to above is one of those perplexing forms, met with now and again, which are somewhat difficult to dispose of satisfactorily. Its characters are such that it might be considered a variety of *Laophonte curticauda* as well as of *L. similis*; in these circumstances it appeared to me to be better to give the form a distinct name.

Genus LAOPHONTODES, *T. Scott*, 1894.

LAOPHONTODES TYPICUS, *T. Scott.*

1894. *Laophontodes typicus,* T. Scott (79), p. 249, pl. 8. figs. 2–8.

This genus and species were described and figured in 1894 in

Part iii. of the Twelfth Annual Report of the Fishery Board for Scotland, from specimens obtained in the Firth of Forth. Its occurrence at Franz-Josef Land shows that it is widely distributed. It was obtained off East Glacier, Cape Flora, on July 21st, 1897. This is a very small Copepod, being only about ·4 mm. ($\frac{1}{60}$ of an inch) in length.

Genus CLETODES, *Brady*, 1872.

CLETODES SIMILIS, *T. Scott.*

1895. *Cletodes similis*, T. Scott (**80**), p. 168, pl. 3. figs. 22–26, pl. 4. figs. 1–3.

This Copepod was dredged off Cape Gertrude in 30 fathoms; it was also obtained off East Glacier. The species was described in 1895, in Part iii. of the Thirteenth Annual Report of the Fishery Board for Scotland, from specimens found in the Firth of Forth.

CLETODES TENUIPES, *T. Scott.*

1897. *Cletodes tenuipes*, T. Scott (**82**), p. 170, pl. 1. figs. 19–27.

C. tenuipes was also dredged off East Glacier, but very few specimens were obtained. It was described and figured from Clyde specimens in Part iii. of the Fifteenth Annual Report of the Fishery Board for Scotland (1897).

CLETODES LONGICAUDATA, *Brady & Robertson.*

1872. *Cletodes longicaudata*, Brady & Robertson (**19**), p. 196.

This was also obtained off East Glacier, and appeared to be moderately rare. This species has long caudal furca.

Genus ENHYDROSOMA, *Boeck*, 1872.

ENHYDROSOMA CURVATUM (*Brady & Robertson*). (Pl. **3**. fig. 17.)

1875. *Rhizothrix curvata*, Brady & Robertson (**22**), p. 197.

A few specimens of what appears to be this species were obtained in some material dredged off East Glacier. There was a slight difference in the armature of the fifth pair of thoracic feet (as shown by fig. 17, Pl. 3), but otherwise the Franz-Josef Land specimens appeared to be identical with the species to which they are ascribed.

Genus DACTYLOPUS, *Claus*, 1863.

DACTYLOPUS TISBOIDES, *Claus.*

1863. *Dactylopus tisboides*, Claus (**23**), p. 127, pl. 16. figs. 24–28.

This, which is a common British species, was moderately frequent in one or two of the Franz-Josef Land gatherings, *i. e.* in a gathering dredged about fifty yards off West Point, Cape Flora, in 2 to 3 fathoms, on June 18th, 1897; in another from West Bay, dredged in about 8 fathoms on July 5th, and in a third collected on the 23rd or 24th of the same month. In some of the specimens there is a tendency for both branches of the fifth thoracic feet to have pellucid markings along the edge of the outer margin.

DACTYLOPUS CORONATUS, *T. Scott.*

1894. *Dactylopus coronatus*, T. Scott (**79**), p. 255, pl. 9. figs 12–20.

This species was obtained amongst sand near East Glacier, Cape Flora, August 5th, 1896; it appeared to be rare. *D. coronatus* was described and figured in Part iii. of the Twelfth Annual Report of the Fishery Board for Scotland (1894).

DACTYLOPUS TENUIREMIS, *Brady & Robertson.* (Pl. 3. figs. 1–4.)

1875. *Dactylopus tenuiremis*, Brady & Robertson (**22**), p. 197.

Several specimens of what seems undoubtedly to be this species were obtained in a gathering of small Crustacea collected off West Point, Cape Flora, in from 2 to 4 fathoms of water, on July 21st, 1897. *D. tenuiremis* is closely related to the next species, but differs from it in the form of the fifth thoracic feet, and in the structure of the first pair, as shown by the figures.

DACTYLOPUS LONGIROSTRIS, *Claus.* (Pl. **3**. figs. 5–8.)

1863. *Dactylopus longirostris*, Claus (**23**), p. 127, pl. 17. figs. 4–6.

This is one of the species described by Dr. Claus in his 'Die freilebenden Copepoden' (pub. 1863), which were obtained in the vicinity of Heligoland. It resembles *D. tenuiremis* in some respects, but the form of the fifth thoracic and especially of the secondary joints is distinctly different; these outer (secondary) joints are in this species broadly oval and leaf-like ("das aussere ovale Blatt"), the proportion of the breadth to the length being nearly as 20 is to 29, whereas in *D. tenuiremis* it is nearly as 15 is to 28; there is also a difference in the general outline as well as in the armature of both the basal and secondary joints of the fifth pair. It may be noted further that, besides the difference in the first swimming-feet already referred to, the structure of the posterior foot-jaws differs slightly in the two species, as indicated by the figures. *D. longirostris* occurred in a gathering from the vicinity of East Glacier, Cape Flora; only a few specimens were obtained. This species, and probably also *D. tenuiremis*, should be regarded as belonging to the genus *Diosaccus*, as both appear to be furnished with two ovisacs.

DACTYLOPUS STRÖMII (*Baird*), var. ARCTICUS, var. nov. (Pl. 5. figs. 11–17.)

1850. *Canthocamptu Strömii*, Baird (3), p. 208, pl. 27. fig. 3.

A number of specimens of a Copepod, which can hardly be distinguished from *Dactylopus Strömii* (Baird), were collected about 50 yards off West Point, Cape Flora, during June and July, 1897. The specimens are from comparatively shallow water—2 to 4 fathoms; and differ from British species of *D. Strömii* chiefly in the following points:—(1) The antennules have nine instead of eight joints (fig. 12); this difference, however, appears to be immaterial, as the number of the joints of which the distal half of the antennules is composed seems to be liable to variation. (2) The posterior foot-jaws (fig. 13) are large and powerful, the second joint is elongate and subcylindrical instead of ovate, and they differ somewhat in their armature. (3) In the fifth pair of thoracic feet the outline of the secondary joint (fig. 15) and the arrangement of the setæ with which it is furnished are somewhat dissimilar to the normal form of the species; and (4) the ova-bearing females carried two ovisacs instead of one. The first pair of swimming-feet (fig. 14), as well as the second, third, and fourth pairs, resemble very closely the same appendages in *D. Strömii*. The species has a wide distribution in the North Sea, and seems to extend all round the British Islands.

Genus THALESTRIS, *Claus*, 1863.

THALESTRIS HELGOLANDICA, *Claus*.

1863. *Thalestris helgolandica*, Claus (23), p. 131, pl. 17. figs. 12–21.

A few specimens of this *Thalestris* were obtained in a gathering from 30 fathoms, collected July 21st, 1897, off East Glacier, Cape Flora. *Thalestris helgolandica* is a well-marked species, and, though apparently not very common, it has evidently a wide distribution. It occurs sparingly at various places around the British Islands.

THALESTRIS POLARIS, sp. n. (Pl. 7. figs. 8–16.)

A *Thalestris*, which I have named as above, occurred very sparingly in gatherings collected at the following places:—From sand near East Glacier on August 5th, 1896; off West Point, Cape Flora, on June 4th, 21st, and July 5th, 1897; and also in July in West Bay, Cape Flora. The following is a description of the species:—

Description of the female.—Body robust, especially the cephalothorax; rostrum very short; entire length from rostrum to caudal furca about ·95 mm. ($\frac{1}{26}$ of an inch). Antennules (fig. 9) short, 9-jointed; the first two joints of moderate length and subequal, the next two shorter and also subequal; the second joint of the flagellum (the fourth from the end) is equal to twice the length of the preceding joint and to the combined lengths of the next two, the end joint is slightly longer than the penultimate one; the formula shows approximately the proportional lengths of all the joints:—

Proportional lengths of the joints	23 .	25 .	15 .	16 .	5 .	10 .	4 .	4 .	6.
Numbers of joints	1	2	3	4	5	6	7	8	9

The posterior foot-jaws (fig. 10) resemble those of *Thalestris hibernica*, Brady & Robertson, both in their form and armature; the other mouth-organs are somewhat similar to those of *Thalestris mysis*, Claus. First pair of swimming-feet moderately slender (fig. 11); terminal claws of both branches slender, and not much more than half the length of the branches from which they spring. Fourth pair (fig. 12) also slender; the inner branches reach to about the end of the second joint of the outer branches, and both are furnished on the inner margins with long plumose setæ. The fifth pair somewhat resemble those of *Thalestris hibernica*, but the secondary joints are comparatively rather larger and extend as far as the end of the basal joints; the basal joint bears five apical setæ, while the surface of both it and the secondary joint appears to be more covered with extremely fine cilia (fig. 13). The caudal furca (fig. 16) are elongate, the length being equal to fully twice the breadth.

Description of the male.—The male differs little from the female except that the antennules are modified for grasping. The inner branches of the second pair of swimming-feet (fig. 14) are two-jointed, and somewhat similar in their structure and armature to the inner branches of the same pair of feet in the male of *Thalestris hibernica*. The secondary joints of the fifth pair (fig. 15) are elongate-ovate; the inner margin is nearly straight and fringed with minute hairs; the outer margin, which is slightly curved and tapers gradually towards the apex, bears three moderately short and stout setæ, there is also a stout and moderately long apical seta and a smaller one at the termination of the inner margin; the basal joint is scarcely produced interiorly, and is provided with three spiniform setæ on the broadly rounded apex, the middle seta being considerably longer than the other two and plumose.

Remarks.—This species has a superficial resemblance to *Thalestris hibernica*, Brady & Robertson, and I was at first inclined to regard it as a northern variety of that form. I had recently, however, the opportunity to compare typical Scottish examples of *Thalestris hibernica* with the Franz-Josef Land specimens, and find that they are quite distinct, the difference in the length of the caudal furca being alone sufficient to distinguish the one from the other.

THALESTRIS FORFICULA, *Claus.*

1863. *Thalestris forficula,* Claus (23), p. 131, pl. 17. figs. 7–11.

The Franz-Josef Land Copepod which I now record under this name is similar to a form described and figured in the 'Annals and Magazine of Natural History' for October 1893, by T. and A. Scott, under the name of *Thalestris forficuloides.* I am now inclined to consider that species as a 'form' of Claus's *Th. forficula.* Its occurrence at Franz-Josef Land extends considerably the distribution of the species. It was obtained in a gathering dredged off Cape Gertrude in 30 fathoms, July 21st, 1897. In Scotland it has been obtained both in the Firths of Forth and Clyde.

THALESTRIS FRIGIDA, sp. n. (Pl. 7. figs. 17–23; Pl. 8. figs. 1, 2.)

Description of the female.—Body robust, length 1·63 mm. ($\frac{1}{15}$ of an inch). Rostrum prominent. Antennules short, moderately stout and 9-jointed; the sixth and last joints are each of them about equal to the combined lengths of the seventh and eighth (fig. 18); the proportional lengths of all the joints are shown approximately by the formula:—

Proportional lengths of the joints ...	48 .	24 .	24 .	20 .	12 .	16 .	7 .	8 .	16.
Numbers of the joints	1	2	3	4	5	6	7	8	9

The mouth-organs are somewhat similar to those of *Thalestris mysis*, Claus, except that there is a slight difference in the armature of the posterior foot-jaws (fig. 19). The first pair of thoracic feet are moderately slender; the seta on the inner margin of the first joint of the inner branches springs from near the middle of the joint; both branches are furnished with a strong terminal claw of moderate length, and the outer margins of the first and second joints of the outer branches, and of the first joint of the inner branches, are fringed with minute spines. The second, third, and fourth pairs are elongate and slender, and have both branches furnished with long plumose setæ (fig. 21). The fifth pair are large and broadly foliaceous, and somewhat resemble those of *Thalestris mysis*, but the secondary joint is considerably smaller than the basal joint, and the armature of the secondary joint is also distinctly different; moreover, both joints, besides being different in general outline, have their surface ornamented with what appears to be numerous minute papillæ (fig. 22). The caudal furca are short (Pl. 8. fig. 2) and about equal to the length of the last abdominal segment, and they are about as broad as long.

Description of the male.—The male is very similar to the female except that the antennules have a modified and hinged structure, to permit of their use as grasping-organs. The inner branches of the second pair of thoracic feet are also modified as shown (Pl. 7. fig. 23). The fifth pair (Pl. 8. fig. 1) are much smaller than in the female; the inner portion of the basal joint, which is only slightly produced, is broadly rounded, and provided with three stout setæ of unequal length—the middle one being the longest; the secondary joint is broadly ovate, the inner margin is furnished with only a few minute hairs, but several stout plumose setæ spring from the outer margin and apex.

Hab. Off East Glacier, Cape Flora, July 1897; only a few specimens were obtained in the Collection.

Remarks. The large size and robust form of this Copepod, together with the large and broadly foliaceous fifth pair of feet of the female, differentiated the species at once from all the others in the Collection.

THALESTRIS JACKSONI, sp. n. (Pl. 8. figs. 3–9.)

Description of the female.—Body moderately stout. Length of the specimen figured 2·5 mm. ($\frac{1}{10}$ of an inch). Rostrum very short. Antennules short, 9-jointed, the sixth joint is considerably longer than any of the other five end-joints (fig. 4); the approximate proportional lengths of all the joints are shown by the formula:—

Proportional lengths of the joints ...	17 .	21 .	15 .	13 .	6 .	10 .	5 .	4 .	6.
Numbers of the joints	1	2	3	4	5	6	7	8	9

The posterior foot-jaws (fig. 5) are stout; the hand somewhat resembles that of *Thalestris rufoviolascens*, but the inner margin is more oblique and the marginal spinules are larger; the other mouth-organs are somewhat similar to those of *Thalestris mysis*. The first pair of thoracic feet are moderately stout, and both branches are armed with strong terminal claws (fig. 6). In the fourth pair the inner branches only reach to about the end of the second joint of the outer branches; both branches bear long plumose setæ (fig. 7). The fifth pair are large and foliaceous: the length of the basal joint is scarcely equal to twice the breadth; this joint bears five setæ on the broadly rounded apex, two of the intermediate (fig. 8) are considerably longer than the others: the secondary joint is oval in outline, its greatest breadth is equal to about half the length, and both the inner and outer margins are fringed with minute cilia; this joint is furnished with six setæ, three on the lower half of the outer margin and three at the apex,—the two outer apical setæ are close together and more slender than the others, which are moderately wide apart as shown in the figure. The caudal furca (fig. 9) are elongate, being fully twice the length of the last abdominal segment, and the two principal setæ are as long as the whole length of the abdomen and furca combined. No males of this species were observed.

Hab. Half mile off Cape Gertrude in 8 fathoms, June 6th, 1897; about fifty yards off West Point, Cape Flora, in 2–3 fathoms, June 20th; and off West Glacier, in 1–3 fathoms, July 6th, 1897.

The species was of rare occurrence in these gatherings.

Remarks. The large size of *Thalestris Jacksoni*, the peculiar form of the posterior foot-jaws, and the form and armature of the large foliaceous fifth pair of thoracic feet, combine to distinguish this from any other *Thalestris* known to me. This fine species is named in compliment to Mr. Jackson, of the Jackson-Harmsworth Arctic Expedition.

Genus WESTWOODIA, *Dana*, 1855.

WESTWOODIA NOBILIS (*Baird*).

1845. *Arpacticus nobilis*, Baird (2), p. 155.

This species was obtained in a gathering collected in West Bay, Cape Flora, July 27th, 1897; a single specimen only was observed. *Westwoodia nobilis* is found sparingly in many places around the British Islands, and appears to be otherwise widely distributed. It is a distinct species, and when living very prettily coloured.

Genus HARPACTICUS, *Milne-Edwards*, 1838.

HARPACTICUS CHELIFER (*Müller*). (Pl. 8. figs. 10–13.)

1776. *Cyclops chelifer*, O. F. Müller (55), p. 2413.

This *Harpacticus*, which is moderately common in the British seas, was of rare occurrence in the Franz-Josef Land collection; the only gathering in which the species was observed was one from West Bay, Cape Flora, collected in July 1897.

It will be observed from the figures on Plate 8, that the Franz-Josef Land specimens of *Harpacticus chelifer* differ somewhat from those from Heligoland and the British seas; the antennules of these Arctic specimens (fig. 10) are 9-jointed, whereas in Dr. Claus's description of the species they are stated to be 8-jointed (achtgliedrig), and this agrees with what I have observed in Clyde specimens. The posterior foot-jaws (fig. 11) are scarcely so angular on the inner aspect as they are found to be in Clyde specimens. There does not appear to be much difference in the structure of the first pair of swimming-feet (fig. 12). In the fifth pair the secondary joints are proportionally smaller than in Clyde specimens, and the inner produced part of the basal joints is more broadly rounded. Notwithstanding these differences, it seems better to regard this simply as a form of *Harpacticus chelifer*.

HARPACTICUS CHELIFER, var. ARCTICUS. (Pl. 8. figs. 14–17.)

An *Harpacticus*, of a more robust form than the last, was of frequent occurrence in some of the gatherings. I was inclined at first to regard this as belonging to *Harpacticus gracilis*, Claus, which it in some respects resembles, but I now prefer to look on it as a robust variety of *Harpacticus chelifer*. The antennules are 9-jointed; the first four joints are proportionally rather shorter than those of *H. gracilis.* The posterior foot-jaws are larger than those of the form last described, but otherwise they resemble them very closely. The first pair of swimming-feet are also larger than those of the form referred to, and there is a slight difference in their structure: the inner branches have the two short end-joints distinct, but the short end-joint of the outer branches appears to be coalescent with the second, so that the outer branches are thus apparently only 2-jointed. The fifth pair (fig. 17) have the secondary joints broadly ovate, and somewhat resemble those of *Harpacticus gracilis.*

This robust variety occurred chiefly in gatherings of Crustacea collected in 2–4 fathoms, about fifty yards off West Point, Cape Flora, during June and July, 1897.

Genus ZAUS, *Goodsir*, 1845.

ZAUS SPINATUS, *Goodsir.*

1845. *Zaus spinatus*, Goodsir (**33** *a*), p. 326, pl. 11. figs. 1–8.

This comparatively well-marked species was dredged at West Bay, Cape Flora, in 2–10 fathoms, July 2nd, 1897; only a few specimens were observed. Its British distribution extends from the Scilly Islands to Shetland.

Genus EUPELTE, *Claus*, 1863.

EUPELTE PURPUROCINCTA (*Norman*).

1868. *Alteutha purpurocincta*, Norman (**59**), p. 298.

This species occurred in the same gathering with *Zaus spinatus* from West Bay, Cape Flora. It has sometimes been described as an *Alteutha*, but Prof. Claus and others consider it to be generically distinct. As a British species, it is to be found all round our shores, but seldom in large numbers. *Eupelte purpurocincta* appeared to be rare in the Franz-Josef Land gatherings.

Genus IDYA, *Philippi*, 1843.

IDYA FURCATA (*Baird*).

1837. *Cyclops furcatus*, Baird (**1** *a*), p. 330, pl. 9. figs. 26–28.

A considerable number of specimens of *Idya furcata* were obtained in the Franz-Josef Land collections; they could usually be distinguished at sight by the characteristic pale purple bands across the dorsal aspect. They occurred in three gatherings collected off West Point, Cape Flora, about 50 yards, in 2–4 fathoms: (1) on June 4th, (2) June 22nd, and (3) July 5th, 1897. Some specimens were also obtained in a gathering dredged at West Bay, in 2–10 fathoms, July 2nd of the same year. As a British species, *Idya furcata* is moderately common.

IDYA MINOR, *T. & A. Scott.*

1896. *Idya minor*, T. & A. Scott (**84**), p. 228, pl. 4. figs. 11–17.

This is a distinctly smaller species than *I. furcata*, and appears to be a scarce form. The only gathering in which a few specimens were obtained was dredged in 2–3 fathoms, about fifty yards off West Point, Cape Flora, on June 18th, 1897.

Genus SCUTELLIDIUM, *Claus*, 1866.

SCUTELLIDIUM TISBOIDES, *Claus.*

1866. *Scutellidium tisboides*, Claus (**24**), p. 21, pl. 4. figs. 8–15.

Several specimens of this species occurred in the same gathering with *Idya minor*, but in no other. It is a moderately large and easily recognized species. It is widely distributed, but apparently not very common. It is one of the rarer of the British species.

Family ASCOMYZONTIDÆ.

Genus DERMATOMYZON, *Claus*, 1889.

DERMATOMYZON NIGRIPES (*Brady & Robertson*).

1875. *Cyclopicera nigripes*, Brady & Robertson (**45**), p. 197.

This species was very rare in the Franz-Josef Land collections. The only gathering in which it was observed was one collected off East Glacier, Cape Flora, and which contained several other interesting species, such as *Munna Fabricii* and *Pleurogonium*. The British distribution of *Dermatomyzon nigripes* extends to the Shetland Islands. Dr. Giesbrecht refers doubtfully to the occurrence at Spitzbergen of this species.

Genus Myzopontius, *Giesbrecht*, 1895.

Myzopontius pungens, *Giesbrecht*. (Pl. 9. figs. 1–10.)

1895. *Myzopontius pungens*, Giesbrecht (53), p. 182.

Description of the female.—Thorax broadly ovate, being about one-third longer than broad; the abdomen is narrow and fully half the length of the thorax; "thoracic segments scarcely produced into lateral processes, neither are the abdominal" (fig. 1). Antennules short, 12-jointed; the terminal joint is elongate, being fully twice the length of the penultimate one and bearing an asthetask near the distal end (fig. 2); the formula shows approximately the proportional lengths of all the joints:—

Proportional lengths of the joints	13	12	6	6	5	5	9	6	8	8	11	25
Numbers of the joints	1	2	3	4	5	6	7	8	9	10	11	12.

Antennæ (Pl. 9. fig. 3) 4-jointed; third joint short, secondary branch very small. Mandibles (Pl. 9. fig. 4) in the form of long, slender stylets. Maxillæ (fig. 5) furnished with two lobes: inner short, oval, and bearing one long and one short apical seta; outer lobe elongate and narrow, and provided with two apical setæ of moderate length. The anterior foot-jaws (fig. 6) are armed with very long and curved terminal claws. The posterior foot-jaws are long and slender (fig. 7); the second joint is elongate, but the last three are shorter and narrower, and the terminal claw is moderately stout and about equal in length to the last three joints. The first four pairs of swimming-feet are somewhat similar in structure, and have both branches 3-jointed; in the first pair (fig. 8) the end-joints of the outer branches are armed with three spines and five plumose setæ; the end-joints of the inner branches have one plumose seta on the outer margin, three on the inner margin, and two at the apex, while the second joints are furnished with two setæ, and the first joints with one on the inner margin. The end-joints of the outer branches of the fourth pair (fig. 9) are furnished with four spines and five setæ; the number of setæ on the inner branches is similar to that on the inner branches of the first pair, except that there are only two setæ on the inner margin of the end-joint, and the inner one of the apical setæ is replaced by a slender sabre-like spine. Fifth pair (fig. 10) small, 1-jointed, cylindrical, the length being about equal to twice the breadth, and furnished with three terminal hairs. The first segment of the abdomen is only slightly enlarged anteriorly, the second and third joints are both shorter than the last joint; the caudal furca are of moderate length, being about as long as the last two abdominal joints combined.

Hab. Off East Glacier and near Cape Gertrude, Northbrook Island. A few specimens only were obtained.

Remarks. There seems to be little doubt that this Franz-Josef Land species is identical with Dr. Giesbrecht's *Myzopontius pungens* from the Bay of Naples, so far as can be made out from the description alone. The Arctic specimens appear to be somewhat larger than those from Naples; the specimen figured measured 1·6 mm. ($\frac{1}{16}$ of an inch), whereas Dr. Giesbrecht gives 0·85 to 1·1 mm. as the size of the female.

Family ONCÆADÆ.

Genus ONCÄA, *Philippi*, 1843.

ONCÄA MEDITERRANEA (*Claus*).

1863. *Antaria mediterranea*, Claus (23), p. 159, pl. 30. figs. 1–7.

A few specimens of *Oncäa mediterranea* were obtained in a gathering collected about fifty yards off West Point, Cape Flora, in 2–3 fathoms, on June 4th, 1897. This Copepod appears to have a wide distribution; and it is also of interest to note that though Mr. Bruce obtained it in quite shallow water at Franz-Josef Land, it has, on the other hand, been found at considerable depths in the tropical seas. Dr. W. Giesbrecht records its occurrence at a depth of 4000 metres *, and I have obtained the same species in a gathering of micro-crustacea from the Gulf of Guinea collected at a depth of 360 fathoms †. What appears to be the same form was recorded from Spitzbergen by Dr. Lilljeborg in 1875 ‡.

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* 'Pelagischen Copepoden des Golfes von Neapel,' p. 591.

† Trans. Linnean Society, 2nd ser. (Zool.), vol. vi. p. 118.

‡ "De under Svenska vetenskapliga Expeditionen till Spetsbergen 1872–1873 derstades samlade Hafs-Entomostraceer" (Öfvers. Akad. Förhandl. Stockholm, Aar 1875).

CIRRIPEDIA.

Family BALANIDÆ.

Genus BALANUS, *Lister.*

BALANUS PORCATUS, *da Costa.*

1788. *Balanus porcatus,* Em. da Costa (25), p. 249.

Several specimens of *Balanus porcatus* were included in the Franz-Josef Land collection; they were nearly all obtained in the vicinity of Cape Flora. They were obtained on floe-ice off Flora Cottage on 24th August, 1896, and others were collected near the same place in September. Other specimens were gathered off Cape Gertrude during June and July 1897, as well as some distance south-west of Elmwood, off Cape Flora, and in the vicinity of a glacier between Cape Flora and Cape Gertrude. It would thus appear that this species was more or less frequent all round the neighbourhood of Cape Flora.

BALANUS CRENATUS, *Bruguière.*

1789. *Balanus crenatus,* Bruguière.

This *Balanus* was very rare in the Collection; the species was represented by only one specimen of the smooth variety, which was dredged in 8 fathoms off Cape Flora, July 1897.

Both species occur in the Glacial clays of Scotland: *B. porcatus* is frequently observed, but *B. crenatus* is scarcer.

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EXPLANATION OF THE PLATES.

Plate 3.

Fig. 1. *Spirontocaris Gaimardii*, rostrum, enlarged.
2. ,, ,, telson, enlarged.
3. (?) ,, *Phipsii*, rostrum, enlarged.
4. ,, ,, telson, enlarged.
5. *Typhlotanais finmarchicus*, superior and inferior antennæ, enlarged.
6. ,, ,, one of the sixth pair of pereiopoda, enlarged.
7. ,, ,, one of the pair of uropoda, enlarged.
8. *Pseudotanais forcipatus*, one of the chelipeds, enlarged.
9. ,, ,, one of the pair of uropoda, enlarged.
10. *Munna Fabricii*, one of the antennules, enlarged.
11. ,, ,, one of the second pair of pereiopoda, enlarged.
12. ,, *Kröyeri*, one of the antennules, enlarged.
13. ,, ,, one of the antennæ, enlarged.
14. ,, ,, one of the second pair of pereiopoda, enlarged.
15. *Pleurogonium spinosissimum*, dorsal view, enlarged.
16. *Candona Harmsworthi*, lateral view, enlarged.
17. ,, ,, dorsal view, enlarged.

Plate 4.

Fig. 1. (?) *Cyclocypris globosa*, lateral view, enlarged.
2. *Herpetocypris arctica*, lateral view, enlarged.
3. ,, ,, dorsal view, enlarged.
4. ,, ,, one of the antennules, enlarged.
5. ,, ,, one of the antennæ, enlarged.
6. ,, ,, post-abdomen, enlarged.

Fig. 7. *Herpetocypris dubia*, lateral view, enlarged.
8. ,, ,, dorsal view, enlarged.
9. ,, ,, one of the antennules, enlarged.
10. ,, ,, one of the antennæ, enlarged.
11. ,, ,, post-abdomen, enlarged.
12. *Pontocypris hyperborea*, lateral view, × 40.
13. ,, ,, dorsal view, × 40.
14. ,, ,, ventral view, × 40.
15. ,, ,, end view, × 40.
16. *Metridia longa*, fifth pair of thoracic feet (♂, right foot), enlarged.
17. ,, ,, ,, ,, ,, (♂, left foot), enlarged.
18. *Oithona similis*, one of third pair of thoracic feet (♀), enlarged.
19. ,, ,, one of fourth pair of thoracic feet (♀), enlarged.

PLATE 5.

Fig. 1. *Dactylopus tenuiremis*, one of the antennules, × 253.
2. ,, ,, posterior foot-jaw, × 253.
3. ,, ,, one of the first pair of swimming-feet, × 253.
4. ,, ,, one of the fifth pair, × 190.
5. ,, *longirostris*, one of the antennules, × 253.
6. ,, ,, posterior foot-jaw, × 253.
7. ,, ,, one of the first pair of swimming-feet, × 253.
8. ,, ,, one of the fifth pair, × 190.
9. ,, *Strömii*, var. *arcticus*, female, lateral view, × 27.
10. ,, ,, ,, one of the antennules, × 127.
11. ,, ,, ,, posterior foot-jaw, × 253.
12. ,, ,, ,, one of the first pair of swimming-feet, × 127.
13. ,, ,, ,, one of the fifth pair, × 95.
14. *Delavalia arctica*, posterior foot-jaw, × 380.
15. *Enhydrosoma curvatum*, one of the fifth pair of feet, × 380.

PLATE 6.

Fig. 1. *Cyclops Brucei*, female, dorsal view, × 27.
2. ,, ,, one of the antennules, × 95.
3. ,, ,, one of the first pair of swimming-feet, enlarged.
4. ,, ,, one of the fourth pair, enlarged.
5. ,, ,, one of the fifth pair, enlarged.
6. ,, ,, abdomen and caudal furca, enlarged.
7. *Delavalia arctica*, female, dorsal view, × 27.
8. ,, ,, one of the antennules, × 95.
9. ,, one of the first pair of swimming-feet, × 127.
10. ,, ,, one of the fourth pair, × 63.
11. ,, ,, one of the fifth pair, × 95.

Fig. 12. *Maraenobiotus Vejdovskyi*, female, lateral view, × 86.
13. ,, ,, one of the antennules, × 253.
14. ,, ,, one of the maudibles, greatly enlarged.
15. ,, posterior foot-jaw, × 803.
16. ,, ,, one of the first pair of swimming-feet, × 253.
17. ,, ,, one of the fifth pair, × 760.
18. (?) *Canthocamptus parvus*, female, lateral view, × 80.
19. ,, ,, one of the antennules, × 570.
20. ,, ,, one of the antennæ, × 570.
21. ,, ,, one of the mandibles, × 380.
22. ,, ,, one of the first pair of swimming-feet, × 253.
23. ,, ,, one of the fourth pair, × 253.
24. ,, ,, one of the fifth pair, × 253.

Plate 7.

Fig. 1. *Laophonte perplexa*, female, lateral view, × 21.
2. ,, ,, one of the antennules, × 190.
3. ,, ,, posterior foot-jaw, × 253.
4. ,, ,, one of the first pair of swimming-feet, × 253.
5. ,, ,, one of the fourth pair, × 190.
6. ,, ,, one of the fifth pair, × 190.
7. ,, ,, caudal furca, × 95.
8. *Thalestris polaris*, female, lateral view, × 32.
9. ,, ,, one of the antennules, × 95.
10. ,, ,, posterior foot-jaw, × 95.
11. ,, ,, one of the first pair of swimming-feet, × 84.
12. ,, ,, one of the fourth pair, × 63.
13. ,, ,, one of the fifth pair, × 84.
14. ,, ,, inner branch of second pair (♂), × 126.
15. ,, ,, one of the fifth pair (♂), × 126.
16. ,, ,, caudal furca, × 40.
17. ,, *frigida*, female, lateral view, × 27.
18. ,, ,, one of the antennules, × 95.
19. ,, ,, one of the posterior foot-jaws, × 127.
20. ,, ,, one of the first pair of swimming-feet, × 63.
21. ,, ,, one of the fourth pair, × 63.
22. ,, ,, one of the fifth pair, × 63.
23. ,, ,, inner branch of second pair (♂), × 126.

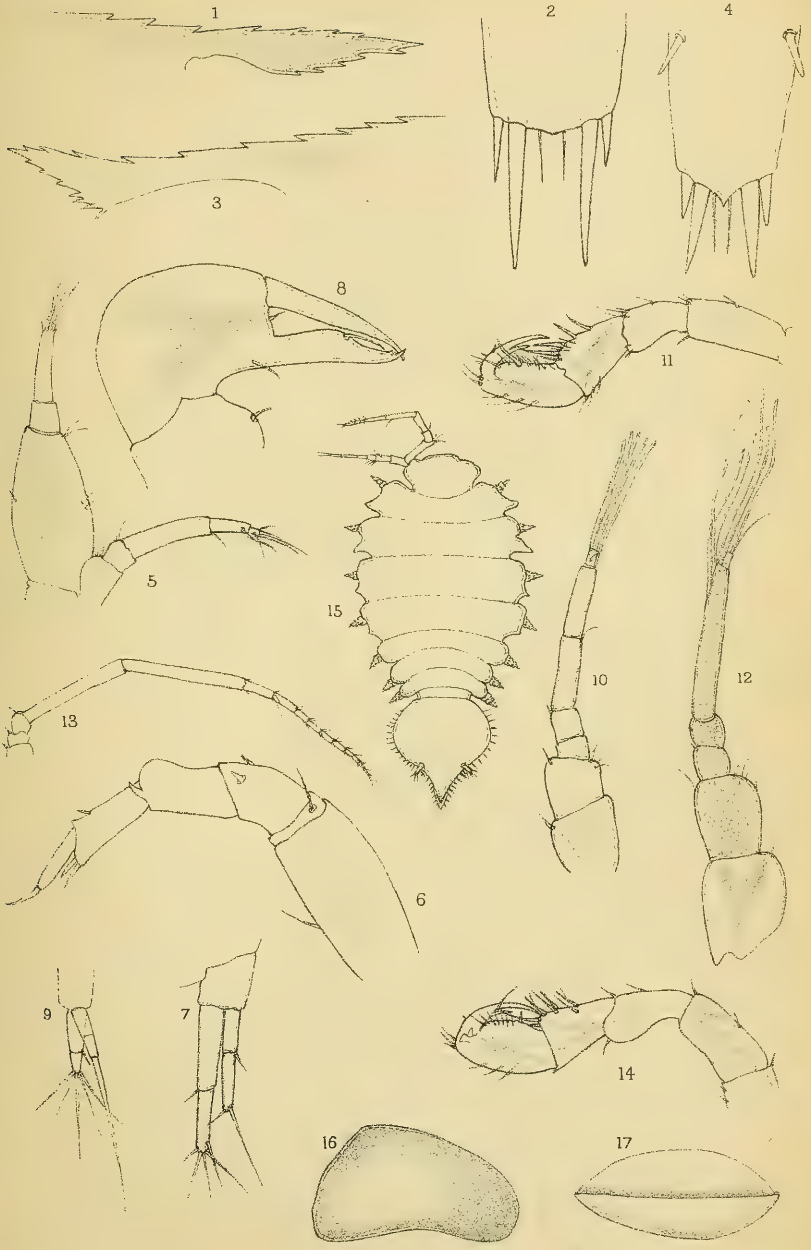
Plate 8.

Fig. 1. *Thalestris frigida*, one of the fifth pair of thoracic feet (♂), × 126.
2. ,, ,, caudal furca, × 80.
3. ,, *Jacksoni*, female, lateral view, × 18.
4. ,, ,, one of the antennules, × 84.
5. ,, ,, one of the posterior foot-jaws, × 95.

Fig. 6. *Thalestris Jacksoni*, one of the first pair of swimming-feet, × 63.
7. ,, ,, one of the fourth pair, × 47.
8. ,, ,, one of the fifth pair, × 63.
9. ,, ,, caudal furca, × 40.
10. *Harpacticus chelifer*, one of the female antennules, × 126.
11. ,, ,, one of the posterior foot-jaws (♀), × 126.
12. ,, ,, one of the first pair of swimming-feet, × 95.
13. ,, ,, one of the fifth pair (♀), × 126.
14. ,, ,, var. *arcticus*, one of the female antennules, × 126.
15. ,, ,, ,, one of the posterior foot-jaws (♀), × 126.
16. ,, ,, ,, one of the first pair of swimming-feet, × 95.
17. ,, ,, ,, one of the fifth pair (♀), × 126.

Plate 9.

Fig. 1. *Myzopontius pungens*, female, dorsal view, × 27.
2. ,, ,, one of the antennules (♀), × 84.
3. ,, ,, one of the antennæ, × 126.
4. ,, ,, mandible, × 95.
5. ,, ,, one of the maxillæ, × 126.
6. ,, ,, one of the anterior foot-jaws, × 95.
7. ,, ,, one of the posterior foot-jaws, × 95.
8. ,, ,, one of the first pair of swimming feet, × 84.
9. ,, ,, one of the fourth pair, × 84.
10. ,, ,, one of the fifth pair of thoracic feet, × 126.
11. *Hoplonyx similis*, one of the anterior coxal plates, enlarged.
12. ,, ,, one of the last pair of epimeral plates of metasome, enlarged.
13. ,, ,, telson, enlarged.
14. *Amathilla pinguis*, one of the last pair of epimeral plates of metasome, enlarged.
15. ,, ,, telson, × 85.
16. *Photis tenuicornis*, one of the first pair of gnathopods (♂), enlarged.
17. ,, ,, one of the second pair of gnathopods, enlarged.
18. *Ischyroceras* (?) *anguipes*, one of the second pair of gnathopods, enlarged.



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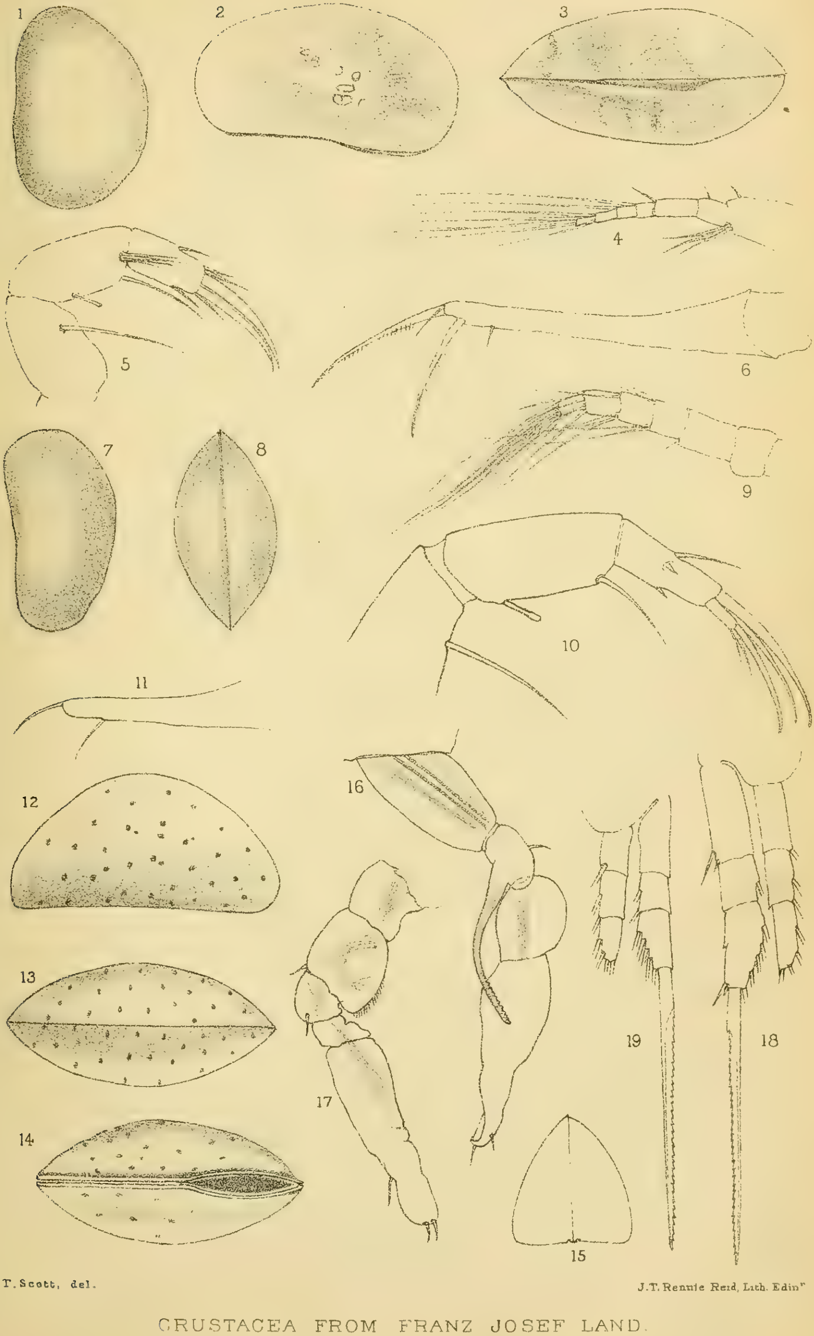

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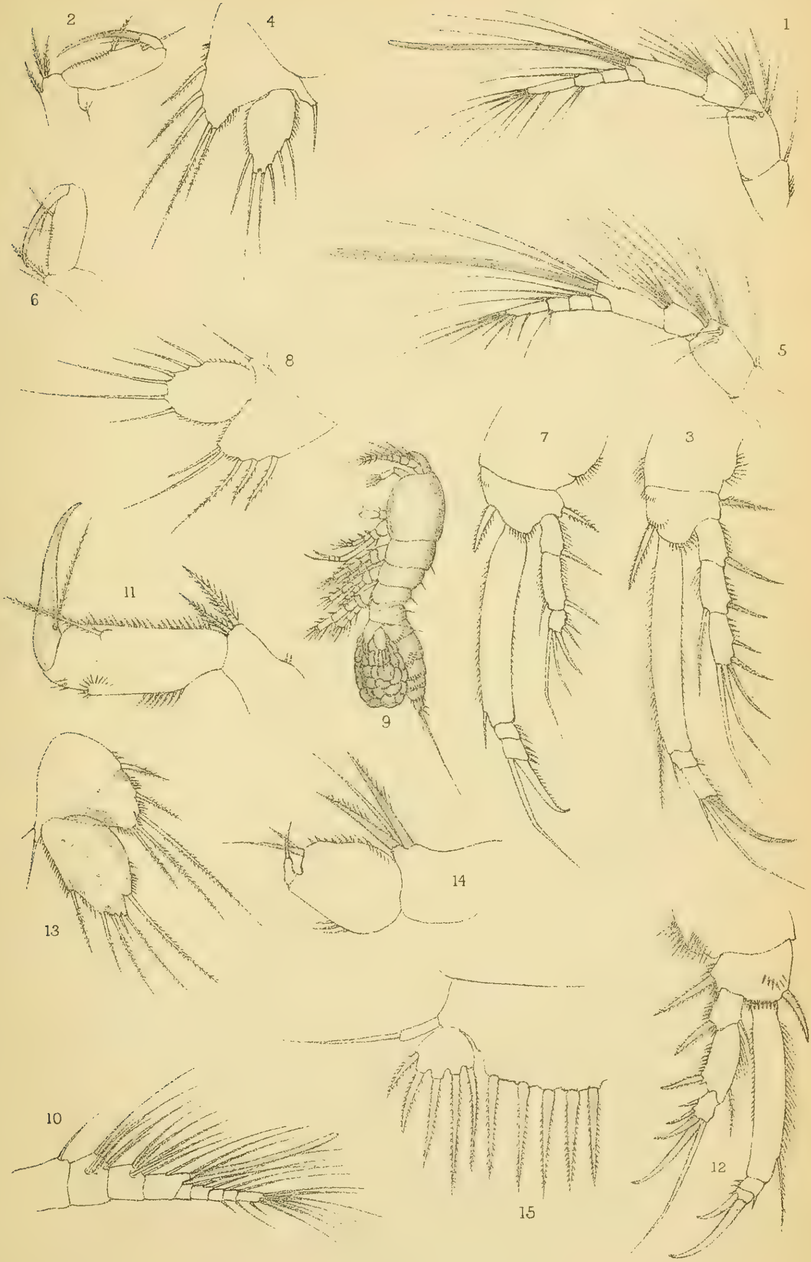

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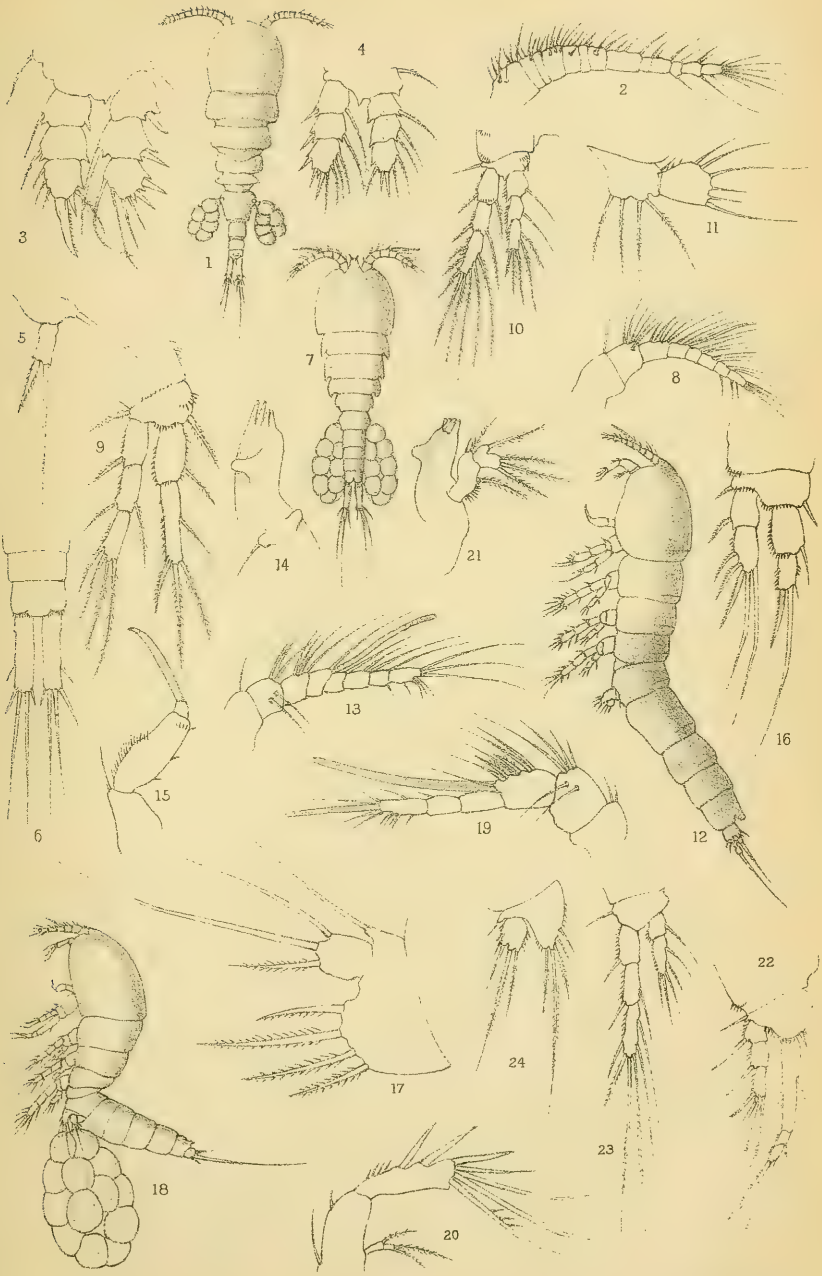

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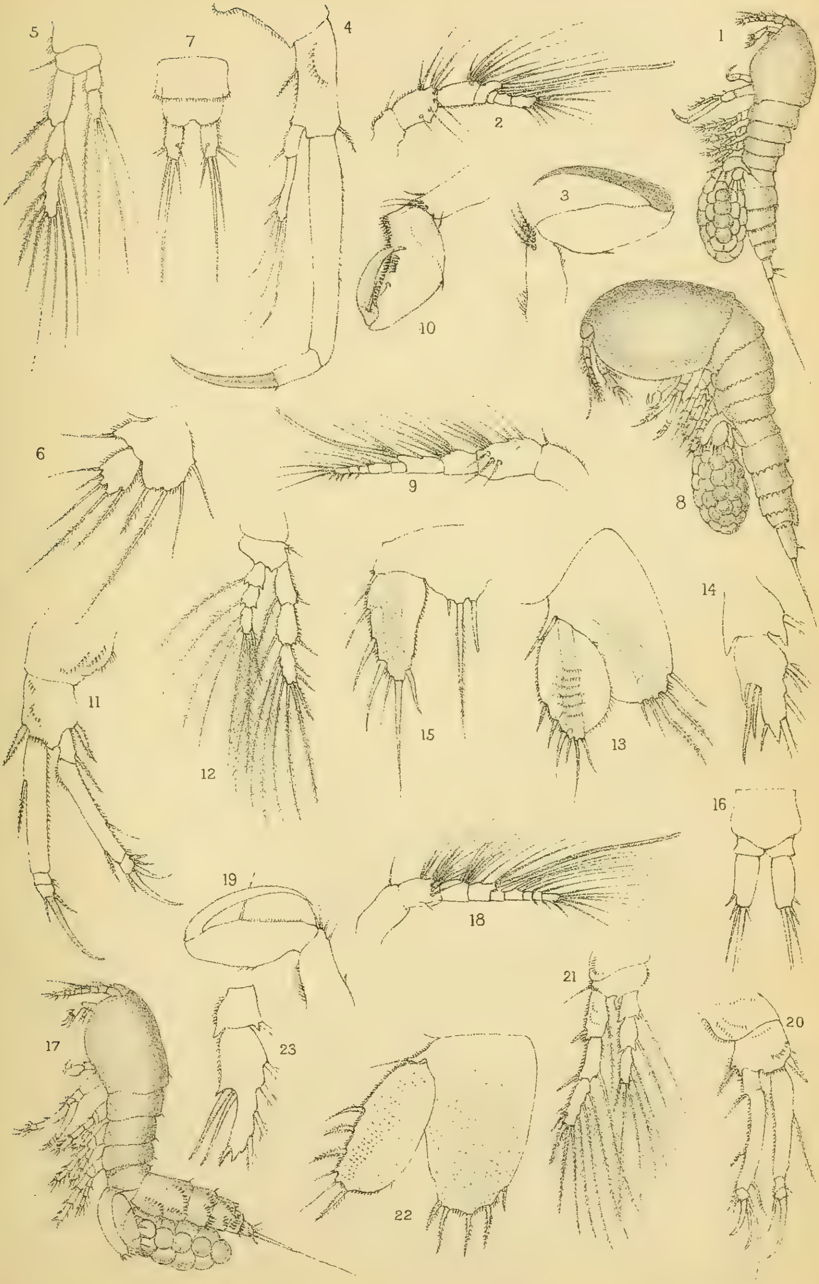

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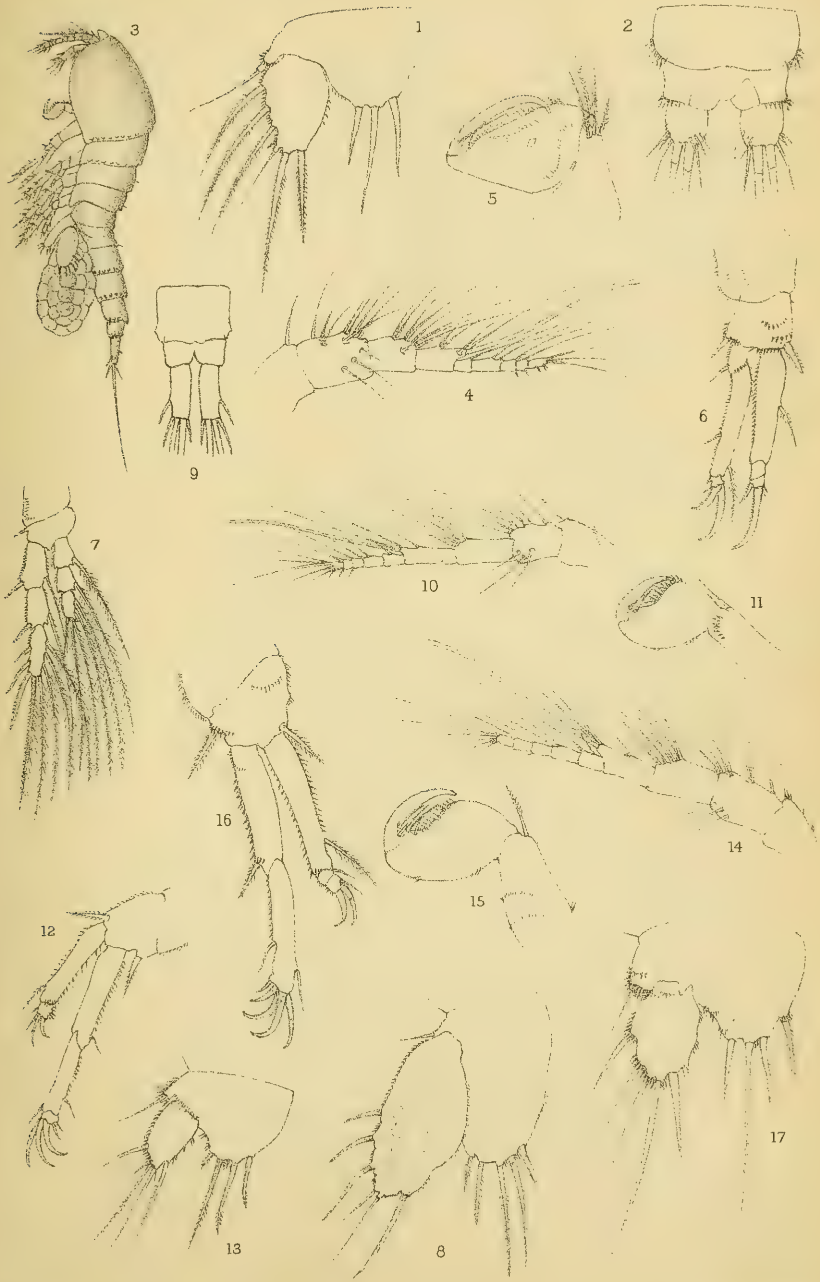

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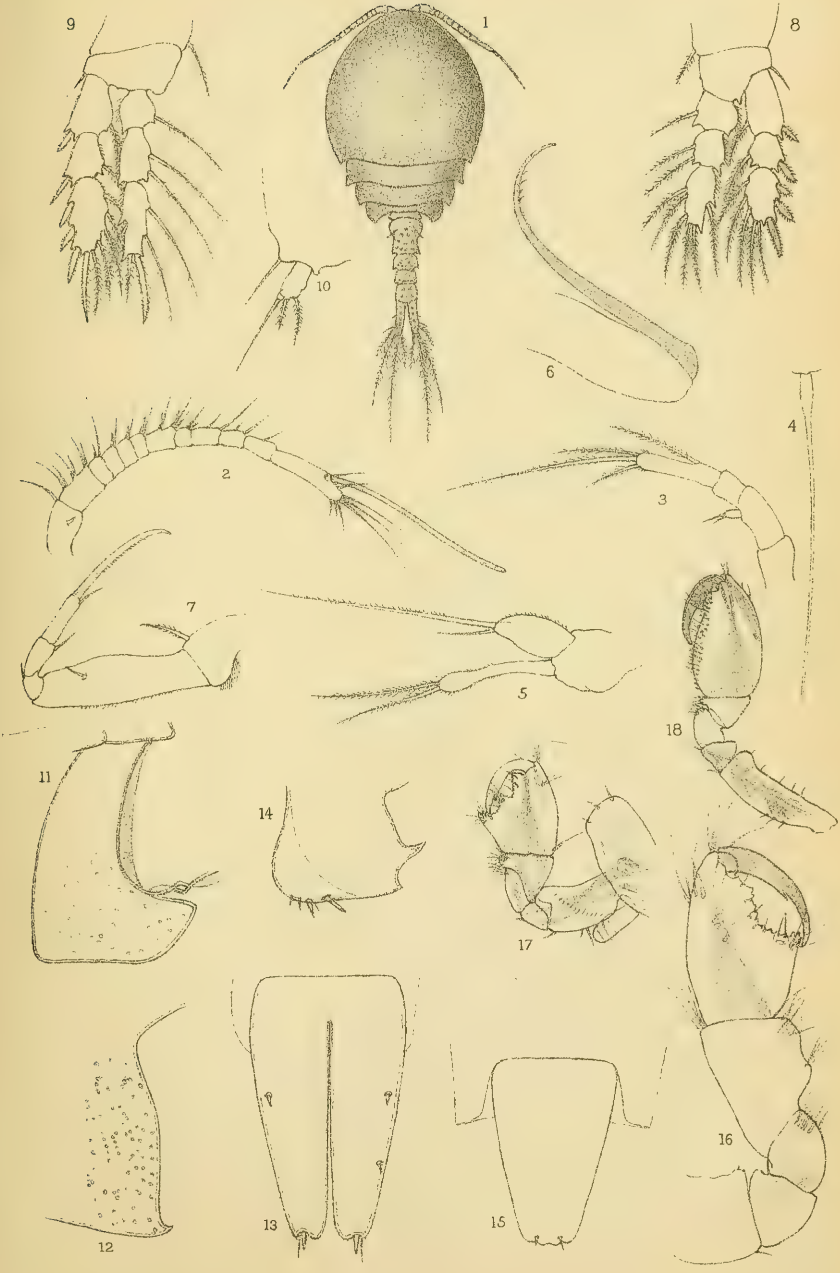

Figs 1–10 A. S. del.
others T. S. del.

J. T. Rennie Reid, Lith. Edin^r.

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Recent *Poritidæ*, and the Position of the Family in the Madreporarian System. By HENRY M. BERNARD, M.A., F.L.S.

[Read 2nd February, 1899.]

IN the last paper dealing with the Stony Corals which I had the honour of reading before this Society *, a phylogeny of the Madreporarian skeleton was sketched out, and suggestions were made as to the lines of development which had been taken by some of the better-known recent forms. I now propose to give an instalment of the morphological results of work done during the past eighteen months on one of the families mentioned in that paper—the Poritidæ. It is hoped that in the course of the next few years the remaining groups of the Madreporaria, both recent and fossil, will be dealt with, and the proposed phylogenetic scheme completed and strengthened by additions and amendments suggested in the course of the work.

In this paper I propose to confine myself to the systematic position of the Poritidæ, and to introduce only so much structural detail as is necessary. The variations of form assumed by *Porites*, a few of which are only incidentally referred to here, deserve separate description. The most important question raised by the work itself, however, was primarily the place of the Poritidæ among the Madreporaria. This point has therefore been worked out first, and the present paper will be shortly followed by a more detailed account of the structure and of the chief lines of differentiation found within the constituent genera.

But, while reserving an account of the structure for fuller treatment in a second paper, a brief description of the corals known as *Porites* will doubtless add to the interest of the following pages. Although both explanate and branching forms are known, the most familiar are smooth round masses, sometimes attaining a circumference of 60 feet. They are built up by a dense crowd of minute cylindrical polyps characterized by twelve short, thick, (?) rudimentary tentacles. The polyps rise fairly high above their skeletal substratum, and when retracted are unable to withdraw entirely into their calicles, as is the usual habit in the Stony Corals. Examination of the dried skeleton shows that the pits are too shallow to take in the polyps; they

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* Journ. Linn. Soc., Zool. xxvi., read December 1897.

are, in fact, little more than surface depressions in a skeletal mass, conspicuous on account of its being a fine porous reticulum. The shallow calicles may be rounded and separated by reticular walls of different thicknesses, or else so crowded together as to be polygonal in outline. The skeletal structure within the calicle is also remarkable. The radial symmetry, which is such a striking feature in the Stony Corals, is in *Porites* more or less obscured. Septa never stand out as radiating plates, but instead 5–6 or more rod-like or granular pali rise up as a central ring from the reticulum which fills up the base of the calicle. Round this ring of pali the rudiments of septal formation can generally be traced.

Such corals as these early attracted the attention of naturalists, and the significant name *Porites* was first associated with them by Pallas (1766), and was eventually accepted by Lamarck as the generic name.

The position which Lamarck assigned to the new genus is given in his classification of the "Lamelliferous" Corals (Anim. s. Vert., ed. 1816, ii. p. 219). It is placed with *Madrepora* in the last section, viz., in that which contained corals with cells circumscribed and covering the whole free surface of the stock, and it follows *Astræa*, which also has cells circumscribed but confined to the upper surface of the stock.

In 1821 * Lamouroux followed Lamarck in placing the genus *Porites* after *Astræa*, but called the group in which the former occurred "Les Madréporées," and that in which *Astræa* occurred "Les Astrées." De Blainville † divided the Stony Corals into "Madrephyllies" and "Madrepores," the Astræids being placed among the former and *Porites* near the end of the latter. Nevertheless, in his observations he admits the apparent kinship of the genus with both *Astræa* and *Madrepora* as suggested by Lamarck, but thought it was much closer with the latter than with the former. The recently established genus *Goniopora*, Q. & G., was rightly placed by De Blainville next to, but in front of, *Porites*.

In 1834 Ehrenberg ‡ placed *Porites* in the "Madreporina," which were quite distinct from the "Astræina." The Madreporina were divided mainly according to their methods of

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* 'Exposition Méthodique,' pp. 56, 60.

† 'Manuel,' pp. 334, 395.

‡ 'Corallenthiere des Rothen Meeres,' pp. 91–115.

budding into two genera, *Heteropora* (= the modern genus *Madrepora*) and *Madrepora*, Ehr. This latter consisted of two subgenera, *Madrepora-phyllopora* (=*Astræopora*, de Blv.) and *Madrepora-porites*, which was a heterogeneous group consisting of Montipores, Stylophores, Alveopores, with a few true Poritids.

Dana* was the first to found the family Poritidæ, of equal value with and closely allied to the family Madreporidæ. It contained two genera, *Porites* and *Goniopora*.

This arrangement of Dana's was, in the main, accepted by Milne-Edwards and Haime in 1851. The Poritidæ, enlarged by the addition of many more genera, constituted, together with a very large family the Madreporidæ, the great section Madreporaria Perforata, as opposed to the greater bulk of the remaining Stony Corals, which were grouped as Madreporaria Aporosa. This recognition of the structure of the coral-skeleton as a feature of fundamental taxonomic importance is the chief merit of the work of these authors, which is the last comprehensive attempt to classify the whole coral system. It was, however, hardly to be expected that this first attempt to solve the difficult morphological problems presented by the coral-skeleton would be successful. It is not, therefore, surprising to find that every advance in our knowledge of corals has led to some sweeping revision of Milne-Edwards and Haime's system. At the present day only two of its five original sections can be said to have held their own, viz., the two most important, the Madreporaria Aporosa and M. Perforata †. That these two are now in their turn on the eve of modification, the extent of which cannot yet be predicted, because the researches which render revision necessary are still too recent, will, it is hoped, be made clear in the following pages. Criticisms of details have not been wanting, but they have mainly referred to the relative positions of families or genera.

No change has, so far, been made affecting the position of the Poritidæ, which is the matter we have especially in hand in this paper. The only expressed doubt as to their affinity with the Madreporidæ with which I am acquainted is in the recent work of Miss Ogilvie ‡, who found it impossible to decide whether the two families were or were not related.

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* 'Zoophytes,' 1848.

† See Martin Duncan's revision of the system in the Journ. Linn. Soc., Zool. xviii. 1884, p. 3.

‡ Phil. Trans. vol. 187, 1896, p. 327.

This brief historical sketch shows that almost all who have studied the Madreporaria have come to the conclusion that *Porites* is in some way related to the Madreporids. The reasons for this conclusion may be briefly arranged under the following heads:—

1. The general similarity of their polyps, with twelve tentacles in a single ring.
2. The fact that the septa are mostly in some low multiple of six. In *Porites* there are almost invariably twelve.
3. The skeletal walls are porous, and in both tend to form reticular cœnenchymas *.

Although the real value of this last point, viz., the possession of porous or reticular walls, has never till recently been understood, it was nevertheless a common character in striking contrast with the solid mural structures found in the Astræidæ.

As opposed to these common characters uniting the two families, we have certain differences keeping them apart. These were described by Dana, who limited the family to two genera, *Porites* and *Goniopora*, as follows:—(1) Extraordinary porosity of the Poritid skeleton as compared with the more regularly lamellate skeleton of the Madreporidæ; (2) the fact that, in the Poritidæ, the skeleton in its relation to the polyp is purely basal and never rises to a deep cup; (3) that, as it grows, the small central depression of the calicle fills up, so that the stars are hardly or not at all traceable through the substance of the corallum, as they always are in the Madreporidæ.

On the other hand, Milne-Edwards and Haime, carried along by their theory of the origin of the Madreporarian skeleton, believed that the "trabecular" character of the septa in *Porites* was the fundamental distinction, the septa in the Madreporidæ being lamellate. The remaining differences above quoted from Dana were no longer applicable, because several other genera with the so-called "trabecular" septa were now included.

As it is useless to attempt to discuss these resemblances and differences until we understand clearly what is meant by the terms used, it is necessary to sketch the fundamental theory

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* Milne-Edwards and Haime also added that the families agreed in having no tabulæ, which are so common in the Astræids. This distinction is incorrect. I have already described tabulæ in *Astræopora* and *Turbinaria*, and find them also in *Goniopora* and specially numerous in *Porites*.

upon which the system of Milne-Edwards and Haime was based. It must be remembered that this system, though 50 years old, has never yet been superseded so far as the two chief divisions of the Stony Corals are concerned, the perforate and imperforate. Though worker after worker finds it obsolete, no comprehensive criticism of it has yet been attempted in connection with systematic work*. I make no excuse, therefore, for reviewing the situation which recent researches have brought about. If I needed any excuse I should find it in the great trouble and perplexity which the word "trabecular" has caused me during the past few years. The reason of the confusion can best be explained by showing with what total absence of precision the term was originally used. I hope to make this quite clear by means of concrete examples.

According to Milne-Edwards and Haime the Madreporarian skeleton was built up by the fusion of vast numbers of spicules like those found isolated in the Alcyonaria. Fusion by terminal growth of isolated spicules would naturally result in a reticulate corallum. Direct evidence of this theory was found in the fact that Madreporaria still existed in which the skeleton was reticular, the septa being a lattice-work. *Porites* showed these primitive skeletal conditions best, but others, e. g. *Goniopora*, *Alveopora*, and *Montipora*, were all sufficiently reticular, or, as it was called, "trabecular" †, to be united with *Porites* in one family. Corals showing a further degree of fusion were the Madreporidæ, in which the septa are for the most part lamellate, and only the walls are reticular. Thus the Poritidæ and the Madreporidæ were classed as Perforata in contrast to those corals, such as the Astræids, which showed a still higher degree of specialization, both septa and walls being solid throughout.

It is needless to criticize the details of this scheme, since it has been recently proved to rest upon an entirely erroneous conception of the origin of the Madreporarian skeleton. We now know, primarily through the researches of Dr. von Koch, that the Madreporarian skeleton is a purely ectodermal secretion, and that the septa which appear to be internal are always clothed

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* The bearing of Miss Ogilvie's work will be alluded to in the course of what follows.

† For criticisms of this term see pp. 137 & 145.

with a layer of ectoderm-cells. The whole skeleton is thus outside the polyp, and could never have been built up by a fusion of spicules developed inside the body.

With regard to the general bearing of Dr. von Koch's discovery on the origin and classification of the Madreporaria, I venture to believe that the phylogenetic scheme which was presented in my last paper to this Society supplies us with a solid foundation on which to build up a natural system. That this scheme was only partially seen by Dr. von Koch himself is not to be wondered at; the clue to it lay hid entirely in the epitheca, the great importance of which seems everywhere to have escaped attention. Dr. v. Koch's conclusion was that the "basal plate" with the "epitheca" (that term being commonly limited to the continuation of the basal plate a short way up the sides of the polyp) together formed the primitive skeletal cup of the Madreporaria *.

This description, though correct in fact, fails to recognize the fundamental morphological importance of the epitheca. My own systematic studies had, on the other hand, led me, along quite independent lines, to the conclusion that the epitheca, from which it is impossible to separate the basal plate as a distinct morphological unit, had been at one time the most important element in the skeleton, and that, though it is now very generally vestigial, it was the original cup-like exoskeleton of the Stony Corals from which all the later internal (septal) skeletons had been developed by infoldings. This view is fully supported by the facts:—(1) That the epitheca forms such cup-like exoskeletons in the earliest stages of many (? all) Stony Corals; (2) that transitional forms such as *Alveopora* occur, in which the primitive importance of the epitheca is much longer retained; (3) that many Palæozoic corals are almost purely epithecate; and (4) that published drawings of sections of *Flabellum* show the septa as if they were still formed as simple infoldings of an external wall †.

This was summed up in my previous paper (*l. c.* p. 514) in the following words:—"The Madreporarian skeleton may be described as the rigid secretion of the basal portion of the columniform body of a polyp into which the flexible upper portion may

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* Gegenbaur's Festschrift, ii. 1896, p. 272.

† *Cf.* p. 134.

be invaginated. In its earliest development a simple cup, it has become complicated in various ways; primarily, by the development of radial infoldings of the stiff external wall, comparable with the infoldings of the chitinous cuticle of Arthropods: secondarily, (1) by further complications of these infoldings so as to form an intricate 'internal' skeleton, which may render the primitive external cup unnecessary, and hence lead to its becoming vestigial; (2) by a process of repeated sheddings of the external hard secretions, and the formation of new ones (dissepiments and tabulæ) across and among the existing 'internal' skeletal structures."

Further work with Madreporarian skeletons has only confirmed this generalization. One or two points, however, require attention. In my former paper these septal infoldings were likened to the apodemes of Arthropods, formed by the infoldings of the chitinous skeleton which sometimes, *e. g.* in the cephalothorax of the Spiders, form together an elaborate internal framework. While this resemblance is structurally accurate, the comparison must be received with caution. The apodematous system of the Arthropods can be shown, even in detail *, to be due, at least in their earliest stages, to muscular action, either directly drawing in the chitin to which it is attached, or causing deep wrinkles or folds across the line of the muscles. But it is difficult to see how the infoldings of the calcareous exoskeleton of the early Madrepores to form septa could have been due to muscular action. Dr. von Koch (*l. c.*) thinks that the septa might have arisen in connection with certain endodermal ridges found in some larvæ. But we shall be probably nearer the truth if we can find a cause for them in the ectoderm itself. Until recently I thought that they were due to increased local activity in the secretion of calcareous matter, which would therefore push in the body-wall. From this point of view I found fault (Geol. Mag. 1897) with Miss Ogilvie's description of the process as an "invagination which became filled up" with skeletal matter. But this terminology, though not felicitous, need not be altogether wrong. It seems to me not unlikely that the puckering which gave rise to the septa was caused by the growth of the basal, and probably best nourished, wall of the polyp, and that this wall, cramped by the primitive exoskeletal epitheca, could

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* Ann. & Mag. Nat. Hist. (6) x. p. 67 (1892).

only increase by the formation of folds. We can well understand how such puckering might be radial in the bases of the mesenterial chambers, but quite irregular in the base of the central cavity, where the radial puckers would meet and fuse together with twists and curves. Under the radial puckers, the ectoderm would secrete the septa; under the central, the columella. This view finds some support in the fact that fresh septa are added by puckering of the ectoderm just below the rim of the epitheca (or subsequently of the theca) of the growing coral, *i. e.* just where the polyp is trying to expand*.

Again, in endeavouring to establish my argument that the septa arose from infoldings of the epitheca, I appealed to sections of *Flabellum.* While this appeal is, I think, perfectly justifiable, the sections demonstrating in a remarkable way the point it was desired to establish, yet I confess that, at the time, I did not see that this case itself (*Flabellum*) required explanation. For such direct infoldings of the epitheca from the external surface cannot be considered as primitive. As far as we can see, the epitheca must primitively have formed a continuous calcareous layer, and, when infoldings began, they must have risen from its inner surface without the possibility of there being any external scar such as necessarily exists in the case of chitinous infoldings in the Arthropods, at least until secondarily obliterated. The direct infoldings of the epitheca of *Flabellum* with external scars are therefore somewhat startling. Dr. Ortmann's sections of *Flabellum*, it is true, show an external layer but with a circumferential dark line†, indicating that this layer itself was formed under a fold. I have already suggested that this discrepancy between Dr. Ortmann's sections and those of Dr. Fowler, Mr. G. C. Bourne, and Dr. von Koch can be explained by supposing that, in the case of his specimens, there had been a bagging of the soft parts over the rim of the epitheca which would cause it to grow as a fold. That some specimens do thus bag over we know from Moseley's account of *Flabellum* (Chall. Rep. ii. p. 162, 1881). But this folded rim is not exactly what is wanted. We should have expected a simple rim of epitheca without any dark

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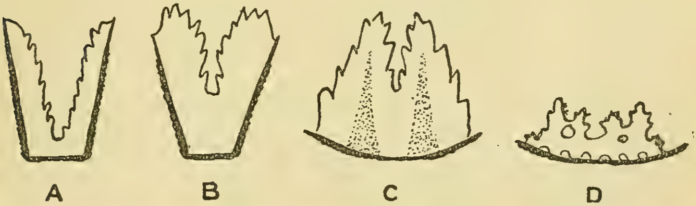
* In my former paper I described other results of this effort to grow, viz. the bagging of the polyp or even its overflowing over the rim of the epithecal cup.

† Zool. Jahrb. iv. (Syst.), pl. xviii. fig. 9 (1889).

line outside the first beginnings of the septa. The fact that this is not found—*cf.*, *e. g.*, Dr. Fowler's sections (Q. J. M. S. xxviii.)—required explanation; and that probably lies in the fact that the puckering of the expanding ectoderm in the early stages of the epithecal cup extends beyond its rim, and that consequently, when this puckered skin secretes its exoskeleton, the latter is puckered or folded from the first.

The last matter to which I wish to refer is still more important, and, moreover, it brings us back to the main subject of our paper, viz., the affinities of *Porites*. One of the special difficulties in dealing with the morphology of the Madreporaria lies in the fact that, for precision's sake, we have to idealize the parent polyp and picture to ourselves the possible transformations of its skeleton, as if it remained stationary. But, as a matter of fact, budding and colony-formation come in to complicate matters greatly. This, therefore, we must face as a difficulty in the way of our line of argument. We have, for instance, assumed that the epithecal cup became vestigial because it was rendered unnecessary by the rising up of the septa (fig. 1) above the edge of the epithecal cup to form an internal theca, which supplied in every way a stronger and better-defended retreat for the polyp than the epithecal cup itself with its edges tending to be filmy and friable. Now, while a comparative study of the different forms of calicle leads me to believe that this is actually what took place, yet, when the habit of budding and colony-formation is taken into account, we are forced to ask whether a reason for the degeneration of the epitheca might not also be found some-

Fig. 1.



A and B. Epithecate stages; the septa developed in A, become exsert in B. C. Thecate stage; the exsert septa replace the epitheca, which becomes vestigial. D. Diagrammatic section of *Porites*.

where in this latter. That such may indeed have been the case we know from the fact that species of *Alveopora* occur in which the lateral expansion of the colony is so pronounced that the usually conspicuous epitheca becomes little more than a film protecting the coral from the substratum, although there are here no exsert septa out of which to form an internal theca in the manner shown in the diagram. The same can also be shown in the genus *Goniastræa*, which multiplies by what is called fissiparity. Two prominent septa mark off the skeleton of the bud *. The skeleton of the colony is here again septate, and the epitheca is flattened out by colony-formation, that is, not in the way shown in the diagram.

This point was not evident in my former paper, even though I left it undecided whether *Porites* was to be regarded as related to Madreporidæ or to *Alveopora.* It was quite clear that the epitheca of *Porites* was flattened out, and that the theca was therefore internal (fig. 1, D); but I saw only two ways in which this could have occurred, and in both the epitheca was slowly replaced in an essentially similar way, viz., by the rising up of an internal theca, formed by the septa becoming more and more exsert. The theca of *Porites* might, I thought, be either a secondary modification of that of the Madreporidæ by the perforation of the lamellate septa, or an independent development from a form like *Alveopora* with horizontal spine-like septa. In this latter case, as the epitheca flattened out, the spines would become vertical and form the vertical "trabeculæ" of *Porites.* I now see, however, that the epitheca might be flattened out in the process of colony-formation, when the skeleton of the bud is marked off by the meeting of septa which cut off a portion of the parent calicle.

We have, then, three apparently possible origins of *Porites.* Of these we may, I think, safely dismiss this last supposition, viz., that the flattening out of the epitheca was due to the rapid lateral budding of some fissiparous coral. Such an origin would give us no explanation of the radial series of "trabeculæ" or of the thick intervening walls.

Returning, then, to the main alternatives, we have to decide

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* This method of budding may be compared with that described in a former paper (Journ. Linn. Soc., Zool. vol. xxvi. p. 495, pl. 33. fig. 10) as that of an Astræid !

whether the internal theca of *Porites* has been developed out of the exsert septal spines of a Favositid, or is a secondary modification of that of the Madreporidæ, with its ring of lamellated septa.

Recent work with both *Goniopora* and *Porites* has led me to the conclusion that this latter view is the correct one. *The septa in both these two genera were once purely lamellate.* Proof of this can be seen in the fact that, both in *Porites* and in *Goniopora*, every transition can be found between the forms with almost purely lamellate septa and others with purely "trabecular" septa. Further, in a great many forms, the costæ round the growing edges run out as vertical lamellæ to the rim of the epitheca, that is, just where primitive conditions might be expected.

This conclusion is not only of permanent importance for the solution of the problem we have in hand, but it deserves the special attention of all students of Stony Corals, because it relieves them for ever of the "trabecula" as a unit of morphological value. The "trabecula," which is in reality merely so much formative tissue, was brought into the system by the theoretical scheme of Madreporarian tectonics put forward by Milne-Edwards and Haime, a scheme which Miss Ogilvie * has recently endeavoured, by considerable emendation and amplification, to place on the surer basis of extended histological research. How great a snare it has been I have already shown † in the case of *Montipora*, which, on account of its "trabeculæ," was ranked by Milne-Edwards and Haime among the Poritidæ. The "trabeculæ" of *Montipora*, that is, if what I called the trabeculæ of that genus are what Milne-Edwards meant, turned out on examination to be very different from those of *Porites* (see further on this point below). Again, if the trabeculæ in *Porites* and *Goniopora*, in which genera of all others they appear to play the most important part, can yet be shown to have no real morphological value, their case finally breaks down.

My own experience is as follows. I began work first with *Goniopora*, its larger calicles admitting of easier examination. At the outset the "trabecula" was accepted as a morphological

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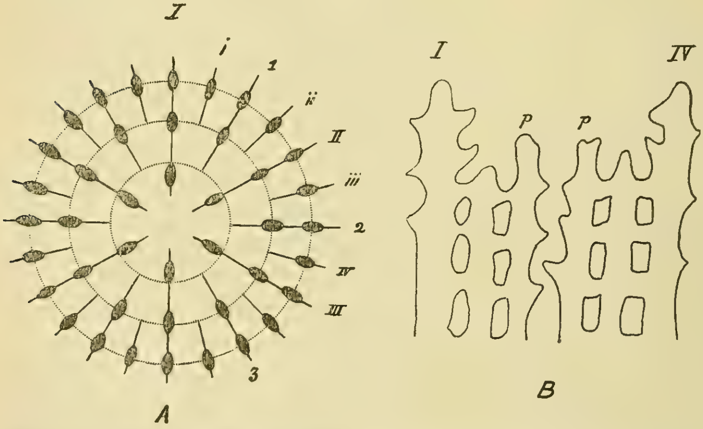
* Phil. Trans. vol. 187, 1896.

† Ann. & Mag. Nat. Hist. xx. 1897.

unit. The following reasons seemed to justify this acceptance:—(1) Well-developed "trabeculæ" occur in the walls of many species. (2) The pali appear to be the tips of others. (3) A vertical section through a corallum frequently shows it to have been built up of long nodulated threads (trabeculæ) running in the line of growth and joined together at intervals by cross-pieces arranged parallel with the surface: this, however, is truer of *Porites* than of *Goniopora*. (4) In some forms there appeared to be a regularity in position and arrangement of the trabeculæ which suggested their having real value.

After examining a great number of specimens, I reconstructed on the simplest possible plan an ideal primitive skeleton of a Goniopore built up of trabeculæ (see fig. 2). But the longer the actual specimens were studied with this hypothetical ancestral form, the more impossible it became. The meshes of the lattice-work were always pores, often very irregular in size and arrangement, in otherwise lamellate septa. Surely some forms would have retained the rectangular lattice-work with the trabeculæ persisting in their primitive importance. But no such condition was found. Then, again, the pali failed as tips of growing trabeculæ. They were plates when the septa were but slightly perforated, and were only tips to the narrow divisions between the large perforations in other cases. Lastly, the finding of the growing

Fig. 2·



Ideal arrangement of the "trabeculæ," if regarded as morphological units, necessary to explain the skeleton of a Goniopore, the columellar tangle being omitted. A, in ground plan: B, in vertical section; *p*, central pali.

edges, already mentioned, in which lamellate costæ ran out to the rim of the epitheca, finally convinced me that the so-called "trabecular" septa are merely perforate lamellate septa.

We have thus reached an important stage in our enquiry as to the position of the Poritidæ: their so-called "trabecular" structure belongs to the terminology of the past. Their thecæ were originally built up of lamellate plates like those of the Madreporids, and the perforation of these plates has to be considered as a secondary characteristic. To this difference between the Madreporid and the Poritid septum we shall return when we have discussed the next most striking contrast between the two families, which may be stated as follows :—

In the Madreporidæ, except in *Montipora* with its immense development of the cœnenchyma, the thecæ are tall and conical. In the Poritidæ, on the contrary, the thecæ are low and shallow. The septa in the latter are therefore not only perforated, *i. e.* poor in quality, but also poor in quantity, that is in size.

This contrast is shown diagrammatically in fig. 1, p. 135, in which C and D are intended to represent individual calicles (ideal parent calicles) of a Madreporid and of a *Porites* respectively. In the former, the septa rise above the flattened epitheca to form a new theca, being mutually supported by synapticulæ which would project from the plane of the figure in the dotted areas. In the latter we have the low basal skeleton of *Porites*; the septa with their synapticulæ being together reduced to a reticulum. Can any explanation be given of these differences? I think so. The diagrams of themselves seem to suggest that the conditions found in *Porites* are due to arrested development. The suggestion is therefore made that these swarms of minute polyps, which are so ubiquitous and appear in such vast numbers that they are reckoned among the principal builders of the coral-reefs, may be regarded as Madreporids arrested at an early stage in their development. This is, in fact, the position I have found myself compelled to assign to the Poritidæ in the Catalogue of the British Museum Madreporaria *.

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* Vol. I. (by the late George Brook) deals with *Madrepora*. Vols. II. & III. contain the Madreporid genera *Turbinaria*, *Astræopora*, *Montipora*, and *Anacropora*. Vol. IV., which is nearing completion, contains the two Poritid genera *Porites* and *Goniopora*, somewhat extended (see below, pp. 143–148).

Let us then see what are the arguments in favour of this suggestion. For the moment, dealing only with *Porites*, we find the polyps, like their calicles, small and degenerate, *i. e.* little grown and with only twelve tentacles. Their skeletal secretions are purely basal, and the animals retreat down upon them rather than into them *. Thus, in relation to the animal, the skeleton is but feebly developed, so feebly indeed that the coralla rarely have any elasticity or beauty of form. They are, for the most part, merely rounded massive concretions such as could be built up of small flat discs.

It may perhaps be objected that such a poorly developed and rudimentary skeleton might also be primitive, but this is certainly not the case here; for a glance at fig. 1 shows that the skeleton of *Porites* belongs to the highest known type, viz., that in which an internal theca has replaced the primitive epithecal cup. This, as above stated, I believe it could only have done by the internal theca being pronounced enough to replace the epithecal cup as a more efficient refuge into which the polyp could contract. Hence we can only account for the internal theca of *Porites* by assuming that it was at one time tall and deep, forming with its jagged septal edges a stronger and better guarded receptacle for the polyp than the primitive epitheca. In other words, the theca of *Porites* must at one time have been tall and composed of lamellate septa, and the fossa, now shallow and quite incapable of containing the polyp, must at one time have been large enough to have allowed the whole polyp to sink down into its recesses (fossa, interseptal and intercostal spaces). The theca, from being a true calicle, has become, in *Porites*, a mere basal pedestal for the comparatively speaking tall polyp which secretes it, it being one of the peculiarities of *Porites* (and of *Goniopora*) for the polyps to rise high above their skeletons.

The internal theca of *Porites* can therefore only be regarded as rudimentary. It is not a vanishing structure, but it belongs to the most specialized type of Madreporarian skeleton, secondarily arrested in its development. This interpretation is further confirmed by comparing the skeleton of *Porites* with that of almost any minute young single coral, such as is frequently found

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* Thurston describes the polyps of *Porites* which can no longer retreat into their calicles as protecting themselves when exposed by a layer of slime. Bulletin of Madras Government Museum, No. 3 (1895), p. 93.

on the corroded bases of large stocks. The septa of such young forms are seen to be irregular and granular, and, as a rule, to rise but little above the columella-tangle. The fossa is consequently shallow. Further, the skeleton has always naturally to pass through a stage when it is small and incomplete, as compared with its secreting polyp, which rises in a column above it. Arrest at such a stage would account for the polyp in *Porites* rising high above its shallow calicle.

Lastly, this argument is quite in keeping with the tendency to bud very early, which I have already noted as characteristic of recent Madreporidæ *. The conditions in *Porites* are simply explained if we assume them to have acquired the habit of budding still earlier, *i. e.* when the skeleton is quite immature.

So far, then, as the genus *Porites*, with its minute polyps and feebly-developed skeletons, is concerned, the above arguments appear to me to be fairly conclusive as to their relationship with some primitive Madreporidæ as fixed young forms.

The chief qualification of this conclusion would tend towards suggesting a polyphyletic origin to *Porites*. There is no reason to suppose that this arrest of development happened only once. If it is possible at all, it is likely to have taken place more than once and at different stages in the phylogenetic development of the Madreporidæ. Indeed, we might ask whether it is absolutely necessary to assume an exclusively Madreporid origin. These points must be left for future discussion. They require a much wider survey of forms than we now possess, and a more profound insight into the essential morphology of the Madreporarian groups.

The genus *Goniopora*, Q. & G.—The first known forms of this genus led to their being placed near, and even among, the Astræidæ (Milne-Edwards & Haime). These last-named authors kept the name *Goniopora* for forms with thick-walled, rather shallow calicles, but gave the name *Porastræa* to those with thin walls. This latter name explains itself. Dana first placed the genus with *Porites*, with which it agrees in almost every respect except in size of calicles. The only difference I have myself been able to discover can be referred simply to increased growth. A third cycle of septa appears, which may be merely rudimentary,

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* Brit. Mus. Madrep. vol. iii. p. 12.

but is most often well developed and with a fourth cycle indicated. The lamellate character of the septa is more evident in the larger septa of *Goniopora* than in the smaller septa of *Porites*, the perforations being about the same size. Thus the perforations as such are of less account in *Goniopora* than in *Porites*, and the vertical section is more of an irregular reticulum than a regular lattice-work, as it frequently is in *Porites*. The close relationship between *Porites* and *Goniopora* suggested by Dana has been universally accepted, Milne-Edwards and Haime abandoning their former position as soon as possible after Dana's work appeared. There has, however, been a tendency to limit the genus too much to forms which have tall thin walls and consequently deep calicles. As a matter of fact, the range of variation is very great; and the collection in the Natural History Museum contains many new and beautiful forms.

Admitting this genus, then, as a near ally of *Porites*, the much greater size of its calicles raises an objection to our conclusions. *Porites*, by the small size of its calicles, might easily be accounted for in the way above suggested as fixed young forms. But how shall we explain the much larger size of the calicles of many Goniopores?

It seems to me that these need not present any great difficulty. Passing over the possibility above suggested, that in these Poritidæ we may have a group made up of fixed young forms of several different corals, whose separate ancestries it would now be extremely difficult to unravel *, there need be no difficulty in deducing the Goniopores from *Porites* directly; and this seems, for the practical purposes of classification, the simplest course to pursue, provided, however, we do not lose sight of the above-mentioned possible polyphyletic origin.

I propose, then, to regard the Goniopores as merely enlarged *Porites*, a kind of giant race which retains the skeletal habit of *Porites*. If once that habit became fixed, there is no reason why further growth should not simply enlarge it without necessarily running it into ancestral Madreporidan lines.

In the present state of our knowledge, I regard anything like certainty in these relationships as unattainable. What I have

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* Here it is of great interest to note that Dana himself suggested that *Goniopora* might occupy a position in the Caryophyllacea corresponding to that which *Porites* occupies in the Madreporacea (Zoophytes, p. 407).

here sketched out is intended to serve merely as a working hypothesis. It may be that a closer study of fossil forms will reveal to us new possibilities. In the meantime, however, we have to analyse the structures of the forms which we have at our disposal, and to arrange them as best we can in a natural order.

Several other genera, recent and fossil, were boldly classed among the Poritidæ by Milne-Edwards and Haime. Any corals showing the "trabecular" structure were placed in the family, which was divided into two subfamilies, *Poritinæ* and *Montiporinæ*.

The *Poritinæ* contained the genera *Porites*, *Rhodaræa*, *Goniopora*, *Litharæa* (foss.), *Protaræa* (foss.), *Alveopora*, *Microsolena* (foss.), *Mæandraræa* (foss.), *Coscinaræa*. In addition to these, *Porites* was divided by Verrill into *Porites* and *Synaræa*; by Duchassaing and Michelotti into *Porites*, *Neoporites*, with a new genus *Cosmoporites*; while Quelch added another, *Napopora*, and described a new genus, *Tichopora*, as closely allied to *Rhodaræa* and *Goniopora*.

Any adequate discussion of these genera should be preceded by a detailed anatomical account of *Porites* and *Goniopora*, showing their ranges of variation. Such an account is in course of preparation. But in the meantime enough has already been said to make the following short notes on the claims of the various genera to a place in the family intelligible. Further, of these genera I propose only to refer to those which I know at first hand. I am not sufficiently acquainted with the fossil forms (which require a much closer study than I have yet been able to give to them) to desire to offer any opinion as to their claims to a place in the family.

Synaræa, Verrill.—This genus was separated from *Porites* by Dr. Verrill *, on the suggestion of Milne-Edwards and Haime, to contain certain forms in which the calicles are quite filled up by the intercalicular skeleton, *i. e.* which show a mere variation in the depth of the calicle. My own study of the variations in *Porites* makes it doubtful whether this is always even a specific, much less a generic distinction.

Napopora, Quelch.—In the genus *Porites* there exist species

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* Bull. Mus. Comp. Zool. vol. i. (1864) p. 42.

in which the thickened walls show tendencies to form extra ridges and hillocks closely resembling those of *Montipora*; indeed, but for the calicles, such specimens would certainly be classed in that genus. These were not known when Quelch made his new genus [*]. There are, however, a good many in the British Museum collection. It seems to me as impossible to separate them from *Porites* because of this rising of the wall, as it is to separate *Synaræa* on account of the sinking of the wall. *If the calicles are built on the same plan*, variations in height of the wall can hardly be considered as generic distinctions.

Both these genera therefore, *Synaræa* and *Napopora*, are merged in the genus *Porites*.

Rhodaræa.—This genus was established by Milne-Edwards and Haime [†], and was thought to differ from *Goniopora* in that the latter had tall thin walls and spongy columella, while *Rhodaræa* had thick low walls with a rosette of pali rising off the columella. These differences are only slight variations on the same essential structure. Even in individual stocks, the development of the pali is always the inverse of that of the walls; where walls are low, the pali are high and conspicuous. In any extended survey, it is found absolutely impossible to separate the specimens on these lines. I propose therefore to merge this genus into *Goniopora*.

Tichopora, Quelch [‡].—The union of *Goniopora* and *Rhodaræa* forms a group which absorbs this proposed genus, in that it came somewhere between them, differing but slightly from either.

Alveopora.—This genus was the subject of my former paper (*l. c.*), so that I need only repeat the conclusion at which I have arrived, that, in spite of its occasional resemblance to individual forms of *Goniopora*, as a primitive type of coral it is yet very far removed from the Poritidæ, which must rank among the most specialized of the Madreporaria.

Coscinaræa, M.-E. & H.—Very little is known of this genus. Only one species seems to be known. It was first figured in Savigny's 'Descr. de l'Égypte,' pl. v. fig. 4, 1809, and named *Meandrina*. These are very puzzling figures, and hardly suggest

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[*] Ann. & Mag. Nat. Hist. xiii. (1883) p. 296.

[†] C. R. xxix. p. 259 (1849).

[‡] Chall. Rep. xvi. (1886) p. 188.

any affinity with *Porites*. A second figure, however, is given, evidently of another specimen, by Milne-Edwards and Haime (Ann. d. Sci. Nat. 3 ser. ix. pl. v. fig. 2, 1848). This was first named *Coscinaræa Bottæ*, M.-E. & H., but afterwards, being identified with Savigny's figure, became *Coscinaræa meandrina*. Dr. Klunzinger has fortunately re-discovered and photographed it as *Coscinaræa monile* of Forskål, and regards it as a Fungid [*].

The remaining subfamily of the Poritidæ, M.-E. & H.—the *Montiporinæ*—consisted of two genera, *Montipora* and *Psammocora*, Dana.

Montipora.—This genus is one of those which Milne-Edwards and Haime forced among the Poritidæ solely on account of its "trabecular" septa. I have already analysed the skeleton of *Montipora* and compared it with that of *Porites* [†]. I was, however, all the while conscious of some misunderstanding; the confusion lay in the word "trabecula." I endeavoured to show that the trabeculæ of *Porites* were not the same as the vertical rods which form such a conspicuous element in most sections of *Montipora*, the secondary development of which could be traced within the genus. I am now, however, not satisfied that Milne-Edwards and Haime meant these vertical rods at all. The word "trabecula" must have meant for them both vertical and horizontal rod-like skeletal processes; and the trabeculæ of *Montipora* were, for them partly at least, the short blunt septal teeth, and not exclusively the long nodulated rods which, in the sections of some forms, so closely resemble the vertical rods in sections of *Porites*. Their express words, in discussing the claims of *Montipora* and *Psammocora* to be classed among the Poritidæ, are: "La structure trabiculaire de leur polypier et principalement de leurs cloisons ne peut laisser aucun doute sur leurs véritables affinités" [‡]. Further, their description of the septal apparatus of *Alveopora* as "trabecular" leaves little doubt that in their use of the word they meant either vertical or horizontal rod-like skeletal matter.

It is not surprising, therefore, if the word "trabecula" ("poutrelle") has caused confusion, for this indefinite application of

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[*] 'Corallenthiere,' iii. 1879, p. 78.

[†] Ann. & Mag. Nat. Hist. xx. 1897; *cf.* also Introd. vol. iii. Brit. Mus. Mad.

[‡] Ann. Sci. Nat. 3 ser. xvi. p. 54 (1851).

the term is quite inconsistent with the original description, where the trabeculæ are said to have "l'aspect de petites tiges noueuses, étranglées d'espace en espace" *. The septal teeth of *Montipora* do not conform to this description, while the vertical rods in that same genus and in *Porites*, as a rule, do.

For the future, however, the word "trabecula" represents merely so much formative tissue, and, if it and its adjectives are retained at all, they can only have descriptive significance. Their intrusion into the morphology of the Madreporaria has so far only led to confusion. I must again, therefore, express my conviction that the more exact description of the trabecula given us by Miss Ogilvie is solely of histological importance, and cannot again give it any weight as a morphological unit.

Returning, however, to the genus *Montipora*, my researches have led me fully to endorse the widespread opinion that it belonged to the Madreporidæ, and not to the Poritidæ. A comparative study of their skeletons showed them, as I thought, to be quite distinct. It is therefore not without interest to note that the conclusion we have now arrived at as to the origin of *Porites* has once more brought them in a manner together. Both may be called Madreporids in which the polyps are fixed at a very low stage of development, but the processes in the two cases are in strange contrast. In *Porites* the whole organization, polyp and skeleton, never gets beyond the early stage at which their development is arrested. But, in *Montipora*, the dwarfing of the polyps seems to have been due to the excessive development of the skeleton as such. The Madreporarian skeleton, in fact, reaches its highest level of specialization in this genus, though at the expense of the polyps. The dwarfing of the polyps in the two genera gave some colour to the classification which placed them in the same family. Indeed, forms occur in both genera which it is not easy at first sight to assign to the one or to the other. Milne-Edwards's distinction, that one has an interstitial cœnenchyma and the other has not, does not hold good, for there are many *Porites* with such thick walls that no difference in this respect can be recognized. The real distinction is found in the calicles. The septa of *Montipora*, composed of six vertical rows of small horizontal teeth round a deep fossa, are unknown

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* 'Les Coralliaires,' vol. i. (1857) p. 32.

in *Porites*; while, on the other hand, the columella-tangle with the paliform granules or rods rising from it, which are characteristic of *Porites*, are never seen in *Montipora*.

Psammocora, Dana, is the last genus which Milne-Edwards and Haime placed in their Montiporine subfamily of the Poritidæ. Dana, from a study of the living coral and on account of its skeletal structure, placed it among the Fungidæ. Its "trabecular" structure, however, compelled Milne-Edwards and Haime to transplant it. So far as I can see, beyond the granular interrupted edges of the septa, which thus appear to be built up of "trabeculæ," this genus has no claim whatever to be classed anywhere near *Porites*, and I agree with Dr. Klunzinger, who replaces it among the Fungidæ, in removing it from the Poritidæ.

Neoporites and *Cosmoporites*, Duchassaing and Michelotti *.—We can discuss these suggested genera together: the differences between them are slight, and the real question is whether they should be separated from *Porites* at all. The type of the suggested *Neoporites* may be taken to be the West-Indian *Porites astrœoides*, Lamarck, which, with a few other West-Indian forms, differs from all the recorded Porites in having deeper calicles and either no pali or else mere traces of them ("pallulis nullis vel subevanidis"). This absence of pali and greater depth of fossa are certainly remarkable characteristics. But I find myself compelled to agree with Dr. Brüggemann in claiming them to be true Porites. On the one hand, it may be urged that the pali are an essential characteristic of *Porites* and *Goniopora*; and here we have forms in which the pali have been secondarily obscured or even suppressed; hence the need for establishing a new genus, and if so the name *Neoporites* is most felicitous, because it betokens an advance on the main genus; further, all the forms which might be grouped as *Neoporites*, and which have been so far described, occur in the West Indies, *i. e.* they have a certain geographical unity which greatly supports the structural evidence in favour of their being a new generic development. On the other hand, I would suggest that, if these specimens are removed from *Porites* on account of the absence of pali, they should for the same

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* 'Coralliaires des Antilles,' Suppl. 1864.

reason be removed from the family. Further, a review of the structural variations not only within the genus, but even often on one and the same specimen, reveals a correlation between the wall and the pali, so that when the one is specially well developed the other is correspondingly aborted. In *Goniopora* we have the species *G. Stokesi*, in which the walls are high and the pali are either absent or else only hinted at. And lastly, forms occur, and will shortly be described, in the Indo-Pacific area which show this same variation, viz., absence of pali. There seems to me, then, no special advantage in separating a few specimens of *Porites* because the deepening calicles have led to the partial or complete suppression of the pali. This variation seems to me not too great to be comprised within the range embraced by the genus.

In connection with what has been said above about the relation of *Porites* to the Madreporidæ, the resemblance between these "*Neoporites*" of Duchassaing and Michelotti, in which the pali are absent from the deep central calicles, and *Montipora* is very interesting: it shows how along two different lines almost the same structure may be reached. That these forms are not Montiporids may be gathered—(1) from their habit, which is more like that of *Porites* than of *Montipora*; (2) from the walls being more boldly reticular than in the majority of Montipores; (3) in the presence of a columella-tangle slowly filling up the fossa, this being characteristic of the Poritidæ but not of the Madreporidæ (excl. *Turbinaria*); (4) in the traces of pali in the shallower young calicles; (5) in the twelve septa nearly equal in size, whereas in *Montipora* six, with a rudimentary second cycle, is the usual septal formula.

SUMMARY.

The foregoing pages contain a preliminary instalment to a revision of the classification of the Madreporaria by Milne-Edwards and Haime, which has been rendered necessary by recent advances in our knowledge of the morphology of the coral-skeleton.

The object of the paper is to record the results, obtained during my work of cataloguing the specimens in the Natural History Museum, as to the position of *Porites* among the Madreporaria. A brief sketch of the history of the question

led to a review of the present situation, in which the fundamental theory on which the existing system of classification which we owe to Milne-Edwards and Haime rests was criticised in the light of recent research. This criticism entailed a re-statement, with slight amplification, of the author's phylogenetic scheme, along the lines of which it is maintained the classification of the Stony Corals will have, for the future, to proceed, *i. e.* until it is again superseded by further advances in morphological science. The chief new points of interest with regard to this scheme related, (1) to the origin of septa; (2) to the various possible methods in which the primitive external epithecal cup may have been flattened and become replaced by an internal skeleton.

This last discussion brought us naturally to the object of the paper, viz., to enquire along what lines of development *Porites* obtained its peculiar internal and so-called "trabecular" skeleton.

The conclusions arrived at were:—

(1) The "trabecular" septum is only a misleading name for perforated lamellate septum.

(2) The Poritid skeleton can be explained as an immature Madreporid skeleton, arrested in its growth by very early budding.

(3) As this may have happened more than once, *Porites* may be polyphyletic in origin.

The paper concludes with a brief discussion of the various genera which have been from time to time united with *Porites* in the same family or else separated from it as generically distinct. The revision suggested leaves the family Poritidæ as Dana left it, with only two genera, *Porites* and *Goniopora*,—*Porites* enlarged by the absorption of *Synaræa*, *Napopora*, *Neoporites*, and *Cosmoporites*, and *Goniopora* also enlarged by the merging with it of *Rhodaræa* and *Tichopora*.

My best thanks are due to my friend Prof. F. Jeffrey Bell for much kindly assistance, and for the warm interest he has taken in these investigations, not only as the Officer in charge of the Collections on the study of which they are based, but also in the interest of zoological science.

Report on the Marine Mollusca obtained during the First Expedition of Prof. A. C. Haddon to the Torres Straits, in 1888–89.

By JAMES COSMO MELVILL, M.A., F.L.S., F.Z.S., and ROBERT STANDEN, Assistant-Keeper, Manchester Museum.

[Read 16th February, 1899.]

(PLATES **10** & **11**.)

EARLY in 1898 Prof. Alfred Cort Haddon, before starting upon a fresh journey of exploration to New Guinea, the coasts of tropical North Australia, and Queensland, favoured us with the request that we would take charge of all the Marine Mollusca collected at low tides, or dredged, during his first expedition to the same region, ten years previously, on the understanding that we would catalogue them and decribe any new forms. This large mass of material had been for a long period lying at Cambridge, almost untouched, only a very few species having been identified by the Rev. A. H. Cooke.

The general condition of the specimens contained in the collection is, as might be expected, variable; but, though many of them are only in a fragmentary state, and the larger proportion of the Pelecypoda are mainly represented by single valves, they are in only rare instances past recognition, and, with the exception of an exceedingly small residuum, we have succeeded to our satisfaction in the work of identification.

Some few indeed, mainly Polyplacophora of three or four kinds, also *Haliotidæ* and various *Cypreæ*, are preserved in spirit, but all these Mollusca are well known, both anatomically and systematically.

The collection is, we consider, of more than usual interest, since its component parts differ in several notable particulars from the gatherings previously made in the same neighbourhood, thus tending to prove the extraordinary richness of molluscan life to be found there. And the area is by no means large, geographically speaking. Situate Long. 142° to 144° E., and Lat. 9° to 11° S., it is hardly more than 75 miles from the mainland of New Guinea, or at all events Saibai Island, to Cape York, N. Australia; this narrowing of the passage between the Arafura and the Coral Seas, through which the South Equatorial Current pours its waters, being some 90 miles in width, and universally known as the Torres Straits.

The whole of this area is contained within the great Indo-Pacific Marine Province, as proposed by S. P. Woodward, 1856, though the merging of that Province with the Australian is, speaking from the molluscan point of view, hazily defined only and, naturally, gradual. This Province is the largest by far, and likewise the most prolific in marine life of all, and though almost unwieldy, it should nevertheless, in our opinion, be still further extended so as to include Southern Japan, treated by Woodward and all who have followed him, as well as by Agassiz, as part of a separate region. The Indo-Pacific Province would then extend from the East coast of Africa, north of the Tropic of Capricorn, to the Red Sea, Persian Gulf, and Arabian Sea, round the whole coasts of India and its adjacent islands, southwards so as to include Madagascar, Mauritius, Bourbon, to Malaya, the East India Islands, and China coasts as far as, and inclusive of, Southern Japan, also taking in tropical Australia, and finally the Pacific Islands with Hawaii. Though so vast, we cannot see how with advantage this tract can be lessened or modified; and one is strengthened in this view when the distribution of many of the tropical Marine Mollusca is considered. The range, for instance, of the most abundant, e. g., *Cypræa helvola*, L., *Nassa arcularia*, L., or *Terebellum subulatum*, L., being that of the Province, even extending beyond its limits into the subtropical waters of Natal, or of Queensland and New South Wales.

Many of the species in the following Catalogue have this wide distribution; and with reference to this fascinating subject, it may be not out of place to refer briefly to the instructive remarks made by Prof. E. von Martens, when enumerating the Mollusca of the Mergui Archipelago *, a few years since. He mentions that out of nearly four hundred species, only one (*Natica unifasciata*, Lam.) was known to have occurred in the New World, besides three, also found on Atlantic shores, and even these were species liable to spread by means of driftwood and other agencies.

There can be little doubt that an unusually large number of endemic forms occur in the region bounded north-westward and northward by the Philippines and Ladrone Islands, westward and to the east by the Arafura Sea and New Caledonian archipelago respectively, the Torres Straits forming part of its southernmost boundary.

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* Journ. Linn. Soc., Zool. vol. xxi. p. 157 (1889).

From a scientific point of view, the following four Expeditions are the most important that have been made in past years to this region.

1. THE VOYAGE OF H.M.S. 'FLY.'

Dr. J. B. Jukes*, in 1842–46, exploring part of North Australia, with the South Papuan coasts, assiduously collected Mollusca. These were mostly described by Arthur Adams and Reeve, while Dr. J. E. Gray, in an appendix to Jukes's narrative, gave diagnoses of several important discoveries, e. g. *Voluta Sophia*, *Cypræa Comptoni*, &c.

2. THE VOYAGE OF H.M.S. 'CHALLENGER.'

The 'Challenger' Expedition†, 1873–76, dredged as follows :—

Station 184, August 29, 1874. E. of Cape York, N.E. Australia, 1400 fathoms; Globigerina-ooze.

Stations 185 & 185^b, Aug. 31, in the same locality, from 128 to 135 fathoms.

Sept. 7 & 8. Torres Straits and Flinders' Passage, 3–11 fathoms.

Station 186, Sept. 8, 1874. Wednesday Island, Cape York, and Albany Island, 3–12 fathoms ; coral-mud.

Station 187, Sept. 9, 1874. W. of Cape York, 6 fathoms.

Station 188, Sept. 10. Off the S.W. of Papua, 28 fathoms ; green mud.

Most of these soundings were successful, and a profusion of new Mollusca of great interest the result.

We are surprised that so few of these are in the collection now before us, as in some instances almost the same localities would seem to have been searched and traversed.

3. THE VOYAGE OF THE 'CHEVERT.'

This expedition started from Sydney early in 1876, Mr. John Brazier being the malacologist attached to the staff. He has published the results in a series of articles, dealing thoroughly

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* Narrative of the Surveying Voyage of H.M.S. 'Fly,' commanded by Captain F. R. Blackwood, R.N., in Torres Straits, New Guinea, and other Islands of the Eastern Archipelago, during the years 1842–46. By J. Beete Jukes.

† Report on the Voyage of H.M.S. 'Challenger' during the years 1873–76. Zoology, vol. xiii. pp. 16–18 ; vol. xv. pp. 710–714.

with the Gastropoda, but the Pelecypoda, so far as we are aware, have not yet been treated. Many new forms, especially amongst the minutiora, are described, but unfortunately not figured, the types all remaining in Australia, we believe mostly in the Australian Museum, Sydney. For our own part, we have been as careful as possible in the comparison of all our undetected forms with these descriptions.

It is to be deplored that Mr. Brazier has not always used language the reverse of vague; still more unfortunate is it that as the Mollusca of the 'Chevert' Expedition were published before those of the 'Challenger,' we are given to understand that they claim priority in not a few instances over Dr. Boog Watson's concise, clear, and admirably illustrated diagnoses. This increase of synonymy is much to be deprecated, and we would press for an insistence of the rule that no mere verbal description should suffice, but that a figure must be published simultaneously, before a new species be recognized.

4. The Voyage of H.M.S. 'Alert' *.

The full and very interesting account of the Mollusca obtained during this expedition has been of the utmost service to us while preparing this paper.

Indeed we are now, as upon many previous occasions, under a deep sense of obligation to Mr. Smith, who has compared with us all doubtful forms and given us every assistance at the British Museum (Natural History).

The specialities of this collection will be dealt with in their proper place. Suffice to state here that of the twenty-four species we consider new to science, one, a Neritoid with some superficial resemblance to *Vanikoro*, must stand as the type of a new genus; and a remarkable *Pholadomya*, with almost equilateral valves, is also noteworthy.

The arrangement adopted in the sequence of the following Catalogue is that of Paul Fischer, as given in the 'Manuel de Conchyliologie,' and we have also followed the same author to a great extent in the nomenclature.

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* Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. 'Alert,' 1881–82. London (Brit. Mus.), printed by order of the Trustees, 1884. Mollusca, by Edgar A. Smith (pp. 34–116).

LIST OF COLLECTING STATIONS *, TORRES STRAITS, 1888.

1. Fringing reef and shore, Thursday Island.

2. 20 miles N.N.W. of Warrior Isl., 5½ fathoms; broken shells and sand. Aug. 15, 1888.

3. Channel between Saibai and New Guinea, 10–17 fathoms; mud and rolled stones, dead shells; very few live animals came up in dredge, mainly sponges; of 3 dredge hauls 1 came up clean with Alcyonarians. Aug. 17, 1888.

4. Between Ormans Reef and the "Brothers Island," 6–7 fathoms. Aug. 18, 1888.

5. Boydong Cays shore. Aug. 26, 1888. (N. Queensland.)

6. 2 miles west of Boydong Cays, 14 fathoms; coral-mud and dead shells. Aug. 27, 1888.

7. Cockburn group, shore of small islet near the south of the three high islands. Aug. 27, 1888. (N. Queensland.)

8. Albany Pass, 10 fathoms; large quantity of sponges. Aug. 29, 1888.

9. Prince of Wales Channel, 8 fathoms; clear rocky bottom and red seaweed. Sept. 15, 1888.

10. Channel between Hammond Isl. and Wednesday spit, 5 fathoms; sand and small rounded pebbles, dead shells. Sept. 15, 1888.

11. Fringing reef, Mabuiag.

12. Channels between reefs, Mabuiag.

13. Fringing reef, Mèr (Murray Island).

14. Channels between reefs, Mèr.

CATALOGUE OF THE SPECIES.

PTEROPODA.

CAVOLINIIDÆ.

1. CAVOLINIA LONGIROSTRIS, *Lesson*.
Station 5, Boydong Cays.

GASTEROPODA.

SIPHONARIIDÆ.

2. SIPHONARIA SIPHO, *Sow*.
Station 5, Boydong Cays; Station 13, Murray Island.

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* Where no precise locality is referred to, it must be understood that the labels attached to those species contained nothing more definite than "Torres Straits.'

ACTÆONIDÆ.

3. ACTÆON SOLIDULUS, *L.*
Station 5, Boydong Cays.

TORNATINIDÆ.

4. TORNATINA GRACILIS, *A. Ad.*
Station 14, Mèr.

SCAPHANDRIDÆ.

5. ATYS DEBILIS, *Pease.*
Station 2, Warrior Island; Station 5, Boydong Cays.

6. ATYS (ALICULA) CYLINDRICA, *Helbling.*
Station 13, Murray Island.

7. CYLICHNA ARACHIS, *Q. & G.*

BULLIDÆ.

8. BULLA ADAMSI, *Menke.*
Station 13, Mèr; Station 5, Boydong Cays.

9. BULLA PUNCTULATA, *A. Ad.*
A West-American species (Panama, &c.), also New Caledonia (*Hadfield*), and various Australian localities (*Cox*, *Angas*, &c.).

10. HAMINEA BREVIS, *Q. & G.*
Station 2, Warrior Island.

11. HAMINEA CROCATA, *Pease.*
Station 2, Warrior Island; Station 5, Boydong Cays.

APLUSTRIDÆ.

12. APLUSTRUM AMPLUSTRE, *L.*
Station 13, Murray Island.

TEREBRIDÆ.

13. TEREBRA (SUBULA) MUSCARIA, *Lam.*

14. TEREBRA (ABRETIA) AFFINIS, *Gray.*
Station 13, Mèr; Station 2, Warrior Island.

15. TEREBRA (MYURELLA) SUBULATA, *L.*
Station 13, Mèr.

CONIDÆ.

16. CONUS MARMOREUS, *L.*
Station 13, Mèr.

17. CONUS (CORONAXIS) MINIMUS, *L.*
Station 13, Mèr (Murray Island).

18. CONUS (NUBECULA) STRIATUS, *L.*

19. CONUS (DENDROCONUS) FIGULINUS, *L.*

20. CONUS (LITHOCONUS) LITTERATUS, *L.* var. MILLEPUNCTATUS, *Lam.*

21. CONUS (RHIZOCONOS) MUSTELINUS, *Hwass.*

22. CONUS (RHIZOCONUS) VITULINUS, *Hwass.*

23. CONUS (CHELYCONUS) RADIATUS, *Gmel.*

24. CONUS (TEXTILE) CANONICUS, *Hwass.*

25. CONUS (HERMES) NUSSATELLA, *L.*

26. DRILLIA TORRESIANA, *Smith.*
Station 8, Albany Pass.

27. MANGILIA (GLYPHOSTOMA) RUGOSA, *Migh.*
Station 13, Mèr.

28. MANGILIA (CYTHARA) GRACILIS, *Rve.*
Station 2, Warrior Island.

29. MANGILIA (CYTHARA) PULCHELLA, *Rve.*

30. MANGILIA (CYTHARA) CHIONEA *, sp. n. (Pl. **10**. fig. 4.)

M. testa ovato-fusiformi, delicatula, nivea, lævigata; anfractibus, inclusis duobus apicalibus lævibus, septem, oblique et fortiter costatis, costis nitidus perlævibus, interstitiis lævigatis, parum nitentibus; apertura oblonga, labro paullum effuso, lævi; columella obscure denticulata. Long. 8, lat. 3·50 mm.

Station 13, Mèr (Murray Island).

A white, fusiform, delicate and very smooth species, seven-whorled (inclusive of the two apical), the lower whorls being strongly obliquely ribbed, the ribs not crowded, the interstices smooth, but not shining; aperture oblong, outer lip slightly effuse, smooth; columella in fine examples minutely denticulate, but worn in most of the examples seen.

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* χίων, snow.

We also have this delicate *Mangilia* from Thursday Island, collected by Mr. Arnold Umfreville Henn, in fine condition.

OLIVIDÆ.

31. OLIVA (STREPHONA) EPISCOPALIS, *Lam.*

An albino form only; slightly deformed in the centre of the last whorl.

Station 5, Boydong Cays.

32. OLIVANCILLARIA (AGARONIA) NEBULOSA, *Lam.*

Station 13, Mèr.

MARGINELLIDÆ.

33. MARGINELLA (PERSICULA) OVULUM, *Sow.*

Station 13, Murray Island.

VOLUTIDÆ.

34. MELO DIADEMA, *Lam.*

35. VOLUTA (AULICA) RUCKERI, *Crosse.*

Perhaps too near *V. piperita*, Sow., to be more than a variety; but the red coloration is uniform in all examples we have inspected.

Station 2, Warrior Island.

36. VOLUTA (AULICA) RUTILA, *Brod.*

Station 2, Warrior Island.

37. VOLUTA (AULICA) SOPHIÆ, *Gray.*

With *V. nivosa*, L., and *V. Norrisi*, Gray, this constitutes a peculiar group—*V. Sophiæ* being quite constant in its markings of rows of transverse blackish-brown spots—extending in range only from the west coast of Australia to the Torres Straits.

Station 2, Warrior Island.

38. VOLUTA (SCAPHELLA) TURNERI, *Gray.*

Station 5, Boydong Cays.

MITRIDÆ.

39. MITRA EPISCOPALIS, *L.*

40. MITRA (CHRYSAME) PEREGRA, *Rve.*

41. MITRA (CHRYSAME) RUBRITINCTA, *Rve.*

Considered by some authors only a stunted variety of *M. ferruginea*, Lam., but in our opinion entitled to good specific rank.

Station 2, Warrior Island.

42. MITRA (STRIGATELLA) DECURTATA, *Rve.*

Station 4, between Ormans Reef and the Brothers Island.

43. MITRA (TURRICULA) CORRUGATA, *Lam.*

Station 13, Murray Island.

44. MITRA (VULPECULA) INTERMEDIA, *Kiener.*

Station 13, Murray Island.

45. MITRA (CASTELLARIA) MODESTA, *Rve.*

Station 2, Warrior Island.

46. MITRA (PUSIA) DICHROA, *Ad. & Rve.*

This species, with *M. tricolor*, Montr., *M. Græffei*, Cr., *M. lævizonata*, Sow., and others, is merged by Tryon in *Pusia luculenta*, Rve., but, we think, erroneously.

FASCIOLARIIDÆ.

47. FASCIOLARIA FILAMENTOSA, *Lam.*

48. LATIRUS POLYGONUS, *Gmel.*, var. TESSELLATUS, *Kobelt.*

Characteristic examples of a form only hitherto reported from Mauritius.

49. LATIRUS (PERISTERNIA) AUSTRALIENSIS, *Rve.*

Station 5, Boydong Cays.

TURBINELLIDÆ.

50. CYNODONTA CORNIGERA, *Lam.*

51. SEMIFUSUS (MEGALATRACTUS) PROBOSCIDIFERUS, *Lam.*

No full-grown specimens were in the collection, but a large operculum, and a mass of nidamental capsules, containing, roundly speaking, fully one hundred and twenty embryonal young. These are all, without exception, decollate, seven- to eight-whorled, averaging 30 mm. longitudinally. The canal is fairly long, the last whorl showing a little of the adult sculpture, and slightly tumid.

This species is classed by Fischer (Man. de Conch. p. 623) as the type of his subgenus *Megalatractus* (1884). It is confined to the shores of Australia.

BUCCINIDÆ.

52. CANTHARUS MOLLIS, *Gld.*

Fine individuals, which we have compared with and cannot separate from the Japanese type.

Station 8, Albany Pass.

53. ENGINA CONCINNA, *Rve.*

Station 2, Warrior Island.

54. ENGINA REEVEI, *Tryon.*

Hab. North America and Mexico, also Australia (*J. Brazier*).

Station 5, Boydong Cays.

55. PHOS SCALAROIDES, *A. Ad.*

Station 5, Boydong Cays.

56. NASSARIA SUTURALIS, *A. Ad.*

This well-marked form is sparingly distributed from the Arabian Sea eastward, being particularly frequent at Bombay (*Abercrombie*) and Karachi (*Townsend*).

Station 8, Albany Pass.

NASSIDÆ.

57. NASSA (ALECTRYON) SUTURALIS, *Lam.*

Station 8, Albany Pass.

58. NASSA (NIOTHA) ALBESCENS, *Dkr.*

Station 13, Murray Island.

59. NASSA (NIOTHA) CREMATA, *Hinds.*

Station 8, Albany Pass.

60. NASSA (ALECTRYON) FRETORUM *, sp. n. (Pl. **10**. fig. 3.)

N. testa breviter oblonga, spira acuminata, albo-cinerea, nitida; anfractibus octo, inclusis apicalibus tribus, lævibus, vitreis, cæteris regulariter longitudinaliter plano-costatis, costis nitidis, lævibus, apud suturas impressis, et infra, juxta suturas, transversim unisulcatis, et sparsim brunneo-maculatis, liris transversis aliter absentibus, ultimo anfractu infra medium

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* *Fretorum*, i. e. *Torresianorum*, inhabiting the Torres Straits.

usque ad basim transversim multiplicato; apertura ovata, labro extus paullum effuso, circa columellam nitide calloso, perlævi, intus striato, ad marginem denticulato, canali brevi. Long. 12, lat. 6 mm.

Station 2, Warrior Island.

We have in vain tried to match this small species. It is undoubtedly an *Alectryon*, its congeners being *N. monile*, Kien., and allies, although, from the description, *N.* (*Niotha*) *multicostata*, A. Ad., a species included in the section remarkable for the deep transverse sulcations, but which are obsolete in it, comes very near *N. fretorum*. Our species would seem to differ in the conspicuous spiral sulcation just below the sutures, in the broader contour in proportion to the length, and one or two minor details. We are especially indebted to Mr. Ernest R. Sykes for carefully comparing this *Nassa* with the incomparable series in the National Collection, South Kensington.

61. NASSA (NIOTHA) ROTUNDA, *Melv. & Stand.* (Journ. of Conch. vol. viii. p. 273, pl. ix. fig. 2, 1896.)

One of the few molluscs, lately described by us from Lifu, that has occurred in this collection. Its nearest ally is *N. plebecula*, Gld.

Station 2, Warrior Island.

62. NASSA (HIMA) PLEBECULA, *Gld.*

Station 5, Boydong Cays.

COLUMBELLIDÆ.

63. COLUMBELLA VARIANS, *Sow.*

Station 13, Mèr.

64. COLUMBELLA (PYGMÆA) FULGURANS, *Lam.*—*α. eufulgurans*; *β. punctata*, Lam.

A series embracing the type with zigzag lines on a black ground, merging into the condition in which the white streaks are broken up into rounded or triangular white spots, and evidently occurring together.

Station 2, Warrior Island; Station 13, Mèr (Murray Island); Station 5, Boydong Cays.

65. Columbella (Pygmæa) Tyleri, *Gray.*
Station 5, Albany Pass.

66. Columbella (Pygmæa) versicolor, *Sow.*
Station 12, Mabuiag, 4 fathoms (Oct. 1888).

67. Columbella (Atilia) galaxias, *Rve.*
Station 5, Boydong Cays.

68. Columbella (Mitrella) semiconvexa, *Lam.*
Station 5, Boydong Cays.

69. Columbella (Conoidea) flava, *Brug.*
Station 13, Murray Island; Station 8, Albany Pass.

Muricidæ.

70. Murex brevispina, *Lam.*
Station 13, Murray Island.

71. Murex (Chicoreus) adustus, *Lam.*
Station 13, Mèr.

Var. fuscus, *Dkr.*
Excepting in the reddish-brown colour of the varices, we cannot trace any specific distinction between this and the typical *M. adustus*, Lam.
Station 8, Albany Pass.

72. Murex (Chicoreus) axicornis, *Lam.*
Station 13, Mèr.

73. Murex (Chicoreus) capucinus, *Lam.*
The vague locality "Philippines," that has been given in our text-books for this species, has been considered unauthentic, as the west coast of South America (Chili) seems to be its headquarters. Its occurrence therefore in the Torres Straits is very interesting.

74. Murex (Pteronotus) saibaiensis, sp. n. (Pl. **10**. fig. 1.)
M. testa trigona, tenui, calcarea, albido-cinerea; anfractibus 5–6, apicali mamillari, vitreo, cæteris trivaricosis, varicibus foliatis, uni-angulatis, expansis, spiraliter liratulis, apud medium anfractûs ultimi simul ac penultimi, inter varices noduliferis; apertura ovata, peristomate foliaceo, delicate squamulato, canali producta, lata. Long. 18, lat. 13 mm.

Between Saibai I. and New Guinea, 10–17 fathoms (Station 3).

A delicate *Pteronotus* which, though apparently full-grown, may yet add two or three varices to its stature before attaining perfection, without in any way altering the characteristic contour of its whorls. It is impossible to match this form exactly with any described species, though its affinities lie with *triformis*, Reeve, *acanthopterus*, Lam., and *eurypteron*, Reeve. It is trigonous, light in texture, of a chalky consistency, cinereous white, five- or six-whorled, these each possessing three varices, and towards the centre of the penultimate whorl, as well as the lowest, nodulous squamæ are noticeable between each varix. The surface is spirally, finely but rather unevenly lirate, the varices being once-angled on the last whorl, immediately below the sutures. Aperture oval, outer lip beautifully fimbriate-squamose, canal prolonged and somewhat broad. Operculum not present.

75. MUREX (OCINEBRA) SALMONEUS*, sp. n. (Pl. **10**. fig. 2.)

M. testa parva, breviter fusiformi, carnea, purpurea vel pallide punicea, multum corrugata; anfractibus septem, arcte variciferis, varicibus pulchre fimbriatulis, costis fistulosis transversim connexis; apertura rotunda, labro extus paullum expanso, fimbriato, incrassato; canali brevi, recurva. Long. 12·50, lat. 6 mm.

This little *Ocinebra* is shortly fusiform, brightly coloured, either pale flesh-colour, pink, or purple, seven-whorled, many-variced, the varices beautifully fringed or squamose, crossed spirally by fistulose ribs; aperture round; canal short, slightly recurved; outer lip expanded, thickened, fringed.

76. MUREX (CHICOREUS) CERVICORNIS, *Lam.*

77. MUREX (CHICOREUS) RAMOSUS, *L.*
Station 13, Murray Island.

78. PURPURA ALVEOLATA, *Rve.*
Station 13, Murray Island.

79. PURPURA PERSICA, *L.*
Station 13, Murray Island.

80. PURPURA (THALESSA) HIPPOCASTANUM, *Lam.*
Station 2, Warrior Island.

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* *Salmoneus*, from the prevailing carneous hue.

81. PURPURA (STRAMONITA) RUSTICA, *Lam.*
Station 13, Murray Island.

82. PURPURA (CRONIA) AMYGDALA, *Kiener.*
Station 13, Murray Island; Station 8, Albany Pass.

83. SISTRUM ARACHNOIDES, *Lam.*
Station 2, Warrior Island.

84. SISTRUM CAVERNOSUM, *Rve.*
Station 13, Mèr; Station 5, Boydong Cays.

85. SISTRUM CHRYSOSTOMUM, *Desh.*
Station 2, Warrior Island.

86. SISTRUM CONCATENATUM, *Lam.*
Station 13, Murray Island.

87. SISTRUM ELATUM, *Blainv.*
Station 5, Boydong Cays.

88. SISTRUM FISCELLUM, *Chemn.*
Station 5, Boydong Cays.

89. SISTRUM HEPTAGONALE, *Rve.*
Station 5, Boydong Cays.

90. SISTRUM MARGARITICOLUM, *Brod.*
Originally described by Broderip as a *Murex* from Lord Hood's Island, this has been found, in its typical form, generally distributed throughout the eastern tropical area, occurring as far north as the coasts of Baluchistan (*Townsend*).

91. SISTRUM OCHROSTOMA, *Blainv.*
Station 2, Warrior Island.

TRITONIDÆ.

92. AQUILLUS (SIMPULUM) GEMMATUS, *Rve.*
Station 13, Murray Island.

93. AQUILLUS (SIMPULUM) PILEARIS, *L.*

94. EPIDROMUS ANTIQUATUS, *Hinds.*

95. EPIDROMUS BEDNALLI, *Brazier.*
Varying in size, but not in sculpture, our largest specimen being long. 11, lat. 5 mm.

96. GYRINEUM (LAMPAS) RANELLOIDES, *Rve.*
Station 13, Murray Island.

97. GYRINEUM (EUPLEURA) JUCUNDUM, *A. Ad.*

In almost every particular, save that of size, this is the exact counterpart of the well-known *Eupleura perca* (Perry), *pulchra* (Gray).

Station 13, Murray Island.

98. GYRINEUM (APOLLON) PUSILLUM, *Brod.*

Mostly of the white variety with violaceous aperture, the largest example of all being uniformly whitish-ochreous.

Station 13, Murray Island.

CASSIDIDÆ.

99. CASSIS (CASMARIA) VIBEX, *L.*

100. CASSIS (SEMICASSIS) TORQUATA, *Rve.*

DOLIIDÆ.

101. DOLIUM PERDIX, *L.*

102. DOLIUM VARIEGATUM, *Lam.*

103. DOLIUM (MALEA) POMUM, *L.*

Station 5, Boydong Cays.

CYPRÆIDÆ.

104. OVULA (RADIUS) ANGASI, *A. Ad.*

Station 11, Mabuiag.

105. CYPRÆA FELINA, *Gray.*

Station 5, Boydong Cays.

106. CYPRÆA (ARICIA) ANNULUS, *L.*

107. CYPRÆA (ARICIA) ARABICA, *L.*

108. CYPRÆA (LUPONIA) ERRONES, *L.*

Some of the nidamental capsules are also present, consisting of coagulated masses of one hundred or more pellucid oval eggs.

Station 9, Prince of Wales Channel.

109. CYPRÆA (LUPONIA) FLAVEOLA, *L.*

Station 13, Murray Island.

110. CYPRÆA (LUPONIA) LYNX, *L.*

111. CYPRÆA (LUPONIA) ZICZAC, *L.*

Station 13, Murray Island; Station 2, Warrior Island.

112. TRIVIA ORYZA, *Lam.*
Station 13, Murray Island.

113. TRIVIA STAPHYLÆA, *L.*
Station 13, Murray Island.

STROMBIDÆ.

114. STROMBUS (GALLINULA) CAMPBELLI, *Gray.*
Station 10, Channel between Hammond Island and Wednesday Spit.

115. STROMBUS (GALLINULA) CANARIUM, *L.*
Station 13, Murray Island.

116. STROMBUS (GALLINULA) ISABELLA, *Lam.*
In our opinion a mere variety of *S. canarium*, L., but some authors place specific reliance on the thinner substance and absence of freckled marking. The distribution of the two species is the same.
Station 13, Murray Island.

117. STROMBUS (GALLINULA) SIBBALDI, *Sow.*
Hitherto considered endemic in Ceylon, a remarkable extension of range is now presented.
Station 2, Warrior Island.

118. STROMBUS (GALLINULA) URCEUS, *L.*
Station 13, Murray Island.

119. STROMBUS (GALLINULA) VARIABILIS, *Swains.*

120. STROMBUS (GALLINULA) VITTATUS, *L.*
Young, but finely coloured, being tesselated with brown. There is also in the collection, from Mèr, a very remarkable but juvenile form, slightly variced, white, fusiform, and closely striate throughout.
Station 4, between Ormans Reef and the Brothers Island; Station 13, Mèr; Station 5, Boydong Cays.

121. STROMBUS (CANARIUM) DENTATUS, *L.*
Only, we think, a sub-species of *S. urceus*, L., but at all events it is the prevailing form.
Station 13, Mèr (Murray Island).

122. STROMBUS (MONODACTYLUS) LAMARCKI, *Gray.*

123. STROMBUS (MONODACTYLUS) MELANOSTOMUS, *Swains.*

124. STROMBUS (CONOMUREX) LUHUANUS, *L.*
Station 13, Murray Island.

125. PTEROCERA (HEPTADACTYLUS) LAMBIS, *L.*
Station 13, Mèr (Murray Island).

126. SERAPHS TEREBELLUM, *L.*
Station 13, Mèr.

CERITHIIDÆ.

127. TRIFORIS GIGAS, *Hinds.*
The largest example measures 42 mm. in length.
Station 13, Mèr.

128. TRIFORIS (INO) EXCELSIOR, sp. n. (Pl. 10. fig. 5.)

T. testa producta, multum attenuata, angusta, brunnea, hic illic rufo-maculata; anfractibus quinque- vel sex-et-viginti, tornatis, apud suturas elevatis, transversim arcte tricarinatis, lævibus; carina infra, juxta suturas, minore, duabus alteris magis conspicuis, interstitiâ interveniente planata, ultimo anfractu quadricarinato, carina bina ad peripheriam addita; apertura rotunda, parva, canali breviter recurvirostri, in uno specimine pone aperturam ipsam clausa. Long. 30, lat. 5 (sp. maj.) mm.

Four or five, mostly imperfect, examples. The form is much acuminate and attenuate, narrow; colour light brown, here and there indistinctly flecked with rufous spotting; whorls 25 or 26, tornate, smooth, elevated at the sutures, closely thrice-keeled transversely, the keel just below the sutures is smaller and less conspicuous than the two lower, the last whorl is four-keeled, there being two on the periphery; the aperture is roundish, small; in one (the most perfect) specimen the recurved and beaked canal is closed with shelly matter behind the aperture.

The only species to which, in size, this very conspicuous *Triforis* could be referred is *T. gigas*, Hinds, also occurring in the same localities. The sculpture, as seen by the above description, is however totally different, being smooth, with no interstitial pitting or gemmuled ribs of any kind. Owing to no one specimen being in a state of absolute perfection, we have been compelled to estimate the number of whorls and the dimensions generally with the aid of two or more examples, each complete in some one particular.

129. Cerithium citrinum, *Sow.*
Station 4, between Ormans Reef and the Brothers Island.

130. Cerithium echinatum, *Lam.*
Station 5, Boydong Cays.

131. Cerithium morus, *Lam.*
Very abundant. A reddish variety also occurs at the Mèr Station.

Station 2, Warrior Island; Station 13, Mèr; Murray Island; Station 4, between Ormans Reef and the Brothers Island.

132. Cerithium novæ-hiberniæ, *A. Ad.*
Station 13, Mèr.

133. Cerithium petrosum, *Wood.*
The name "*tuberculatum*," having been twice used by Linnæus, must be abandoned in favour of that of Wood.

Station 2, Warrior Island; Station 4, between Ormans Reef and the Brothers Island.

134. Cerithium piperitum, *Sow.*
Station 13, Murray Island.

135. Cerithium salebrosum, *Sow.*
Only broken individuals occurred, referred with some little doubt as above. The finest examples we have seen of *C. salebrosum* come from Lifu (*Hadfield*). It is rare, and found generally, though sparingly, in the Philippines, with south-eastward extension of range.

Station 5, Boydong Cays.

136. Cerithium variegatum, *Quoy.*
This, as identified by Mr. E. A. Smith (Voy. of H.M.S. 'Alert,' 1881–2, p. 64), is a variety of the protean *C. morus*, L., from which it differs in its more attenuate fusiform shape, and the colour-banding, with a smaller series of apical tubercles.

137. Cerithium zebrum, *Kiener.*

138. Cerithium (Vertagus) aluco, *L.*
Station 5, Boydong Cays.

139. Cerithium (Vertagus) lineatum, *Lam.*
We do not agree with Tryon (Man. Conch. ix. p. 148) that this is a variety of *C. asper*, Lam. The shell is uniformly

coarser, besides being, in proportion to its length, larger in all its parts, and often spirally banded.

140. CERITHIUM (VERTAGUS) PULCHRUM, *A. Ad.*
Station 2, Warrior Island.

141. CERITHIUM (VERTAGUS) SOWERBYI, *Kiener.*
Station 5, Boydong Cays.

142. CERITHIUM (VERTAGUS) VERTAGUS, *L.*
Station 5, Boydong Cays.

143. CERITHIUM (LAMPANIA) ZONALE, *Brug.*
Station 5, Boydong Cays.

144. CERITHIUM (COLINA) CONTRACTUM, *Sow.*

We consider this distinct from the type of *Colina*, *C. pinguis*, Ad., being attenuate, contracted, nine- or ten-whorled, the three last whorls almost straight and of uniform thickness. The species are now being frequently found in the North Indian Ocean, and in other places, *C. pinguis* having been formerly considered peculiar to South Africa.

Station 13, Mèr.

145. CERITHIUM (COLINA) TÆNIATUM, *Sow.*
Station 13, Murray Island.

146. BITTIUM TORRESIENSE, sp. n. (Pl. **10**. fig. 6.)

B. testa parva, elongato-cylindracea, pallide ochracea vel fulva et albo-maculata; anfractibus undecim, apicalibus inclusis tribus, albidis (vel, in altero specimine, fulvis), uniformibus, perparvis, lævibus, tribus his proximis pulchre gradatis, cæteris apud suturas impressis, longitudinaliter recte gemmato-costulatis, quinque ordinibus spiraliter dispositis, in specimine typico gemmis vel tuberculis hic ochraceis, illic albidis, ultimo anfractu ad basim liris quinque concentrice prædito, apertura ovata, canali brevissimo, peristomate tenui. Long. 5, lat. 2 mm.

Station 14, channels between reefs, Mèr.

We have given much attention to the deep-sea forms of *Bittium*, especially those described in the Reports of H.M.S. 'Challenger' from N.E. Australia and the Torres Straits. The only one which could challenge comparison with the shells before us is *B. xanthum* [*], Watson, but in the following

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[*] *Cf.* Voyage H.M.S. 'Challenger,' Gastropoda, vol. xv., Zoology, p. 537.

particulars *B. torresiense* seems to differ:—first, the texture is more delicate in Watson's species; secondly, the tuberculated gemmæ, forming longitudinal ribs, are closer, and the interstices simple, with no intervening liræ whatsoever. The whorls are eleven in our species, as against eight, and the apical whorls are similar, both in number and form, but the painting is different, being flecked in one type with white. The dimensions are similar.

Three examples.

147. POTAMIDES (TYMPANOTONUS) PALUSTRIS, *L.*

148. POTAMIDES (TYMPANOTONUS) RETIFERUS, *Sow.*
Station 1, Thursday Island.

149. POTAMIDES (TEREBRALIA) SULCATUS, *Born.*
Station 13, Mèr.

MODULIDÆ.

150. MODULUS OBTUSALIS, *Phil.*

PLANAXIDÆ.

151. PLANAXIS SULCATUS, *Born.*

"In interstices of coral shore-rock, the smaller being from extreme high water-line, the larger a very little lower down" (*A. C. H.*).

Station 5, Boydong Cays.

152. PLANAXIS (QUOYIA) DECOLLATUS, *Quoy.*
All of a dwarf form.

TRICHOTROPIDIDÆ.

153. SEPARATISTA BLAINVILLEANA, *Petit.*

A very large and perfect example, the dimensions of which are: long. 11, diam. 17 mm., thus much exceeding that of the others recorded. It is a rare inhabitant of the Pacific islands, and has not before been known to occur in the region embraced by our paper.

Flinders' Entrance, near Mèr, 20 fathoms, Dec. 21st, 1888.

VERMETIDÆ.

154. VERMETUS (SIPHONIUM) MAXIMUS, *Sow.*
Station 12, Mabuiag.

155. VERMETUS (BIVONIA) QUOYI, *H. & A. Ad.*
Three varieties—cinereous, pale purple, and flesh-coloured.
Station 13, Mèr.

156. VERMETUS (THYLACODES) NOVÆ-HOLLANDIÆ, *Rouss.*
An obliquely concentrically rugose shell, attached to branches of madrepore. Endemic, so far as Australian shores are concerned.
Station 13, Mèr.

157. SILIQUARIA CUMINGII, *Mörch.*
Station 5, Boydong Cays.

158. SILIQUARIA PONDEROSA, *Mörch.*
A fine series, showing much variation in torsion.
Station 4, between Ormans Reef and the Brothers Island; Station 1, Thursday Island; Station 13, Mèr.

TURRITELLIDÆ.

159. TURRITELLA MULTILIRATA, *Ad. & Rve.*
Station 5, Boydong Cays.

160. MATHILDA EURYTIMA, *Melv. & Stand.*
(Journ. of Conch. vol. viii. 1896, p. 310, pl. xi. fig. 73.)
Precisely agrees, in sculpture and detail, with our Loyalty Island type.

LITTORINIDÆ.

161. LITTORINA FILOSA, *Sow.*
Station 13, Murray Island.

162. LITTORINA (MELARAPHE) MAURITIANA, *Lam.*
Station 5, Boydong Cays.

163. TECTARIUS MALACCANUS, *Phil.*
Station 5, Boydong Cays.

LITIOPIDÆ.

164. DIALA ALBUGO, *Wats.*
Station 5, Boydong Cays.

165. ALABA PYRRHACME, *Melv. & Stand.*
(Journ. of Conch. vol. viii. 1896, p. 310, pl. ix. fig. 70, as *Rissoa.*)

Agreeing with the Loyalty Island types (*Hadfield*), and also with examples from Thursday Island (*A. U. Henn*).

Station 5, Boydong Cays *.

RISSOIDÆ.

166. RISSOINA SCOLOPAX, *Souvb.*

Identical with Loyalty Island examples (*Hadfield Coll.*).

Station 5, Boydong Cays.

167. RISSOINA THAUMASIA, *Melv. & Stand.* (Journ. of Conch. vol. ix. 1898, p. 31, pl. i. fig. 3.)

This agrees exactly with the Madras type (*J. R. Henderson* and *E. Thurston*, in Mus. Brit.).

168. RISSOINA TRIANGULARIS, *Wats.*

We have this from Thursday Island (*A. U. Henn*).

Station 5, Boydong Cays.

169. RISSOINA (PHOSINELLA) CLATHRATA, *A. Ad.*

Station 5, Boydong Cays.

170. RISSOINA (MOERCHIELLA) SPIRATA, *Sow.*

Two varieties, one of which approaches var. *deformis*, Sow., the other var. *artensis*, Montr., a New Caledonian form.

Station 2, Warrior Island; Station 13, Mèr.

CAPULIDÆ.

171. CALYPTRÆA TORTILIS, *Rve.* (=*C. equestris*, L., var. ?).

Station 5, Boydong Cays.

VANIKORIDÆ.

172. VANIKORO CANCELLATA, *Lam.*

A smooth variety, exhibiting hardly any dorsal cancellation. It is the type of the genus, named after the Island Vanikoro in the Pacific Ocean. The name, though barbarous, should, in our opinion, be retained, as the genus was definitely described by Quoy and Gaimard in 1832, thus having precedence over *Merria*, Gray, 1839; and a yet longer period over *Leucotis*, Swainson, 1840, and *Narica*, Récluz, 1841.

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* Mr. C. Hedley, in his Mollusca of Funafuti (Mem. Austral. Mus. iii. p. 43, 1899), makes our *A. pyrrhacme* the type of his new genus *Obtortio*.

NATICIDÆ.

173. NATICA AREOLATA, *Récluz.*
Station 5, Boydong Cays.

174. NATICA GAULTIERIANA, *Petit.*
Station 5, Boydong Cays.

175. NATICA (NEVERITA) BICOLOR, *Phil.*

176. NATICA (MAMMA) AURANTIA, *Lam.*
Station 6, Mèr.

177. NATICA (MAMMA) FLEMINGIANA, *Récluz.*
Station 5, Murray Island; Station 6, Mèr; Station 5, Boydong Cays.

IANTHINIDÆ.

178. IANTHINA SMITHIÆ, *Rve.*
An Australian form hardly differing from the common *I. fragilis*, L.
Station 5, Boydong Cays.

SCALARIIDÆ.

179. SCALARIA LYRA, *Sow.*
Station 5, Boydong Cays.

180. SCALARIA OBLIQUA, *Sow.*
Station 5, Boydong Cays.

181. SCALARIA SUBAURICULATA, *Souvb.*
Station 5, Boydong Cays.

182. EGLISIA TRICARINATA, *Ad. & Rve.*, Voy. 'Samarang,' p. 49.
The single example is very imperfect, but possesses two anfractual carinæ only, on the upper whorls. *Turritella leptomita*, Melv. & Sykes (Proc. Mal. Soc. ii. p. 176, pl. xiii. figs. 12, 12 *a*), represents a very nearly allied species from the Andamans, the whorls possessing three to four keels on the upper, four at least on the lowest whorl. So rarely found are these nearly allied *Eglisiæ* that the anatomy is practically unknown, but the operculum being scalaroid they have on this account been transferred from the Turritellidæ to the Scalariidæ.
Station 5, Boydong Cays.

183. SCALIOLA ELATA, *Semper.*
Station 5, Boydong Cays.

EULIMIDÆ.

184. EULIMA AUSTRALASIACA, sp. n. (Pl. **10**. fig. 7.)

E. testa fusiformi, politissima, crassiuscula, paullum incurva; anfractibus 10–11, condensatis, lacteis, apud suturas paullulum impressis, ultimo anfractu crasso, varicibus obsoletis; apertura ovata, peristomate præsertim apud basim, incrassato, lævissimo. Long. 7, lat. 3 mm.

A very shining, polished, milky-white, opaque *Eulima*, fusiform, slightly incurved, ten- or eleven-whorled, apex small; whorls very slightly impressed at the sutures, the last whorl thickened, especially towards the base; aperture oval; peristome thick, exceedingly smooth.

This species slightly resembles *E. latipes*, Watson, collected at Flinders' Passage, Torres Straits, in 7 fathoms, during the 'Challenger' Expedition, but is much larger in every part, and the spire does not so rapidly contract. The aperture, too, is large proportionately. The lateral varices are quite inconspicuous or obsolete.

185. EULIMA (LEIOSTRACA) ACICULA, *Gould.*
Station 14, Mèr.

PYRAMIDELLIDÆ.

186. OBELISCUS TEREBELLOIDES, *A. Ad.*

Possibly a variety, but, if so, a very remarkable one, of *O. dolabrata*, L., being much narrower in proportion, more numerous in the whorls, with the columellar plicæ but two in number.

Station 5, Boydong Cays.

187. CINGULINA SPINA, *Cr. & Fischer.*
Station 5, Boydong Cays.

NERITIDÆ.

188. NERITA POLITA, *L.*; and var. AURORA, *Dkr.*
Station 13, Murray Island; Station 5, Boydong Cays.

189. Nerita signata, *Macleay*.

Station 5, Boydong Cays.

190. Nerita undata, *L.*

Station 4, Ormans Reef; Station 13, Murray Island; Station 5, Boydong Cays.

191. Nerita (Thelicostyla) albicilla, *L.*

192. Nerita (Peleronta) funiculata, *Rve.*

193. Nerita (Peleronta) plicata, *L.*

Station 13, Mèr (Murray Island).

Magadis *, genus novum.

Testa imperforata, depressa, orbicularis, albo-calcarea, longitudinaliter arcte lamellata, lamellis irregularibus; anfractus 3, quorum apicalis obtusus, globularis, interstitiæ inter lamellas arcte et pulcherrime sub lente spiraliter striatæ; apertura lunaris; peristoma rotundum, fere continuum; labri intus margo columellaris latus, planatus, dentibus minutissimis præditus, extus crassiusculus, planatus, lævis. Operculum . . . . . ?

194. Magadis eumerintha †, sp. n. (Pl. **10**. figs. 8, 8 *a*.)

M. testa ut suprà. Alt 2·25, diam. 4·50 mm.

Station 14, Mèr, channels between reefs.

A truly remarkable mollusc, and one for the reception of which it is imperative to create a new genus. It is undoubtedly a neritoid, but the close longitudinal lamellæ suggest affinity with *Vanikoro*, Quoy, e. g. *V. Gueriniana*, Récluz.

It is unlike any shell known, either recent or fossil, being small, depressed, orbicular, imperforate, of a chalky yellowish-white consistency, longitudinally closely lamellate, three-whorled (inclusive of the obtuse and globular apical whorl); the interstices between the lamellæ are everywhere closely and very beautifully striate; aperture lunar and wholly neritoid; columellar area straight, wide, and furnished with numerous very fine and minute teeth; peristome almost continuous; outer lip lunar, smooth, somewhat thickened. We have not seen the operculum.

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* *μαγάδις*, a harp.

† *Eumerintha*, *εὖ μήρινς*, well furnished with strings or lamellæ.

TURBINIDÆ.

195. PHASIANELLA (ORTHOMESUS) NIVOSA, *Rve.*
Station 8, Albany Pass; Station 5, Boydong Cays.

196. TURBO MARMORATUS, *L.*
Station 13, Murray Island.

197. TURBO PETHOLATUS, *L.*
Station 13, Mèr.

198. TURBO (SENECTUS) ARGYROSTOMUS, *L.*
Station 2, Warrior Island; Station 13, Mèr.

199. TURBO (SENECTUS) CHRYSOSTOMUS, *L.*
Station 2, Warrior Island; Station 13, Mèr.

200. TURBO (SENECTUS) FOLIACEUS, *Phil.*

201. TURBO (SENECTUS) SPARVERIUS, *Gmel.*

202. ASTRALIUM PETROSUM, *Mart.*
Station 2, Warrior Island; Station 13, Mèr (Murray Island).

TROCHIDÆ.

203. TROCHUS (TECTUS) FENESTRATUS, *Gmel.*

204. TROCHUS (LAMPROSTOMA) MACULATUS, *L.*

205. CLANCULUS ATROPURPUREUS, *Gld.*
Station 10, Channel between Hammond Island and Wednesday Spit.

206. CLANCULUS UNEDO, *A. Ad.*
Station 13, Mèr.

207. CANTHARIDUS TORRESI, *E. A. Smith.*
Station 13, Mèr.

208. MONODONTA CANALIFERUS, *Lam.*
Station 13, Mèr.

209. CHRYSOSTOMA PARADOXUM, *Born.*
Station 13, Murray Island; Station 5, Boydong Cays.

210. UMBONIUM VESTIARIUM, *L.*
Station 13, Mèr; Station 5, Boydong Cays.

211. MINOLIA GLAPHYRELLA, *Melv. & Stand.* (Jour. of Conch. vol. viii. 1895, p. 125, pl. iii. fig. 18.)

Agreeing with the type from Lifu (*Hadfield Coll.*). The peculiar style of apical liration, and the presence of a distinct peripherial angle, together with the difference in coloration—*glaphyrella* being almost invariably straw-coloured and blotched below the suture with equidistant brown spots—distinguish this from *M. pudibunda*, Fischer.

Station 5, Boydong Cays.

212. MINOLIA PUDIBUNDA, *Fischer.*

Station 5, Boydong Cays.

213. MINOLIA VITILIGINEA, *Mke.*

Station 14, Mèr.

214. CALLIOSTOMA (EUTROCHUS) SEPTENARIUM*, sp. n. (Pl. 10. fig. 9.)

C. testa conica, profunde sed anguste umbilicata, solida; anfractibus septem, duobus apicalibus applanatis, vitreis, cæteris arctissime et pulchre transversim septem-costulatis, costis gemmuliferis, interstitiis obliqui-striatis, ultimo anfractu apud peripheriam acutangulo, ad basim novem lirarum concentricis ordinibus prædito, circa umbilicum ipsum paullum calloso; apertura quadratula, labro crassiusculo, marginem apud columellarem unidentato, apud umbilicum parum reflexo. Alt. 10·50, diam. 9 mm.

Station 8, Albany Pass, 10 fathoms, Aug. 29, 1888.

A pyramidally conical shell, deeply but narrowly umbilicate, solid; whorls seven, all, with the exception of the two apical which are smooth and glossy, being closely spirally seven-ribbed, these ribs thickly and regularly formed of gemmæ, contiguous and crowded, the interstices between these beaded riblets are indistinctly obliquely striated; the last whorl is sharply angled at the periphery, and at the base there are eight or nine concentric rows of the same kind of beaded ribs as under the whorls, the interstices very similarly obliquely striate; the aperture square, outer lip slightly thickened, whilst at the columellar

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* *Septenarius*, "consisting of seven," in allusion to the spiral beaded riblets, uniformly seven in each whorl.

margin a small central tooth is observable. A resemblance, but merely superficial, may be traced to *C. fragum*, Phil.

215. Calliostoma speciosum, *A. Ad.*

216. Euchelus angulatus, *Pease.*

217. Euchelus atratus, *Gmel.*
Station 13, Mèr; Station 2, Warrior Island.

Delphinulidæ.

218. Delphinula formosa, *Rve.*
Station 13, Mèr.

219. Liotia varicosa, *Rve.*
Station 1, Thursday Island.

Cyclostrematidæ.

220. Microtheca Acidalia, sp. n. (Pl. **10**. figs. 10, 10 *a*.)

M. testa candida, depresso-globosa, sculpturata, profunde umbilicata; anfractibus quatuor, quorum apicali simplici, nitido, cæteris transversim pulcherrime carinatis, antepenultimo tribus, penultimo, cum ultimo, quatuor carinis præditis, arcte noduloso-gemmatis, gemmis nitidissimis, interstitiis transversim arcte liratis, ultimis anfractu effuso; regionem circa umbilicarem incrassato, nitido, plus minus crenulato, fere lævi; apertura rotunda, peristomate crassiusculo, continuo; operculo . . . . ? Alt. 3·50, lat. 5 mm.

Though small, one of the most exquisite shells yet discovered. It is pure white, depressedly globular, four-whorled, inclusive of the small and shining apical whorl, the remaining three being in the uppermost or antepenultimate whorl thrice transversely or spirally keeled, in the two lower whorls four times; these keels or spiral ribs are closely studded with, or indeed composed of, white shining gemmæ which are round, crowded, and brilliant; the rest of the shell is finely and delicately spirally lirate or sculptured. Aperture round, white within; peristome thin, continuous. The basal portion of the surface is thickened round the umbilical region and more or less crenulate.

M. crenellifera, Ad., the type of the genus, which we have received from Bombay (*Abercrombie*), though originally reported from Japan only, has the base and thickened crenulate umbilica ornamentation very similar, but differs in form, being more elongate and quite smooth and plain to the apex. Pilsbry* queries *Microtheca* as a probable subgenus of *Teinostoma*, Ad., but our strong opinion is that it should be separated generically. In *Teinostoma* the callosity entirely covers the umbilicus. We should, indeed, consider *Microtheca* nearer *Cyclostrema*, Marryat.

The type, *M. crenellifera*, to which allusion has just been made, was originally described by Adams as a species of *Isanda*, Ad., with which it possesses a certain amount of conchological affinity; but until the anatomy of these minute molluscs be more diligently studied, the compilation of special monographs is useless, and no arrangement can be other than purely tentative.

The species before us is, however, much nearer *M. crenellifera*, Ad., than *Isanda coronata*, Ad., which last we have received from the Papuan region, though it does not occur in Dr. Haddon's present collection. We have also obtained it from shell-sand collected a few years ago by Mr. Arnold Umfreville Henn, at Magnetic Island, Queensland, where it is very abundant.

Microtheca crenellifera occurring, as just pointed out, both in Japan and Bombay, will no doubt be found in intermediate stations, but it has hitherto occurred almost singly, and is very scarce in European collections. It is five-whorled, globose, white, shining, smooth save for one spiral costulate crenulation below the sutures, which are much impressed, and for the crenate callosity round the umbilicus, which has its counterpart in *M. Acidalia*.

Of this new species two examples, quite perfect and precisely similar, occurred, which we think worthy of one of the epithets formerly bestowed on Aphrodite.

STOMATIIDÆ.

221. STOMATELLA MARIEI, *Cr.*
Station 13, Mèr; Station 5, Boydong Cays.

222. STOMATELLA SULCIFERA, *Lam.*
Station 13, Mèr.

223. GENA STRIATULA, *A. Ad.*
Station 2, Warrior Island; Station 8, Albany Pass.

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* Tryon, Man. Conch. x. pp. 16, 106.

HALIOTIDÆ.

224. HALIOTIS VARIA, *L.*
Station 13, Mèr (Murray Island).

225. HALIOTIS (PADOLLUS) OVINA, *Chemn.*
Station 13, Mèr.

226. HALIOTIS (TEINOTIS) ASININA, *L.*
Station 5, Boydong Cays.

FISSURELLIDÆ.

227. FISSURELLA (GLYPHIS) CORBICULA, *Sow.* ?

Not quite normal, as the perforation is more rotund than in either typical *F. corbicula* or *F. lanceolata*, Sow. The solitary example was so covered with extraneous growths and somewhat broken, that we cannot with absolute certainty pronounce upon it.

Station 8, Albany Pass.

228. FISSURELLA (GLYPHIS) JUKESI, *Rve.*
Station 2, Warrior Island.

229. SCUTUS UNGUIS, *L.*
Station 10, Channel between Hammond Island and Wednesday Spit.

230. RIMULA EXQUISITA, *A. Ad.*
Station 10, Channel between Hammond Island and Wednesday Spit.

231. PHENACOLEPAS LINGUA-VIVERRÆ *, sp. n. (Pl. **10**. fig. **11**.)

S. testa ovata, candida, parum nitida, subpellucida, rotunde antice convexa, apice incurvo, acuminato, marginem posticum superimpendente, undique longitudinaliter arcte radiatim costulata, costulis arctissime et minute papilliferis, intus albida, margine parum incrassato. Alt. 5, lat. 11, diam. 8 mm.

Two specimens, precisely alike, of a beautiful, thickly longitudinally radiate shell, the radiations being closely studded with white papillæ; the form is ovate, apex incurved, much overhanging the posterior margin, front side elevated and convex; surface of the interior white, the margin hardly thickened.

Phenacolepas, Pilsbry 1891, must take the place of *Scutellina*, Gray 1847, non Agassiz 1841 (*Echinodermata*).

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* *Lingua-viverræ*, civet-cat's tongue, from the small papillæ.

POLYPLACOPHORA.

CHITONIDÆ.

232. CHITON PICTUS, *Rve.*

We are indebted to Mr. E. R. Sykes for the following and other notes on the Polyplacophora of the collection:—"Having examined Reeve's types, I am unable to separate his species from that of Gould, originally described from Fiji. Two sets of figures in the Moll. U.S. Explor. Exped. bear the number 434: the present species is represented by the right-hand set; the others being apparently a slip for 431. The slits in the largest specimen are: head-valve 8, tail-valve 12" (*E. R. S.*). This species was also found very sparingly by Mr. Brazier during the 'Chevert' expedition, at Darnley Island. Endemic in the Torres Straits.

Station 13, Mèr.

233. ISCHNOCHITON (HAPLOPLAX) sp.

One very young specimen of a species of *Haploplax*; when alive it measured about 4 to 5 mm. "It is closely allied to *I.* (*Haploplax*) *purus*, Sykes; but the girdle-scales are large and striate. Too young to describe" (*E. R. S.*).

Station 10, Channel between Hammond Island and Wednesday Spit.

234. TONICIA FORTILIRATA, *Rve.* ?

"One immature specimen, which may belong to this species; it does not show the granulose lateral areas, but this may be due to its youth" (*E. R. S.*).

The localities given for *T. fortilirata* by Mr. Edgar Smith (Voy. 'Alert,' 1881–82, p. 84) are Port Darwin, 8–10 fathoms (*Coppinger*); and Raine's Island (*Reeve*). Endemic.

Station 14, Channel between Mèr and Davar.

235. TONICIA CONFOSSA, *Gould.*

Station 13, Mèr.

236. ACANTHOPLEURA SPINIGERA, *Sow.*

Station 13, Mèr.

237. ACANTHOCHITON. Two species.

(i.) "One, immature, striate at the beaks and granulose on the lateral areas" (*E. R. S.*).

Station 13, Mèr, on reef.

(ii.) "Two young specimens of an interesting form, chiefly noteworthy for the sculpture, which consists of radiating riblets from the beaks of the valves" (*E. R. S.*).

Station 10, Channel between Hammond Island and Wednesday Spit.

238. SCHIZOCHITON INCISUS, *Sow.*
Station 13, Mèr.

239. CRYPTOPLAX STRIATUS, *Lam.*
Station 13, Mèr.

240. CRYPTOPLAX OCULATUS, *Q. & G.*
In many stages of growth, some being unusually fine.
Station 13, Mèr.

SCAPHOPODA.

DENTALIIDÆ.

241. DENTALIUM PSEUDO-SEXAGONUM, *Desh.*
Station 1, Thursday Island.

242. DENTALIUM JAVANUM, *Sow.*
Station 8, Albany Pass.

PELECYPODA.

OSTREIDÆ.

243. OSTREA TUBERCULARIS, *Lam.*
Station 8, Albany Pass.

ANOMIIDÆ.

244. PLACUNANOMIA (MONIA) IONE, *Gray.*
Station 13, Mèr.

245. PLACUNA LOBATA, *Sow.*
Station 2, 20 miles N.N.W. Warrior Island, 5¾ fathoms, Aug. 15, 1888 (*A. C. H.*).

SPONDYLIDÆ.

246. PLICATULA AUSTRALIS, *Lam.*
Station 13, Mèr.

247. PLICATULA IMBRICATA, *Mke.*
Station 5, Boydong Cays.

248. SPONDYLUS BARBATUS, *Rve.*
Station 13, Mèr.

249. SPONDYLUS FOLIACEUS, *Chemn.*

250. SPONDYLUS NICOBARICUS, *Chemn.*

251. SPONDYLUS OCELLATUS, *Rve.*

252. SPONDYLUS PACIFICUS, *Rve.*

LIMIDÆ.

253. LIMA SQUAMOSA, *Lam.*

The Torres Straits form is indistinguishable from that occurring in the Mediterranean. We have traced it across the Isthmus of Suez to Red Sea waters, then along the coasts of India and Ceylon, eastward, uninterruptedly.

Station 13, Murray Island; Station 14, Mèr, channel between reefs; Station 2, Warrior Island.

254. LIMA (LIMATULA) BULLATA, *Born.*
Station 5, Boydong Cays.

255. LIMA (LIMATULA) TORRESIANA, *E. A. Smith.* ('Challenger' Rep. vol. xiii. p. 291, pl. xxiv. figs. 5, 5 *a.*) (Pl. **11.** figs. 19, 19 *a.*)

Many examples, but for the most part only disassociated valves, of this rare endemic species. These are less convex than the type, and we therefore consider a figure necessary. Measurements as follows:—Alt. 12, lat. 10, diam. 8 mm.

Station 13, Mèr (Murray Island); Station 8, Albany Pass; Station 5, Boydong Cays.

256. LIMA (CTENOIDES) FRAGILIS, *Chemn.*
Station 1, Thursday Island (Sept. 1888); Station 2, Warrior Island; Station 12, Mabuiag (Oct. 1888).

257. LIMA (CTENOIDES) TENERA, *Chemn.*
Station 2, Warrior Island.

258. LIMA (MANTELLUM) ARCUATA, *Sow.*
Station 10, between Hammond Island and Wednesday Spit.

259. LIMA (MANTELLUM) INFLATA, *Lam.*
Station 13, Mèr.

PECTINIDÆ.

260. AMUSSIUM PLEURONECTES, *L.*
Station 5, Boydong Cays.

261. PECTEN (PSEUDAMUSSIUM) ARGENTEUS, *Rve.*
Station 2, Warrior Island.

262. PECTEN BLANDUS, *Rve.*
Station 14, Mèr, channels between reefs.

263. PECTEN CRASSICOSTATUS, *Sow.*
Station 14, Mèr.

264. PECTEN CROUCHI, *Smith.*
Station 10; Station 8, Albany Pass. Mauritius (*Smith*), where it has hitherto been considered endemic.

265. PECTEN LEMNISCATUS, *Rve.*
Station 8, Albany Pass.

266. PECTEN LENTIGINOSUS, *Rve.*
Station 2, Warrior Island; Station 5, Boydong Cays.

267. PECTEN LIMATULA, *Rve.*
Station 5, Boydong Cays.

268. PECTEN MADREPORARUM, *Petit.*
Station 5, Boydong Cays.

269. PECTEN PALLIUM, *L.*
Station 5, Boydong Cays.

270. PECTEN SENATORIUS, *Gmel.*
Station 8, Albany Pass.

271. PECTEN (CHLAMYS) CUNEATUS, *Rve.*
Station 2, Warrior Island.

AVICULIDÆ.

272. AVICULA AQUATILIS, *Rve.*
Station 2, Warrior Island.

273. AVICULA ALA-CORVI, *Chemn.*
Station 14, Mèr.

274. AVICULA CROCEA, *Chemn.*

275. AVICULA MALLEOIDES, *Rve.*
Station 14, Mèr.

276. MELEAGRINA ANOMIOIDES, *Rve.*

277. MELEAGRINA MARGARITIFERA, *L.*

278. MELEAGRINA TEGULATA, *Rve.*

279. VULSELLA LINGULATA, *Lam.* (*Mya vulsella*, L.)
Station 8, Albany Pass.

280. CRENATULA FLAMMEA, *Rve.*
Station 2, Warrior Island.

281. PERNA ATTENUATA, *Rve.*
Station 5, Boydong Cays.

282. PERNA AUSTRALICA, *Rve.*

283. PERNA LENTIGINOSA, *Rve.*
Station 10, between Hammond Island and Wednesday Spit.

284. PINNA FUMATA, *Hanley.*
Station 14, Channel below Mèr.

285. PINNA (ATRINA) NIGRA, *Chemn.*

MYTILIDÆ.

286. MYTILUS HORRIDUS, *Dkr.*

287. MYTILUS (AULACOMYA) HIRSUTUS, *Lam.*

288. SEPTIFER NICOBARICUS, *Chemn.*
Station 13, Murray Island; Station 5, Boydong Cays.

289. MODIOLA ARBORESCENS, *Chemn.*
Station 5, Boydong Cays.

290. MODIOLA AUSTRALIS, *Gray.*
Station 10, Hammond Island and Wednesday Spit.

291. MODIOLA CINNAMOMEA, *Chemn.*

292. MODIOLA (ADULA) LANIGERA, *Dkr.*
Station 2, Warrior Island.

293. MODIOLA LIGNEA, *Rve.*

294. MODIOLA PHILIPPINARUM, *Hanley.*
Station 5, Boydong Cays.

295. MODIOLARIA CUMINGIANA, *Dkr.*
Station 2, Warrior Island; Station 5, Boydong Cays.

296. LITHOPHAGUS CANALIFERUS, *Hanley.*
Station 5, Boydong Cays; Station 11, Mabuiag.

297. LITHOPHAGUS GRACILIS, *Phil.*
Station 2, Warrior Island.

298. LITHOPHAGUS HANLEYANUS, *Dkr.*

299. LITHOPHAGUS TERES, *Phil.*
Station 2, Warrior Island; Station 13, Mèr.

ARCIDÆ.

300. ARCA NAVICULARIS, *Brug.*
Station 2, Warrior Island; Station 5, Boydong Cays.

301. ARCA ZEBRA, *Swains.*
Station 5, Boydong Cays.

302. ARCA ZEBUENSIS, *Rve.*
Station 5, Boydong Cays.

303. BARBATIA DECUSSATA, *Sow.*
Station 14, Mer; Station 8, Albany Pass, 10 fathoms.

304. BARBATIA VOLUCRIS, *Rve.*
Station 2, Warrior Island; Station 11, Mabuiag.

305. BARBATIA FUSCA, *Brug.*
Station 13, Murray Island; Station 5, Boydong Cays.

306. BARBATIA IMBRICATA, *Brug.*
Station 2, Warrior Island; Station 8, Albany Pass; Station 5, Boydong Cays.

307. BARBATIA LIMA, *Rve.*
Station 10, Hammond Island; Station 5, Boydong Cays.

308. BARBATIA TENELLA, *Rve.*
Station 5, Boydong Cays.

309. BARBATIA TRAPEZINA, *Lam.*
Station 5, Boydong Cays.

310. BARBATIA (VENUSTA) LACTEA, *L.*
This species ranges throughout the whole of the Eastern hemisphere, being a common British shell, and its headquarters may be considered the Mediterranean. It is one of the few European marine Mollusca that occur the other side of the Isthmus of Suez.

Station 8, Albany Pass.

311. BARBATIA (ACAR) ACERÆA*, sp. n. (Pl. 10. fig. 15.)

B. testa delicata, candida, pulchre cancellata, subquadratim oblonga, convexiuscula, umbonibus incurvis, prominulis, nequaquam approximatis, margine dorsali utrinque recto, antice truncato, deinde breviter marginem apud ventralem rotundato, latere postico oblique producto, subcarinato, superficie alba, delicatissime liratim costulata, liris ad latera crassioribus, sub lente nodosis; pagina intus alba, concava, cardine dentibus plurimis parum rectis prædito, ligamento externo, sinu palliali inconspicuo. Alt. 7, lat. 15, diam. 6 mm. (spec. maj.).

Four examples, all quite perfect, of an exceedingly highly sculptured little *Acar*, white, elegantly chased, and furnished with many close longitudinal radiating liræ; these, when viewed with the aid of a lens, are nodose, and are thicker, both posteriorly and anteriorly, than in the centre of the shell-surface. In form it is quadrately oblong, very convex, the umbones not approximate, but incurved and conspicuous; dorsal margin straight, produced on both sides of the umbones, anteriorly truncate, and finally merging in the rounding off of the ventral margin, this being exactly parallel to the dorsal edge. Posteriorly, the shell is obliquely produced, subcarinate. Within, the surface is white, very concave; pallial sinus only obscure; hinge with very many oblique teeth in either valve, regularly arranged.

312. BARBATIA (ACAR) DIVARICATA, *Sow.*
Station 5, Boydong Cays.

313. BARBATIA (ACAR) DOMINGENSIS, *Lamarck.*

A West Indian species that seems to be making more headway, so far as distribution is concerned, in the Eastern tropics than almost any other Pelecypod. It has also recently come across our notice from the Arabian Sea and North-Indian Ocean (*Townsend*).

Station 5, Boydong Cays.

314. BARBATIA (ACAR) SCULPTILIS, *Rve.*

315. ANADARA ANTIQUATA, *L.*
Station 13, Mèr (Murray Island).

316. ANADARA CLATHRATA, *Rve.*
Station 5, Boydong Cays.

317. PARALLELIPIPEDUM SEMITORTUM, *Lam.*
Station 5, Boydong Cays.

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* ἀκέραιος, pure.

318. Pectunculus Hoylei, sp. n. (Pl. **11.** fig. 24.)

P. testa orbiculari, æquilaterali æquivalvi, solidiuscula, umbonibus prominulis, approximatis, dorsaliter recta, ad latera utrinque bis rufomaculata, radiatim fortiter costata, costis ad octo et viginti, uniformibus, pulchre nodoso-squamatis, nodulis interdum superficiem apud mediam evanidis, interstitiis transversim squamato-liratis; cardine dentibus ad viginti in valva utraque instructo, albis, simplicibus; pagina intus albescente, ad latera interdum roseo-tincta. Alt. 24, lat. 25, diam. 15 mm. (spec. max.).

Station 2, Warrior Island; Station 5, Boydong Cays.

Superficially this interesting new form approaches *P. nodosus*, Reeve, a rare Ceylonese species, in which the ribs are of the same character, but bolder, wider in proportion, and consequently much fewer numerically, being only eighteen as against twenty-eight in *P. Hoylei.* The coloration also is more varied in the Ceylonese shell. Our species is almost colourless, being whitish, tinged here and there with faint red streaks, and conspicuously twice-blotched with red maculations both posteriorly and anteriorly. The surface is thickly ribbed, the ribs being beautifully scaly-nodulous, the interstices between them being also squamoso-lirate. The teeth of the hinge in either valve are some twenty in number, simple. Interior whitish, tinged in most specimens laterally with faint rose-colour.

We dedicate this *Pectunculus* to Mr. William Evans Hoyle, Director of the Manchester Museum, as a small recognition of many kindnesses experienced at his hands.

319. Pectunculus vitreus, *Lam.*

This, the flattest and most placunoid of all *Pectunculi*, was, at the time of its discovery, one of the rarest of Mollusca, and for many years was only known by one valve, brought home by the voyageur M. Péron, and deposited in the Musée Royale, Paris. Prof. Haddon dredged about a dozen specimens, one of them being alive and perfect, though young. This shows orange-brown flecking and pure white interior. It has occurred at Mauritius and one or two other places in the Eastern tropics, and this is an interesting extension of its range.

Station 5, Boydong Cays; Station 10, between Hammond Island and Wednesday Spit.

320. LIMOPSIS CANCELLATA, *Rve.*

Station 5, Boydong Cays; Station 10, between Hammond Island and Wednesday Spit.

321. LIMOPSIS WOODWARDI, *A. Ad.*

This may possibly be only a variety of *L. cancellata*, Rve.

Station 5, Boydong Cays; Station 10, between Hammond Island and Wednesday Spit.

322. CUCULLÆA CONCAMERATA, *Chemn.*

Station 10, Hammond Island.

NUCULIDÆ.

323. NUCULA OBLIQUA, *Lam.*

324. NUCULA SIMPLEX, *A. Ad.*

325. LEDA DARWINI, *Smith.*

Station 5, Boydong Cays.

TRIGONIIDÆ.

326. TRIGONIA UNIOPHORA, *Gray.*

Station 14, Mèr.

CARDITIDÆ.

327. CARDITA CARDIOIDES, *Rve.*

Station 5, Boydong Cays.

328. CARDITA MARMOREA, *Rve.*

Station 14, Mèr.

329. MYTILICARDIA CRASSICOSTATA, *Lam.*

Station 2, Warrior Island; Station 8, Albany Pass; Station 14, Mèr.

330. MYTILICARDIA MURICATA, *Sow.*

Station 14, Mèr.

331. MYTILICARDIA VARIEGATA, *Brug.*

Station 14, Mèr.

CRASSATELLIDÆ.

332. CRASSATELLA ZICZAC, *Rve.*

Station 8, Albany Pass.

ERYCINIDÆ.

333. KELLIA PHYSEMA*, sp. n. (Pl. **10**. fig. 14.)

K. testa pellucida, vitrea, globulari, bullacea, convexa, nitida, æquivalvi, umbonibus haud conspicuis, contiguis, sub lente delicatissime irregulariter concentrice lirata, margine dorsali rapide declivi, postice, simul ac antice, leniter rotundata; intus pellucida, ad margines lactea, ligamento interno, cardine dentibus duobus in utraque valva prædito. Alt. 8, lat. 7·50, diam. 4 mm.

A most fragile and delicate globular pellucid *Kellia*, round the margins somewhat milky, otherwise vitreous, equivalve, with inconspicuous umbones, smooth, very microscopically concentrically lirate, the margins rounded, orbicular; ligament internal; inner surface of shell almost pellucid; the hinge provided with two teeth, one central one lateral, in each valve.

334. TELLIMYA EPHIPPIOLUM †, sp. n. (Pl. **10**. figs. 13, 13 *a*.)

T. testa tenui, albescente; valvis cymbæformibus, profunde convexis, umbonibus parvis, antice obliquis, contiguis, superficie in medio depressa, utrinque lobata, præcipue marginem apud ventralem, antice subproducta, rotundata, postice curta; intus alba, subpellucida, sub lente circa margines minutissime longitudinaliter striata. Alt. 4, lat. 5, diam. 5·50 mm.

Station 5, Boydong Cays.

The ventrally depressed surface of the valves of this little species are very peculiar, and they are also extremely convex, the umbones contiguous, inclining anteriorly; within, the margins are microscopically longitudinally striate. The nearest ally would seem to be *T. triangularis*, Gould.

GALEOMMIIDÆ.

335. SCINTILLA ALBERTI, *Smith.*
Station 2, Warrior Island.

336. SCINTILLA HYALINA, *Desh.*
Station 8, Albany Pass.

TRIDACNIDÆ.

337. TRIDACNA ELONGATA, *Lam.*
Station 13, Murray Island.

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* φύσημα, a bubble.

† *Ephippiolum*, dim. of *ephippium*, a saddle.

338. TRIDACNA SERRIFERA, *Lam.*
Station 14, Mèr.

339. TRIDACNA SQUAMOSA, *Lam.*
Station 14, Mèr.

CARDIIDÆ.

340. CARDIUM TENUICOSTATUM, *Lam.*
Station 5, Boydong Cays.

341. CARDIUM (TRACHYCARDIUM) DIANTHINUM*, sp. n. (Pl. **11**. figs. 25, 25 *a*.)

C. testa oblique rotunda, tenui, pallide straminea, sæpe ad medium carneo vel puniceo-suffusa, sæpe unicolore, vel straminea vel undique punicea, longitudinaliter costata, costis quinque et triginta, planatis, postice serrulatis, et antice minute squamatis, umbonibus contiguis, parvis, ligamento externo; intus variante, interdum straminea, interdum carnea, marginibus postice dentatis, superficie interna delicate longitudinaliter lirata. Alt. 14, lat. 12, diam. 8 mm. (spec. maj.).

Station 10, Channel between Hammond Island and Wednesday Spit.

A variably coloured, delicate, and bright little shell, its chief peculiarities being the obliquely rounded outline (in one variety somewhat squarely set towards the ventral margin), and the smooth ribs, fine and close, some 35 in number, only serrulate posteriorly and in front minutely scaly. Within, the surface varies as do the outer valves in coloration, the delicate ribs showing through, so thin is the substance of the shell.

Several specimens.

342. CARDIUM (TRACHYCARDIUM) ELONGATUM, *Brug.*

One magnificent example, of narrower contour than the type figured by Reeve, and which does not possess so many ribs, these being only 38 in number, as against 43 or 44 in normal specimens. The colour too is less vivid, and shows no trace of rufous, being of a pale cinereous-ochre.

Station 14, Mèr.

343. CARDIUM (TRACHYCARDIUM) LACUNOSUM, *Rve.*

A variety only, the ribs being but 30 in number, the super-

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* *Dianthinus*, resembling a carnation.

ficies highly coloured, and somewhat stunted and incrassate. Reddish ochraceous without, pure milky-white within; marginal teeth acute and red-tipped.

Station 8, Albany Pass.

344. Cardium (Trachycardium) maculosum, *Wood.*
Station 2, Warrior Island.

345. Cardium (Trachycardium) rubicundum, *Rve.*
Station 5, Boydong Cays.

346. Cardium (Trachycardium) rugosum, *Lam.*
Station 5, Boydong Cays.

346 *a*. Cardium (Trachycardium) serricostatum, sp. n. (Pl. **11**. fig. 20.)

C. testa ovata, crassiuscula, cinereo-alba, fere æquilaterali, umbonibus incurvis, contiguis; valvis longitudinaliter costatis, costis ad quadraginta, prominulis, delicate serrulatis, antice et postice squamulosis, interstitiis excavatis, margine dorsali utrinque leniter declivi, regulari, lateribus posticis, simul ac anticis marginem ad ventralem rotundatis; intus cinereo-alba, circa margines striato-dentata; dentibus cardinalibus fortibus, lateralibus prominulis. Alt. 20, lat. 18, diam. 12 mm.

Station 4, Ormans Reef; Station 13, Murray Island.

Several valves of a distinct species we have been quite unable to match. The peculiarly serrated, squarely-set ribs, some forty in number, are characteristic. The interstices are deeply excavate, the umbones not very prominent, contiguous. Shell almost equilateral, the dorsal margin on each side of the umbones gently rounded off, both posteriorly and anteriorly, towards the ventral margin. Within, the shell is ashy-white, towards the margins striato-dentate, hinge teeth strong, laterals prominent.

Three or four examples.

347. Cardium (Trachycardium) transcendens, sp. n. (Pl. **11**. fig. 21.)

C. testa ovata, delicata, arctissime et pulcherrime longitudinaliter tenuicostata, costis circa octo et quinquaginta, umbonibus lævibus, nitidis, contiguis, paullulum antice inversis; valvis convexis, margine dorsali utrinque rapide declivi, postice et antice leniter marginem apud ventralem rotundatis, superficie pallide straminea, ad latera puniceo-maculata, et undique carneo- et puniceo-suffusa, ad margines flavescente, ligamento externo; intus superficie pallide carnea, ad medium ochraceo-punicea, nitida, delicatissime striata, apud margines serrata. Alt. 25, lat. 21, diam. 15 mm.

A remarkably elegant *Trachycardium*, its nearest ally being *C. maculosum*, Wood, which it resembles in coloration, and to some extent in form, it being, however, more equally oval, and possessing about 58 as against 38 ribs. *C. obovale*, Sow., and *C. mauritianum*, Desh., likewise *C. arenicolum*, Reeve, are akin, but each possesses salient and marked individual characteristics of its own. The species now before us differs from all others of its section in its exceedingly fine longitudinal costulations and very delicate pink and pale yellow colour. It is roundly oval, thin, with the umbones red, shining, closely approximate; valves extremely convex, dorsally speedily sloping both ways, and then gently rounding off into the ventral margin. Within, the surface is delicately longitudinally striate, pale flesh-colour, yellowish red in the contre, shining, the margin of the valves serrated.

348. Cardium (Trachycardium) variegatum, *Sow.*

349. Cardium (Papyridea) papyraceum, *Chemn.*

350. Cardium (Lævicardium) Bechei, *Ad. & Rve.*

One young valve only. A species of extreme rarity, and almost unknown in collections. Two magnificent specimens, formerly in the Colonial Exhibition of 1884, are now in the British Museum (Nat. Hist.).

Station 2, Warrior Island.

351. Cardium (Lævicardium) biradiatum, *Brug.*

Station 13, Mèr; Station 8, Albany Pass.

352. Cardium (Lævicardium) lyratum, *Sow.*

353. Hemicardium subretusum, *Sow.*

Station 10, Hammond Island.

354. Hemicardium (Fragum) unedo, *L.*

Station 13, Mèr; Station 5, Boydong Cays.

355. HEMICARDIUM (CTENOCARDIUM) FORNICATUM, *Sow.*
For many years unique, this exquisite shell has been lately found, though always rarely, in the Arabian Sea (*F. W. Townsend*), as well as now in the Torres Straits.

356. HEMICARDIUM (CTENOCARDIUM) FRAGUM, *L.*
Station 13, Murray Island; Station 5, Boydong Cays.

357. HEMICARDIUM (CTENOCARDIUM) IMBRICATUM, *Sow.*
Station 13, Murray Island.

CHAMIDÆ.

358. CHAMA DIVARICATA, *Rve.*
Station 10, between Hammond Island and Wednesday Spit.

359. CHAMA FIBULA, *Rve.*

360. CHAMA FIMBRIATA, *Rve.*
Station 5, Boydong Cays.

361. CHAMA PELLIS-PHOCÆ, *Rve.*
Station 14, Mèr.

362. CHAMA PULCHELLA, *Rve.*
Station 14, Mèr.

363. CHAMA REFLEXA, *Rve.*
Station 5, Boydong Cays.

364. CHAMA (ARCINELLA) SPINOSA, *Brod.*
Station 5, Boydong Cays.

CYPRINIDÆ.

365. LIBITINA ANGULATA, *Lam.*
Station 8, Albany Pass.

VENERIDÆ.

366. DIONE INFLATA, *Sow.*
Station 5, Boydong Cays.

367. LIOCONCHA HEBRÆA, *Lam.*
The smaller *Lioconchæ* are somewhat difficult to differentiate. Though they may not be considered particularly variable, yet so

many so-called "species" were described in the earlier years of this century by Lamarck, Deshayes, and others, that much confusion naturally exists, and we should not be surprised if some future monographer were not only to merge this with *L. tigrina*, Lam., and *L. Sowerbyi*, Desh., but also make more sweeping reforms still.

Station 5, Boydong Cays.

368. Lioconcha picta, *Lam.*

Station 14, Mèr.

369. Pitar regularis, *Smith* (as *Caryatis*). ('Challenger' Rep. vol. xiv. pl. i. figs. 3–3 *b*.)

Pitar, Römer, has priority of five years over *Caryatis* of the same author.

370. Circe castrensis, *L.*

Station 2, Warrior Island; Station 5, Boydong Cays; Station 4, Ormans Reef.

371. Circe pectinata, *L.*

We believe that it will be found that the *Circe* (or *Crista*) *pectinata*, L., and *C. gibbia*, Lam., are the extreme forms of one variable species. *Gibbia*, as its name would imply, is the large swollen-valved shell, coarsely longitudinally nodulous-costate; whilst normal forms of *pectinata* are flatter, simply oblong, and the nodules, though present, hardly developed. *Gibbia*, again, is as a rule colourless, with the exception of a dark bluish-brown variegation posteriorly; while *pectinata* is, in all examples we have seen, more or less flecked throughout with zigzag brown markings. The distribution of both species is much the same, and embraces the whole of the tropical East Indies.

Station 14, Mèr; Station 5, Boydong Cays.

372. Circe rivularis, *Born.*

Station 5, Boydong Cays.

373. Dosinia cærulea, *Rve.*

374. Dosinia histrio, *Gmel.*

It is common and variable in the Arabian Sea and Persian Gulf (*Townsend*); Andamans (*Booley*); Madras and S. Indian Ocean (*Henderson*); Ceylon (*Layard*), &c. A variety from Murray Island is the *D. lyrata*, Sow.

Station 2, Warrior Island; Station 13, Murray Island; Station 5, Boydong Cays; Station 4, Ormans Reef; Station 10, Hammond Island.

375. CHIONE (OMPHALOCLATHRUM) CHEMNITZII, *Hanley*.
Station 8, Albany Pass.

376. CHIONE (OMPHALOCLATHRUM) COSTELLIFERA, *Ad.*
Station 13, Murray Island.

377. CHIONE (OMPHALOCLATHRUM) EMBRITHES*, sp.n. (Pl. **11**. figs. 23, 23 *a*.)

C. testa percrassa, multum convexa, ovato-rotunda, æquivalvi, inæquilaterali, umbonibus inversis, approximatis, superficie concentrice costulata, costis tornatis, interstitiis arctissime sculptis, deinde calcareo-tessellatis, longitudinaliter quadriradiata, interdum sparsim brunneo-maculata, interdum unicolore, lunula perexcavata, latere antico multum compresso, deinde marginem apud ventralem rotundato, postico abbreviato; pagina intus alba, nitida, circiter impressionem muscularem posticam pulchre rubescente, linca palliali conspicua, sinuosa; cardine incrassato, dentibus cardinalibus simul ac laterali postico conspicuis, antico perminimo, marginibus intus serrulatis. Alt. 28, lat. 30, diam. 22 mm. (spec. maj.).

Station 8, Albany Pass; Station 4, Ormans Reef.

Hitherto mixed up and confounded with *C. toreuma*, Gould, also inhabiting the same seas, this species can be with ease differentiated by the extremely excavate lunule and less frequent concentric laminæ. Besides these distinctions, the interstitial spaces between the laminæ are more delicately tornate, and assume a lateritial pattern, resembling layers of minute bricks, laid regularly, some being of chalky-white consistency. The substance of the shell, below the umbones especially, is peculiarly massive. Each valve is ornamented with three or four conspicuous longitudinal rays. Within, the surface is white, shining, beautifully stained with red round the posterior muscular impression, the pallial line being conspicuous and sinuous; the hinge is thickened; the cardinal teeth and the posterior lateral large, the anterior exceedingly small; the margins of the valves being serrate within.

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* ἐμβριθής, heavy.

378. Chione (Omphaloclathrum) Lamarckii, *Gray.*
Station 2, Warrior Island.

379. Chione (Omphaloclathrum) marica, *L.*
Station 5, Boydong Cays; Station 13, Murray Island.

380. Chione (Omphaloclathrum) Listeri, *Gray.*
Station 13, Murray Island.

381. Chione (Omphaloclathrum) subnodulosa, *Hanley.*
Station 10, Hammond Island.

382. Chione (Omphaloclathrum) toreuma, *Gould.*
Station 2, Warrior Island.

383. Anaitis calophylla, *Hanley.*
Station 5, Boydong Cays.

384. Anaitis thiara, *Dillwyn.*
Station 4, Ormans Reef; Station 10, Hammond Island.

385. Paphia glabrata, *Desh.*
Our specimens are more rostrate than the type.
Station 10, Hammond Island.

386. Paphia mitis, *Desh.*

387. Tapes Deshayesii, *Hanley.*

388. Tapes malabarica, *Sow.*
Station 4, Ormans Reef.

389. Tapes (Parembola) litterata, *L.*
Station 2, Warrior Island.

390. Tapes (Parembola) radiata, *Chemn.*

391. Tapes (Textrix) sulcosa, *Phil.*
Station 2, Warrior Island; Station 4, Mèr.

392. Tapes (Textrix) textrix, *Chemn.*

393. Katelysia scalarina, *Lam.*
Station 8, Albany Pass.

UNGULINIDÆ.

394. DIPLODONTA ETHIMA *, sp. n. (Pl. **11**. figs. 17, 17 *a*.)

D. testa oblique globulari, tenui, profunde convexa, umbonibus contiguis, incurvis, margine dorsali antice rapide declivi, rotundato, postice primum fere recto, deinde abrupte marginem circa ventralem rotundato, superficie extus alba, parum nitente, concentrice rudi-lirata; pagina intus alba, cardine duobus dentibus parvis in valva utraque prædita, linea palliali simplici, inconspicua. Alt. 11, lat. 11, diam. 8 mm.

A thin, globular, somewhat oblique *Diplodonta*; the umbones, owing to the great convexity of form, rather conspicuous and incurved anteriorly. Though this shell possesses no very marked characteristics, we have been unable to match it with any of the numerous described species.

395. DIPLODONTA SUBCRASSA, *Smith*. (Rep. Zool. Coll. Voy. H.M.S. 'Alert,' 1881–82, p. 104, pl. 7. figs. L, LI.)

We have been confirmed in our naming by the author, with whom we compared our examples with the type, which came from West Island, Prince of Wales Channel (Station 9).

396. DIPLODONTA SUBGLOBOSA, *Smith*. ('Challenger' Rep., Lamellibranchs, p. 197, pl. 14. figs. 10, 10 *a*.)

Two valves, on which Mr. E. A. Smith has also kindly pronounced an opinion, remarking that these are more adult than the types, and have a slight difference in shape.

PSAMMOBIIDÆ.

397. PSAMMOBIA RASILIS †, sp. n. (Pl. **11**. fig. 18.)

P. testa oblonga, tenui, fere lævi, umbonibus inconspicuis, roseo-suffusis, superficie carnea, longitudinaliter septem-radiata, concentrice rudi-striata, margine dorsali antice recta, prolongata, ad juncturam marginis ventralis uniangulata, postice abbreviata, longitudinaliter corrugata, ligamento externo; intus pallide punicea, subpellucente, cardine in altera valva dente bifido, in altera indiviso, prædita, linea palliali sinuata. Alt. 16, lat. 27, diam. 3·50 mm. (spec. maj.).

An elegantly rayed oblong species, almost smooth, tinted with rose at the inconspicuous umbones, flesh-coloured as to its

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* ἔθιμος, usual, commonplace.

† *Rasilis*, smoothish.

surface, and longitudinally seven-rayed; its dorsal margin is prolonged, and almost straight till its sudden angle on merging into the ventral margin, anteriorly, while the hinder margin is abbreviated, the surface being longitudinally wrinkled; the ligament is external; within, the surface is pale pink; the hinge has in one valve a bifid, in the other an undivided single tooth; the pallial line is sinuate.

398. Psammobia (Gari) anomala, *Desh.*

Our specimens do not show the usual radiations of this delicate shell.

Station 5, Boydong Cays.

399. Psammobia (Gari) marmorea, *Desh.*

Station 13, Mèr.

400. Psammobia (Gari) ornata, *Desh.*

A yellow, prettily rayed variety.

Station 13, Mèr.

401. Psammobia (Gari) præstans, *Desh.*

402. Psammobia (Gari) pulcherrima, *Desh.*

403. Soletellina virescens, *Desh.*

A curious shining pale ochraceous variety, with two longitudinal broad orange flames, one on each side of the umbones, very evanescent towards the ventral margin. It is a rare form, and seldom met with.

Station 13, Murray Island.

404. Asaphis deflorata, *L.*

It is possible that all the *Asaphis* of the Western hemisphere, e. g. *A. dichotoma*, Anton, *A. coccinea*, Mart., &c., are but varieties of one variable form, equally abundant in the East.

Station 2, Warrior Island; Station 5, Boydong Cays.

Solenidæ.

405. Solenocurtus (Azar) coarctatus, *Gmel.*

Station 13, Murray Island.

Mesodesmatidæ.

406. Mesodesma præcisa, *Desh.*

Station 8, Albany Pass.

MACTRIDÆ.

407. MACTRA APICINA, *Desh.*
Station 13, Murray Island.

408. MACTRA ACHATINA, *Chemn.*

409. MACTRA (HEMIMACTRA) ASPERSA, *Sow.*

410. MACTRA (OXYPERAS) COPPINGERI, *Smith.*
This very interesting form occurred but sparingly, and much encrusted with nullipores.
Station 4, Ormans Reef.

411. RAETA GRAYI, *H. Adams.*
Hab. Borneo.

412. LUTRARIA ARCUATA, *Desh.*

413. LUTRARIA RHYNCHÆNA, *Jonas.*

MYIDÆ.

414. CORBULA CRASSA, *Hinds.*
Station 10, Hammond Island; Station 5, Boydong Cays.

415. CORBULA MACGILLIVRAYI, *Smith.*

416. CORBULA TAHEITENSIS, *Lam.*

417. CORBULA TRUNCATA, *Hinds.*

GASTROCHÆNIDÆ.

418. GASTROCHÆNA CUNEIFORMIS, *Lam.*

419. GASTROCHÆNA PLICATILIS, *Desh.*

TEREDINIDÆ.

420. TEREDO NUCIVORA, *Speng.*
Station 14, Mèr.

DIBRANCHIA.

LUCINACEA.

LUCINIDÆ.

421. LUCINA (DIVARICELLA) MACANDREÆ, *H. Ad.*
We have seen this only previously from the Red Sea (*Capt. Shopland*). Slightly coarser in sculpture than *L. ornata*, Rve.,

but very similar. Indeed all the *Divaricellæ* need a more critical differentiation.

Station 5, Boydong Cays.

422. LUCINA (DIVARICELLA) ORNATA, *Rve.*

423. LUCINA (CODAKIA) EXASPERATA, *Rve.*
Station 5, Boydong Cays.

424. LUCINA (CODAKIA) FIBULA, *Rve.*
Station 5, Boydong Cays.

425. LUCINA (CODAKIA) INTERRUPTA, *Lam.*
Station 13, Murray Island.

426. LORIPES ICTERICA, *Rve.*
Station 2, Warrior Island.

427. LORIPES HADDONI, sp. n. (Pl. 10. fig. 12.)

L. testa alba, orbiculari, æquivalvi, fere æquilaterali, tenui, umbonibus rostratis, haud prominulis, contiguis, inflexis, lunula excavata, angusta, superficie concentrice striata, ligamento interno; cardine valvæ sinistræ dentibus primariis duobus, dextræ uno dente majore centrali prædito; intus marginem circa ventralem longitudinaliter striata, linea palliali conspicua, haud multum sinuosa. Alt. 13, lat. 13, diam. 6 mm.

Station 2, Warrior Island.

A typical *Loripes*, white, rather thin, orbicular, finely concentrically striate, the umbones not very prominent, rostrate, inflexed; lunule narrow, excavate; the hinge of the left valve with two small primary teeth, of the right with one large tooth. Within, the surface is white, rudely longitudinally striate; pallial line conspicuous, broadly sinuous.

Two perfect examples and one valve.

428. CORBIS ELEGANS, *Desh.*
Station 13, Mèr.

TELLINIDÆ.

429. TELLINA (TELLINELLA) ASPERRIMA, *Hanley.*

430. TELLINA (TELLINELLA) IRIDESCENS, *Bens.*
Station 2, Warrior Island.

431. TELLINA (TELLINELLA) STAURELLA, *Lam.*

432. TELLINA (TELLINELLA) VIRGATA, *L.*
Station 5, Boydong Cays.

433. TELLINA (TELLINELLA) VULSELLA, *Chemn.*
Station 5, Boydong Cays.

434. TELLINA (DONACILLA) RHOMBOIDES, *Gmel.*
Station 5, Boydong Cays.

435. TELLINA (DONACILLA) SEMITORTA, *Sow.*

436. TELLINA (DONACILLA) VIRGULATA, *Hanley.*

437. TELLINA (TELLINIDES) EMARGINATA, *Sow.*

438. TELLINA (ANGULUS) PHILIPPINARUM, *Hanley.*

439. TELLINA (ANGULUS) PROCRITA *, sp. n. (Pl. 10. fig. 16.)

T. testa nitida, lata, ovata, tenui, pallide straminea, delicate radiis puniceis decorata, planata, umbonibus inconspicuis, planissimis, antice vix declivi, deinde abrupte rotundata, latere postico breviter rotundato, margine ventrali leniter utrinque declivi; intus pellucente, puniceo-suffusa, radiis conspicuis, cardine parvo, normali. Alt. 18, lat. 21, diam. 3·50 mm.

A shining, very flattened, broadly ovate *Tellina*, pellucid, with pale straw ground-colour, radiately ornamented with pale pink; the umbones are very flattened and inconspicuous; anteriorly the sides hardly slope until they suddenly merge into the rounded ventral margin, the posterior side is roundly contracted. Within, the radiation shows through, the hinge is small and normal, pallial sinus very obscurely seen.

440. TELLINA (ANGULUS) VERNALIS, *Hanley.*
Station 5, Boydong Cays.

441. TELLINA (ARCOPAGIA) PINGUIS, *Hanley.*
Station 5, Boydong Cays.

442. TELLINA (ARCOPAGIA) SAVIGNYI, *A. Ad.*
Station 5, Boydong Cays.

443. TELLINA (ARCOPAGIA) TESSELLATA, *Desh.*

SCROBICULARIIDÆ.

444. SEMELE DUPLICATA, *Sow.*

445. SEMELE JUKESI, *A. Ad.*
Station 10, Channel between Hammond Island and Wednesday Spit, Sept. 15, 1888.

446. SEMELE LAMELLOSA, *Sow.*

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* *πρόκριτος*, select, choice.

CUSPIDARIIDÆ.

447. CUSPIDARIA LATISULCATA, *Ten.-Woods.*

Station 13, Mèr; Station 5, Boydong Cays.

PANDORIDÆ.

448. PANDORA sp.

It is unfortunate that the only specimen in the collection is in such unsatisfactory condition as to preclude a more detailed description, for we are convinced it is new. Valve acinaciform, trapezoid, inæquilateral, arcuate and produced posteriorly, ultimately suddenly truncated and merged into the rounded ventral margin; anterior margin much abbreviated; umbones pointed, not conspicuous; surface radiately unequally wavy-costulate, which show through on the interior surface.

Station 13, Mèr (Murray Island).

PHOLADOMYIDÆ.

PHOLADOMYA, *Sowerby*, 1823.

§ PARILIMYA, subgenus novum.

Valvæ fere æquilaterales, antice solum paullum hiulcæ, costæ longitudinales valde obscuræ, umbones parvi.

449. P. (PARILIMYA) HADDONI, sp. nov. (Pl. **11**. figs. 22, 22 *a*, 22 *b*.)

P. testa cinereo-albida, delicatula, tenui, æquivalvi, fere æquilaterali, oblonga, postice clausa, antice paullum hiante; umbonibus parvis, antice incurvis, approximatis, latere antico declivi, breviter truncatulo, marginem versus ventralem subrotundato, postice paullum magis producto, denique leniter rotundato, superficie fere lævi, concentrice inæquiliter rudi-striatula, radiatim costulis arctis, pellucidis, quasi-internis pulchre ornata; ligamento externo; pagina intus cardine utriusque valvæ fere simplici, dente marginali obscuro, parvo, nitido, quasi detrito, fossa triangulari valvam apud dextram; linea palliali fere obsoleta.

Alt. 17, lat. 22, diam. 9 mm. (spec. maj.).

Alt. 9, lat. 13, diam. 6 mm. (spec. min.).

"Station 2, Warrior Island, at 5½ fathoms, amongst broken shells and sand. August 15, 1888."—*A. C. H.*

Shell thin, equivalve, and almost equilateral, very delicate, smoothish, oblong, and slightly gaping anteriorly, the posterior portion of the valves closed in repose. The umbones are hardly prominent, and incline forwards, being closely approximate; the anterior margin is at first sloping, then somewhat truncately rounded off, and merging into the ventral margin, while posteriorly it is slightly produced and gently rounded. The surface of both valves is alike, smoothish, milky- or ashy-white, semipellucid, indistinctly but rudely concentrically striate, and closely beset with radiating quasi-internal riblets, hardly standing out beyond the superficies; indeed in young examples these radiations appear as pellucid lines imbedded in the internal layers of the shell. The ligament is external. Within, the hinge of either valve is almost destitute of teeth or any processes whatsoever, save that a small, worn-looking, centrally situated lamellar tooth is present, most conspicuous in the left valve, though there is a corresponding tooth and an elongately triangular pit in the right valve also.

A few remarks on this peculiarly interesting genus may not be out of place here.

Pholadomya, instituted by the elder Sowerby in 1823, is one in which but very few recent species are embraced, since certain forms described by Agassiz as nearly akin to the type (for example, *P. caspica*) have been, and rightly, relegated to the toothless section of the Cardiidæ, e. g. *Adacna*, Eichwald.

P. candida, Sow., the original type, is still of extremely infrequent occurrence, nearly all the specimens hitherto obtained having been cast ashore from considerable depths after storms and hurricanes off the island of Tortola, in the Antilles. The anatomy has been worked out by Sir Richard Owen, who describes the mantle-margins as being united, save where space is left for the foot and outlets occur for the siphonal and anal orifices; the gills on either side single, the outer lamina produced dorsally, and there is also an accessory, bifurcate foot. A fine example of the shell in the private collection of one of us exhibits a large, papyraceous, fragile, white, extremely inæquilateral surface, equivalve, very convex centrally and towards the umbones, widely gaping both anteriorly and posteriorly. In form obliquely trapezoid, anteriorly roundly truncate, concentrically rudely striate, and, centrally only, rayed from the umbones to the ventral margin; rays much elevated, about eleven in number, broader towards the ventral margin, nodulous where the rude concentric striæ cross them. Within, slightly nacreous, showing, owing to its extreme tenuity, the precise obverse of the external sculpture; hinge with an elongate trigonal "fossa," and a marginal "lamina" in either valve.

The great thinness of the substance causes the shell often to be worn away at the umbones; this is owing to incessant friction in opening and shutting the valves. Here we have the typical *Pholadomya*, a more appropriate cognomen than which could not have been possibly coined, for the resemblance to a large *Pholas* (e.g. *P. costata*, L.) is very striking. Many extinct forms approach the recent shell both in size, facies, and ornamentation, and several even exceed it in beauty and magnitude. These are mainly Secondary and Tertiary fossils, especially abounding in the Liassic or Jurassic rocks. In the majority of instances, owing to the shell-substance having been originally so thin, they are mere casts, but are exact replicas of their former analogues in all salient particulars.

In 1842* Agassiz subdivided the genus into various sections, considering the presence or absence of a posterior area ("aire cardinale circonscrite") of primary consequence. Thirty-four years later, Meek, in 1876†, considered that only two divisions were worthy of establishment, viz.: *Pholadomya* (type, as before, *P. candida*, Sow.), distinguished by an elongate inæquilateral form, gaping at both extremities, and roundly truncate in front; and *Procardia*, to contain the short, gibbous, subtrigonous, extremely truncate, and often elevated forms, to which the greater proportion of the fossil species belong. These now exceed two hundred in number.

Turning again to the recent forms, the second, discovered only a few years ago, is *P. Loveni*, Jeffr., of the typical section of the genus, and we consider it here worth while reproducing Dr. Gwyn Jeffreys's original description, so as to place it side by side with that of our new species, to which, however, it does not bear much near resemblance. This is a remarkably interesting

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* L. Agassiz, Études critiques sur les Mollusques fossiles: Neuchâtel, 1842–45.

† A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri country: U.S. Geol. Survey of the Territories (Meek), 1876.

mollusc, evidently of wide distribution, ranging from the mid-Atlantic Ocean to Sicilian localities in the Mediterranean.

"*Pholadomya Loveni*, Jeffreys, Proc. Zool. Soc. 1881 ('Lightning' and 'Porcupine' Exped., 1868–70), p. 934, pl. lxx. fig. 7.

"Shell inequilateral, wedge-shaped, gaping at the posterior end, convex, of a pearly nature, partly semi-transparent, lustreless; *sculpture,* 10–12 longitudinal ribs, besides some intermediate striæ; these are more or less interrupted by strong periodical marks of growth, so as to give the ribs a nodulous appearance; the sides are ribless; the whole surface is covered with minute prickly tubercles; *colour* white; *margins* rounded on the anterior side, inclining upwards towards the other side, which is also rounded but slightly truncate, sloping at the back from each side of the umbo; *beaks* bluntly triangular, turned inwards; umbones prominent; *ligamental pit* in the right valve obtuse-angled, placed outside underneath the beak, and defined outwards by a thin plate; *hinge-line* sloping towards the posterior side; *hinge-plate* thin, sinuous, reflected; *teeth* none; *inside* highly glossy and nacreous; *scars* conspicuous. L. 0·4, B. 0·5.

"'Porcupine' Exped. 1870; Atl. St. 22, 28 *a*; Med. 55.

"None of the specimens are quite perfect. One of them indicates twice the size given in the description. That figured is from the 'Josephine' Expedition.

"*Dist.* Palermo, frequent (Monterosato), 162 fathoms. Off Marseilles ('Travailleur' Exped. 1881); Villa Franca, Azores ('Josephine' Exped.), 320–600 fathoms."—*J. G. J.*

Into the two groups proposed by Meek we are unable precisely to allocate the *P. Haddoni*. To this, indeed, we can find nothing near akin, unless an obscure species described by Mr. Bullen Newton in 1892*, as occurring in the Upper Keuper Sandstone, Shrewley, Warwickshire, prove its ally. Certainly from figure and description it appears analogous, particularly as to being nearly equilateral, with radiately ribbed surface, these ribs, however, being far more pronounced. It was provisionally named *Pholadomya* (?) *Richardsii*, after Mr. E. P. Richards, the discoverer.

From the differentiation we have given above, and which need not be recapitulated, we plead justification for the creation of a

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* J. of Conch. vii. p. 411, fig. 2 (1894).

new subgeneric division. It only remains to say that several examples (mostly, however, single valves, though one at least occurred quite perfect) were found of *P. Haddoni*, dredged at about 5 to 6 fathoms in the localities above cited. It is not, therefore, a deep-sea form.

In dedicating this mollusc to its discoverer, we would once again tender him our best thanks for having given us every facility and latitude in the preparation of this Report; and, we may add, it is by his express desire that all the types have been permanently deposited in our National Collection at the British Museum (Natural History), South Kensington.

EXPLANATION OF THE PLATES.

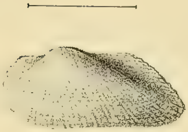
Plate 10.

Fig. 1. *Murex* (*Pterenotus*) *saibaiensis*, sp. n.
2. *Murex* (*Ocinebra*) *salmoneus*, sp. n.
3. *Nassa* (*Alectryon*) *fretorum*, sp. n.
4. *Mangilia chionea*, sp. n.
5. *Triforis* (*Ino*) *excelsior*, sp. n.
6. *Bittium torresiense*, sp. n.
7. *Eulima australasiaca*, sp. n.
8, 8 *a*. *Magadis eumerintha*, sp. n.
9. *Calliostoma* (*Eutrochus*) *septenarium*, sp. n.
10, 10 *a*. *Microtheca Acidalia*, sp. n.
11. *Phenacolepas lingua-viverræ*, sp. n.
12. *Loripes Haddoni*, sp. n.
13. *Tellimya ephippiolum*, sp. n.
14. *Kellia physema*, sp. n.
15. *Barbatia* (*Acar*) *acerœa*, sp. n.
16. *Tellina* (*Angulus*) *procrita*, sp. n.

Plate 11.

Fig. 17, 17 *a*. *Diplodonta ethima*, sp. n.
18. *Psammobia rasilis*, sp. n.
19, 19 *a*. *Lima* (*Limatula*) *torresiana*, E. A. Smith, var.
20. *Cardium* (*Trachycardium*) *serricostatum*, sp. n.
21. *Cardium* (*Trachycardium*) *transcendens*, sp. n.
22, 22 *a*, 22 *b*. *Pholadomya Haddoni*, sp. n.
23, 23 *a*. *Chione* (*Omphaloclathrum*) *embrithes*, sp. n.
24. *Pectunculus Hoylei*, sp. n.
25, 25 *a*. *Cardium* (*Trachycardium*) *dianthinum*, sp. n.


12.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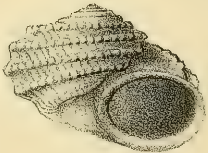
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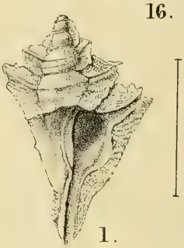
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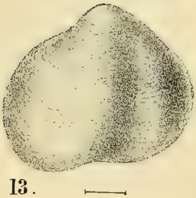
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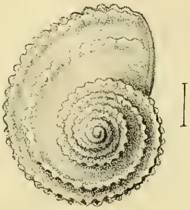
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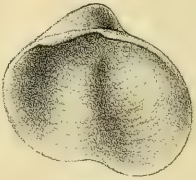
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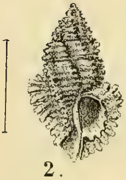
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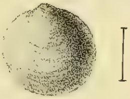
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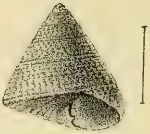
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4.

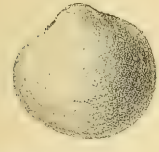

7.

J. Green del. et lith.

Mintern Bros. imp.

MOLLUSCA FROM TORRES STRAITS.

Melvill & Standen. LINN. SOC. JOURN. ZOOL. VOL. XXVII. PL. 11.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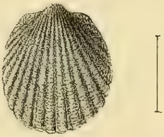
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17a.


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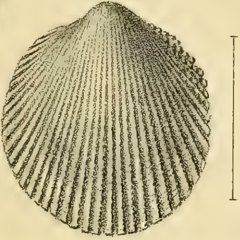
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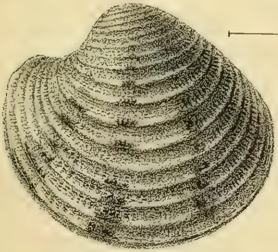
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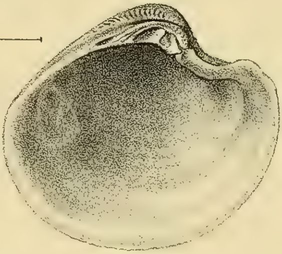
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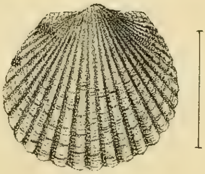
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MOLLUSCA FROM TORRES STRAITS.

Note on the External Nares of the Cormorant.

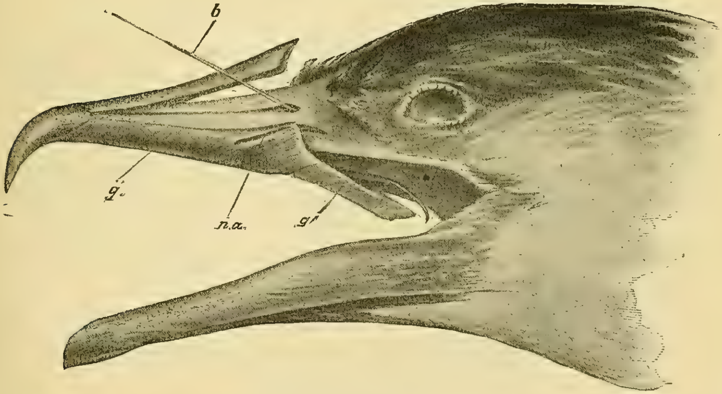
By W. P. Pycraft, A.L.S.

[Read 2nd March, 1899.]

The following short note, with two figures, is intended as a supplement to a similar contribution to the pages of this Journal made by Prof. J. C. Ewart *.

In that communication Prof. Ewart described the external nostril as a "mere slit situated at the end of a shallow superficial groove, which runs backwards along the beak parallel with its lower edge, and lying between its lower and middle third." And concerning it he wrote: "When a bristle is introduced into the slit, it never succeeds in forcing a passage into the nasal cavity. If the skin which forms the outer boundary of the slit is carefully reflexed, a groove is exposed which runs from the external slit-like nostril to a narrow canal lined apparently by modified mucous membrane . . . . . . it is possible to pass through this canal,

Fig. 1.



Left side view of the head of a Cormorant (*Phalacrocorax carbo*) in which the rhamphotheca has been displaced to show the horny plug which has been withdrawn from the aperture of the external nares.—*b*, bristle; *g*, gnathotheca; *g′*, posterior maxillary portion of the gnathotheca; *n.a.*, external narial aperture.

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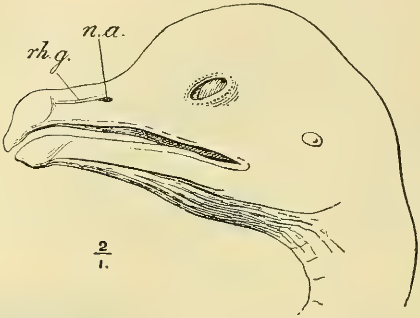
* Vol. xv. 1881, p. 455.

without forming a false passage, a bristle about the size of an ordinary horse-hair . . . . ."

The external nostril in every species of adult Cormorant which I have examined appears to lie without and below the rhinothecal groove (fig. 1, *n.a.*), and not at its end as just described. As seen in the figure, it is represented by a shallow groove pointing downwards and forwards to the tomium. Its upper end joins the rhinothecal groove at its base, where it passes into the naked skin of the lores.

Fig. 2.



Left side view of the head of an embryo Cormorant to show the relatively large narial aperture lying within the rhinothecal groove.—*rh.g.*, rhinothecal groove.

I have not been able to find any trace of this narial groove, or aperture, in the Gannets.

I failed entirely to pass even the finest bristle up this groove into the nasal cavity, though I tried in many species of Cormorant—one a fresh, and the rest spirit-specimens.

My next step in this investigation was to force the rhamphotheca from the jaw. The rhinotheca was first raised and then the gnathotheca. This last brought away with it a short rod-like plug (fig. 1, p. 207)—apparently an inward and backward continuation of that part of the rhamphotheca surrounding the external narial aperture, indicated by the groove just described (fig. 1, *n.a.*). Thus, instead of surrounding the aperture and giving place in this region to mucous membrane, the sheath seems to have grown inwards so as to form a horny tubular lining. Microscopical examination—made in the first instance by my friend Mr. H. M. Bernard, and afterwards confirmed by myself—showed that the lumen of the "plug" was completely blocked up by delamination of fragments of the horny layers from its inner surface. A bristle passed down the narial aperture, now thrown open by the removal of the plug, made its exit as usual at the posterior nares.

The nasal cavity is a small chamber devoid of any trace of turbinal folds, and more or less imperfectly divided into anterior and posterior moities by a vertical transverse partition depending from the roof into the chamber, the ventral border of the partition being free.

In the embryo (fig. 2) the narial aperture lies within the rhinothecal groove, much as described by Ewart in the adult, and is still open. It is interesting to note that the oblique groove for this aperture in the adult is not yet indicated, neither is the segmented portion of the posterior end of the gnathotheca, so marked in the Gannets though comparatively slightly developed in the Cormorants (fig. 1, *g*′).

Mr. F. A. Lucas in 'The Auk' (vol. xiv. p. 87) has an interesting note on the external nares of the embryo and nestling Cormorant. He finds the nostrils still open in the oldest of the nestlings in his collection; the age of these he estimates at 28 days. He considers "that the external nostrils close about the time the young Cormorants take to the water and begin to feed themselves.'

On so-called "Quintocubitalism" in the Wing of Birds; with special reference to the *Columbæ*, and Notes on Anatomy. By P. Chalmers Mitchell, M.A., F.L.S.*

[Read 16th March, 1899.]

(Plates **12** & **13**.)

Since the results of Wray's investigations were published **(1)**, the occurrence of two well-marked modes of disposition of the quill-feathers on the upper part of the wing of birds has been well known, and the explanation of the existence of the two conditions has been sought by many zoologists. In one mode of disposition, that known as "quintocubitalism," the quill-feathers which abut on the ulna are arranged in a regular and even series, each feather with its upper and lower covert being of approximately the same size and lying at the same approximate distance from its neighbours on the distal and proximal sides. In the disposition termed "aquintocubital" the first four quills, counting from the distal towards the proximal end of the ulna, are arranged precisely as in the quintocubital wing, but, after the fourth, there is a gap in which there is an upper and lower covert precisely as in the regular arrangement but no quill between them. Thereafter the quills follow in regular series. It appears as if the fifth quill had been lost without any other disturbance of the series, and the condition was called "aquintocubital," *i. e.* without the fifth cubital, on account of this ready interpretation. It appears to me that it would be more convenient to state the facts in another way. Immediately distad of the cubital quills

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* [This Memoir is complementary to that by Mr. W. P. Pycraft, which follows (*infra*, pp. 236–254). During the autumn of 1898, Mr. Pycraft intimated his intention of early presenting to the Society a memoir on the so-called Aquintocubitalism in the Bird's wing, and in subsequent conversation with Mr. Mitchell he discovered that the latter had already arrived at the same main conclusion as himself, and that he had lodged a preliminary statement concerning it with the Editor of a scientific journal. When these facts became known to the Officers of the Linnean Society, they approached the two gentlemen with a proposal that their memoirs might be presented at one of the Society's meetings and published together in its Journal, and to this they willingly agreed, Mr. Chalmers Mitchell very generously withdrawing the afore-mentioned press notice.

Except that the authors agree on the main issue, to which they came "independently and unknown to one another," their papers will be found to supplement each other—one author having approached the subject through the study of development, the other through that of adult anatomy.—Ed.]

there is a variable remex, which when normally developed, as in *Nothura*, is in obvious series with the cubital remiges, and which is frequently smaller in size but connected to the cubital series by a special plica of membrane as in most pigeons, but which may be absent; although in the case of the Columbæ, to which this memoir has special reference, I have not noticed a case of absence. I believe the simplest way to state the facts is to adhere strictly to the division of the remiges or wing-quills into primaries and secondaries, to consider the carpal remex as the first secondary, and then to say that, after the fifth secondary, there may be a gap more or less equivalent to the space which would be occupied by a sixth secondary in even series, after which the secondaries continue in normal series; or that the secondaries may all lie in normal series without the occurrence of a gap. For the first condition, that hitherto known as "aquintocubital," I propose the term "*diastataxic*"; for the second condition, that known as "quintocubital," I propose the term "*eutaxic*." These new terms are simply descriptive; they convey no implication as to the way in which the two conditions arose, and they appear to me to be equally applicable, whether we accept the current view that the diastataxic condition has come about by the disappearance of a fifth secondary from an eutaxic series, or if, as I believe, there is no lost feather. If there be no missing feather, it is obvious that the diastataxic condition might have arisen from the eutaxic condition by elongation of the wing in the region of the gap without the addition of a quill to the series; or that the eutaxic condition might have come from a diastataxic condition by the closing-up of the quills without consequent obliteration of the gap. I hope in this memoir to show reasons for the latter view—for, in fact, the view that the diastataxic condition is architaxic.

For some time I have been engaged in a special study of the Columbæ. These, like most of the larger groups of birds, have been described as diastataxic, and, without question, the wing in the majority of them presents a well-marked gap. This is well seen in the wing of a common pigeon, where the gap is as large as in a duck or in an eagle, and is occupied by an apparently normal covert. In *Turtur chinensis* (Pl. 13. fig. 7) there are ten primaries with their major coverts placed (as I find invariably among the Columbidæ) distally to the corresponding quills; then comes a moderately-sized carpal remex bound down by a special fold of the wing-membrane to the next secondary; the carpal covert is, like all the secondary major coverts, proximad of the corresponding quill in insertion. After the carpal remex there follow four secondaries, then a gap which is slightly exaggerated in the drawing, then six other secondaries in even series. The major covert in the gap is bound to the major covert proximal to it by a thin slip of membrane. In *Geotrygon montana* (Pl. **13**. fig. 5) the carpal covert is very small, and under it lies a small remex bound down to the next secondary in normal fashion. Then follow twelve secondaries placed at almost equal distances, so that at first sight the arrangement appears to be eutaxic. Examination of the interspaces, however, shows that there is a small additional covert clearly belonging to the major series but with no corresponding quill. The same condition is very plain in *Œna capensis*; it is only the presence of the covert that makes it possible to regard the wing as diastataxic. The odd covert is plainly crowded, a condition which is still more plain in the specimen than in the diagram, in which for convenience of drawing the relative size of the feathers as compared with the interspaces has been minimized. I have found in a certain number of the Columbæ that the wing is practically the same as in *Geotrygon* and *Œna*, with the most important difference that there appears to be no extra covert, and that, in consequence, the wing must be regarded as eutaxic, and the group Columbidæ added to those among which both eutaxic and diastataxic conditions occur. Nearly two years ago, when I found this eutaxic condition in *Columbula picui*, I showed the specimens to my friend Mr. Beddard, in whose laboratory in the Zoological Gardens I was prosecuting my work, and with my consent he noticed the observation in his recent work on Birds (2. p. 305). With that exception the observation is new to literature, and since then I have found the same condition in a number of other pigeons. In *Geopelia cuneata* (Pl. **12**. fig. 1) and in *G. tranquilla* there are ten primaries, each with a distal major covert; then comes the small carpal covert and remex, the latter with its usual slip binding it to the adjacent secondary; then follow in even series ten fully-developed secondaries, each with normal proximally-placed major coverts, and in the diastataxic interspace there is neither any trace of gap nor an extra covert. In *Leucosarcia picata* (Pl. **13**. fig. 2) the conditions are identical, except that there are eleven fully-developed secondaries. In *Geophaps plumifera* (Pl. **13**. fig. 3) the same condition exists, except that there are twelve fully-developed secondary quills. In *Columbula picui* there are ten primaries and also twelve fully-developed secondaries. In *Starnœnas cyanocephala* (Pl. **13.** fig. 6) there are ten primaries, then an unusually large carpal remex with the normal binding fold and covered by a small carpal covert; then follow twelve fully-developed secondaries without any trace of the diastataxic gap. In *Phlogœnas cruentata* there are nine primaries, then a normal covert and remex, then twelve fully-formed secondaries, with no trace of the gap.

It appears, then, that the Columbæ form an interesting addition to Kingfishers and Swifts, some members of which groups exhibit the one condition, others the other; and it is among such groups that we may hope to find an explanation of the divergence in structure [*]. The mere statement of the facts as they occur among the Columbæ seems to me at once to suggest an extremely probable explanation. In most pigeons the wing is diastataxic, with a large gap occupied by a "covert." In some pigeons (e. g. *Œna* and *Geotrygon*) there is practically no gap but a covert crowded into the interspace which forms the gap in most pigeons; in *Geopelia cuneata* and *G. tranquilla*, in *Columbula*, *Leucosarcia*, *Starnœnas*, *Geophaps*, and *Phlogœnas* there is no gap, and there is apparently no extra covert.

It is now necessary to consider a third row of feathers, for simplicity not represented in the figures in the Plates, but shown in fig. 1 in the text. Lying apparently in between the quills and coverts, but really belonging to a more dorsal series, there is a small feather marked 3 in the figure; except in the gap marked x there is plenty of room for these third-series feathers. In the gap, even in a diastataxic bird (fig. 1, I), there is a certain crowding of these feathers, which are rather smaller than the others of their series. In a diastataxic bird where there is no actual gap, as in *Œna* or *Geotrygon* (fig. 1, II), the two feathers on either side of the actual covert are exceedingly crowded, and are markedly degenerate, relatively much more so than in the diagram, while the covert itself is smaller in size. In the eutaxic birds (fig. 1, III) there is only one feather in this interspace; as a result the interspace does not differ from the other interspaces. Which of the three crowded feathers has remained I cannot be certain, but I think it probable that it is

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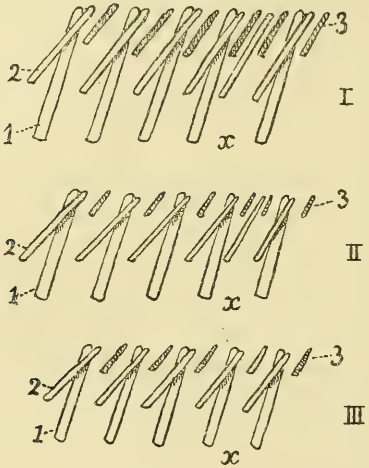
[*] The late Mr. Seebohm made the suggestion that eutaxic species may possibly have arisen from diastataxic ancestors by suppression of the coverts (Classification of Birds, 1895, Suppl. p. 8).

the so-called diastataxic covert in a form so much reduced as to appear to be one of the ordinary third series. My explanation is, then, that pigeons were originally diastataxic with a full gap occupied by one feather of the upper-covert series and two small feathers of the third series. In some pigeons there has been a closing-up of the ranks of quills so that there is no actual gap in the diastataxic space, while into this reduced space there are crowded three feathers, the two smaller markedly reduced and the covert itself not seldom noticeably smaller. Finally, a certain number of pigeons have become absolutely eutaxic by the suppression of the two smaller feathers, leaving the covert in a reduced form, or at least by the suppression of two of the three feathers. The eutaxic condition is a modification of the more primitive diastataxic condition, and intermediate conditions occur.

Fig. 1.



I. Diagram of secondaries (1), coverts (2), third-series feathers (3), in Columbæ; *x*, diastataxic gap. Complete diastataxic condition.

II. *Geotrygon*: same lettering, showing reduced diastataxic gap (*x*) with three crowded feathers in it.

III. *Leucosarcia*: same lettering. Eutaxic condition. No gap in the interspace (*x*), and only one feather, which may be one of series 3, or 2.

Systematic Position of the Eutaxic Pigeons.

The nomenclature I have followed is that used in the 'List of Animals' published by the Zoological Society, as I obtained my specimens from the Zoological Society's Gardens. These names are identical with those in the British Museum Catalogue, except in the cases of the bird I name *Phlogœnas cruentata,* which is there called *P. luzonica*, and the bird I name *Geophaps plumifera*, which is there named *Lophophaps plumifera.*

Garrod (3) considered the classification of pigeons from the point of view of anatomy. He does not place *Geophaps*, but of the other eutaxic forms, *Leucosarcia* is placed in his family *Phapidæ*, and the others each in a different division of his family *Treronidæ.* According to the British Museum system, all the eutaxic forms belong to the family *Peristeridæ* but are distributed among four different subfamilies. It is clear that these eutaxic forms cannot be regarded as forming a separate group by themselves. Here and there, almost at random, among the great mass of diastataxic forms occur a few eutaxic forms. If, as I have attempted to show in the earlier part of this paper, the eutaxic condition be a simple derivative of the diastataxic condition, then it is not surprising to find that quite different genera are convergent in this respect. I shall now show that there is considerable reason, based on anatomy, for regarding these eutaxic pigeons as convergent in other respects.

Anatomical Reasons for the supposition that Eutaxic Pigeons are not Primitive.

To avoid constant repetition of the names of the seven pigeons the wing of which displays the eutaxic condition, I shall refer to them according to the following list:—

Geopelia cuneata	A.
Geopelia tranquilla	*a.*
Phlogœnas cruentata	B.
Phlogœnas ? luzonica	
Starnœnas cyanocephala	C.
Geophaps plumifera	D.
? *Lophophaps* ,,	
Columbula picui	E.
Leucosarcia picata	F.

When the anatomical differences presented by a large number of closely-related individuals are considered, it is generally possible to come to a conclusion as to what conditions are more primitive and what are secondary. In different groups certain structures are on the wane, others are in process of development, and such general changes appear to characterize whole groups; the complete assemblage of related animals appears to be moving in the same direction; the same structures appear to be in process of advancement or of degeneration, so that the special characters of the whole group tend to become more and more accentuated. In this general progress, individual species or genera may advance specially rapidly or may lag behind; and those which are most or least advanced in the direction of the whole group are by no means necessarily most closely related to one another, although in the structures most affected by the general course of the changes, strong convergent resemblances result. In the case of pigeons for instance, there are anatomical considerations by which one may consider particular individuals or species more or less "pigeony" pigeons (to coin a convenient inelegancy), and the species which are most "pigeony" are not specially related one to the other. For some time I have been engaged on the anatomy of this group with the special view of tracing such progressive advances and degenerations. The work involves dissection of many hundreds of individuals, and it will be long before I am in a position to publish final results. There are many sources of error, some of which can be eliminated only by comparison of the anatomy of many individuals of the same species and the same variety. I have for the present purpose drawn on my notes only for such points as appear to me to be unusually clear; and in this way, although I leave out many features which I have no personal doubt will prove of interest, I gain in immediate certainty and brevity. The general conclusion to which I come is that the eutaxic forms display a number of anatomical features which show them to be well to the front among pigeons generally in the progressive changes for which evidence is to be found among pigeons—that, in fact, they are more "pigeony" than their diastataxic allies. I do not mean that every eutaxic pigeon exhibits every progressive advance or degeneration more notably than every diastataxic form, but that on the whole they do exhibit such changes in an unusual degree.

In the argument which I am attempting to develop there is the apparent flaw that advance in one direction is not necessarily associated with advance in other anatomical structures. It is a familiar condition to find extreme specialization in certain directions associated with extremely primitive conditions in other directions. From this point of view, it might be said that even were the eutaxic condition primitive it would not be surprising to find that birds primitive in that respect were much specialized in other directions. I am not yet prepared to meet this argument fully in its application to pigeons; I can only say that I find that where the lines of progressive change are clear, there appears to me to be a high average of association among the changes. Taking only the changes characteristic in a group, individuals with one of the changes well marked have a high average of the other changes. Groups are, in fact, characterized by a tendency to particular variations in particular structures; these variations are individual and in a state of flux in the more primitive species, but tend to become fixed as specific or generic characters in more advanced types.

Muscular Anatomy.

M. rhomboideus superficialis.—In the majority of *Columbidæ* according to Fürbringer (4), and I am able to corroborate him, the origin of this muscle is fleshy. In A, *a*, B, C, and E it has become tendinous, while in E part of the anterior end of the muscle is a degenerate fibrous sheet. In the vast majority of birds this muscle has passed into what is certainly the secondary condition of being tendinous in origin. The Columbæ are peculiar in that most of them present the more primitive condition, but in five out of the seven eutaxic forms this primitive condition has been lost.

M. supracoracoideus.—The great development of this muscle is one of the special features of the anatomy of the Columbæ. In its highest development, it extends to the extreme tip of the sternum and invades the keel to a considerable extent. A special feature, which will be noticed with the osteology, is the tendency to formation of a strong smooth ridge of insertion which carries the line of the coracoid across the anterior edge of the keel. In all the seven eutaxic pigeons the muscle and its ridges has reached the extreme development found in the group. Associated with this extreme development is a markedly bipinnate arrangement of the muscle-fibres on their central tendon; the extent to which this occurs varies among pigeons, but is strongly marked in all the eutaxial forms.

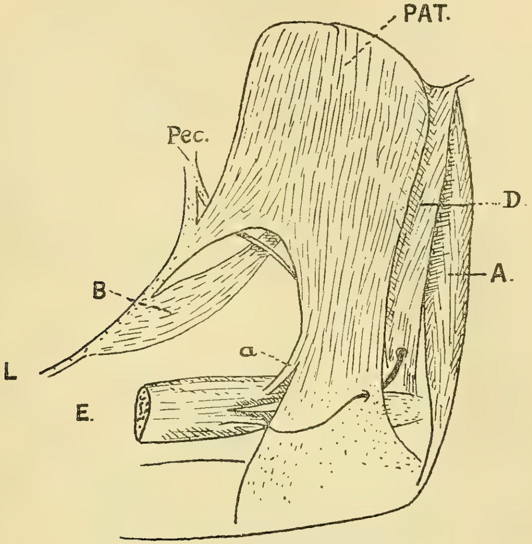
M. coracobrachialis externus.—This muscle from the coracoid to the planum bicipitalis of the humerus is a large muscle in Ratites, but in Carinates is on the wane, entirely disappearing in some of the Passeres. In the Columbæ generally it is very small and partly covered by the biceps tendon, but frequently possesses a fair proportion of muscular fibres. In all the eutaxic pigeons it is extremely small, in some of them being practically reduced to a tendon.

M. latissimus dorsi anterior et posterior.—These muscles are extremely variable among birds, and pigeons show a considerable range of difference. The general tendency among them is for the anterior muscle, originally narrow and strap-like, to extend its origin and to broaden out; the posterior, on the other hand, is becoming reduced. In all the eutaxic pigeons, the anterior muscle has a fairly broad origin ranging from about the third last cervical, or just in front of that, to the first or second dorsal. In this respect these pigeons cannot be said to be markedly in front of the diastataxic forms, but they occupy an advanced place among the progressive forms. On the other hand, they are all markedly advanced in the degeneration of the posterior muscle. In E there is a slight fibrous representative of it, in the others it is completely absent. In diastataxic forms it is frequently present, with distinct origin and insertion; in *Columba* it is variable individually and specifically.

Group of Alar Muscles.—In the angle between the humerus and forearm there are a number of muscular structures to which great attention has been paid by Garrod, Gadow, Fürbringer, Beddard, and others; and those structures have been shown to possess considerable systematic value. In pigeons generally there is great variety in the component parts of this group of structures, and the differences both in their general aspect and in their individual details have great significance. The general tendency undoubtedly is to increase the musculature attached nearer the proximal end of the forearm and to decrease that more distally inserted. The mechanical effect of these changes, which obviously are progressive in the group, is to strengthen the muscular pull, which from its insertion nearer the fulcrum increases the rapidity of the upward movement of the forearm on the humerus. In this general tendency towards change, a more Passerine-like condition is being attained by many pigeons. The eutaxic pigeons show the changes, some of them in an extreme form, all of them notably; and in this respect it is interesting to remember that the Passerines are a eutaxic group.

Biceps patagialis.—This important patagial muscle is in origin a slip from the biceps brachialis which runs to the long tendon of the deltoides patagialis. In fig. 2 B, I show it in a condition which is usually primitive among pigeons, and which I found as an individual abnormality in *Columba livia*. The whole slip from its origin to insertion is muscular. In fig. 3 I the normal pigeon-condition is shown. The origin from the biceps is reduced to a rounded tendon or even a thin aponeurosis arising partly from the wing-membrane. In fig. 3 II the most advanced pigeon-development is represented. The muscle is now fully specialized, and has a long tendon at each end with a considerable muscular belly. The insertion is now very low down on the longus tendon, the tendon of the biceps slip running parallel with that for a considerable distance. The muscle is in fact losing its primitive function and becoming really more of an accessory to the radial extensors. It appears to me to be a probable suggestion that this extreme development may be tending really to the final extinction of the muscle, and therefore to a Passerine-like condition. My immediate point, however, is

Fig. 2.

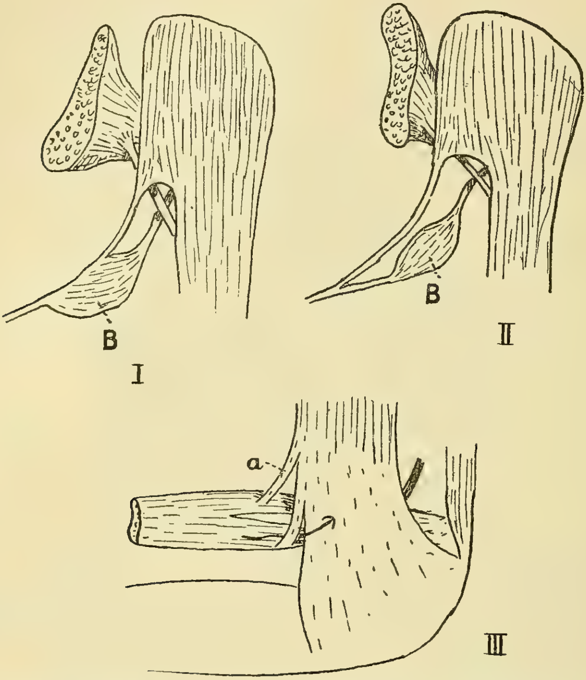


Alar muscles of *Columba livia*.

PAT. Deltoides patagialis. Pec. Pectoralis propatagialis. B. Biceps patagialis slip, an unusually primitive condition not common in *Columba livia*. L. Longus tendon. A. Anconæus scapularis. D. Deltoides major. E. Extensor metacarpi radialis. *a*. Fürbringer's 'alpha' slip.

that in the eutaxic pigeons the biceps slip tends to be highly specialized. In D the normal pigeon-condition is present; in A, E, and F, the normal insertion with a considerable origin by

Fig. 3.



I. *Geophaps plumifera.* II. *Geopelia tranquilla.* III. *Phlogœnas cruentata,* showing differentiation of brevis tendon into α, β, and γ slips of Fürbringer.

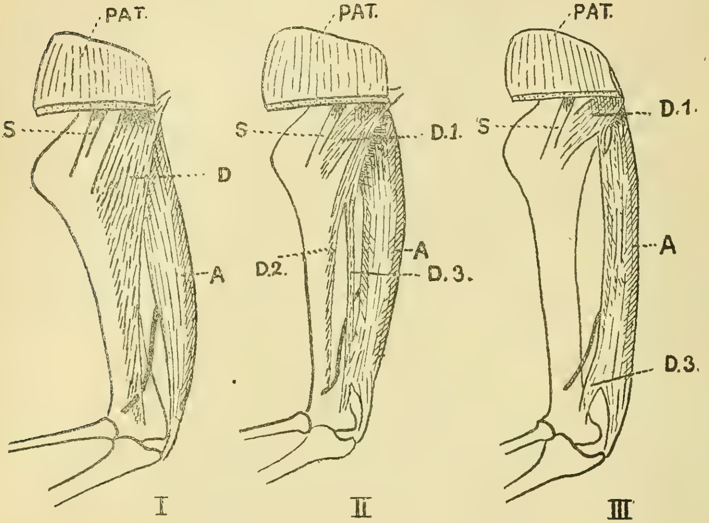
aponeurosis from the wing-membrane; in *a*, B, and C, the extreme development with a long tendon at either end.

Deltoides patagialis.—In fig. 2, Pat., the normal pigeon-condition is shown. The belly of the muscle divides into two peaks, that to the longus being certainly smaller but quite well marked. The distal end of the brevis is divided only into a distal slip running to the extensor, and made known by Fürbringer as 'alpha'; the two slips 'beta' and 'gamma' are not differentiated, but are represented by a single diffuse sheet. In A, *a*, D, E, and F the longus slip is proportionately rather smaller; in B and C it is exceedingly small, almost absent, and the small longus tendon arises almost directly from the general muscle. As for the differentiation of the brevis tendon of insertion into 'alpha,' 'beta,' and 'gamma,' it occurs in A, *a*, B, E, and F, the pectoralis slip forming a considerable portion of 'beta.' In the others the normal condition is attained, not passed.

Pectoralis slip.—In the simple pigeon-condition, as in fig. 2, Pec., the pectoralis muscle gives off two slips partly muscular and continuous at origin, and these run in almost equal proportions to the longus and brevis tendon. The general tendency is for the longus slip to weaken or disappear, and for the brevis slip to become an exceedingly sharply-marked round tendon passing under the deltoides patagialis, and ultimately forming part of the 'alpha' or 'beta' tendon. This ultimate condition recalls that common in Passerines, where there is only a single tendon running to the brevis. The longus part of the patagial is absent in B, C, D, and very short and slight in the others.

Deltoides major.—The series of progressive changes found among pigeons in this muscle are of very great significance and interest. They concern its insertion, size, and subdivision. Typically, the muscle is moderately well developed and is inserted for a varying distance down the humerus. In pigeons there are two grades in its development. In the first grade, as Fürbringer showed, the muscle tends to increase the length of its insertion until ultimately it reaches almost to the distal end of the humerus, where it may be pierced by the large nerve which supplies the forearm. This condition, represented in fig. 4 I, is shown at its maximum in most of the specimens of *Columba livia* which I have dissected, but in some specimens it has not been reached. Among the eutaxic pigeons it occurs in B. In the others, a second series of changes begin. In D the muscle is completely divided into two portions. The upper and smaller portion is inserted to the humerus near the distal end of the supracoracoideus muscle-tendon. In A, *a*, C, E, and F this first part is similarly separated off. The second part in D reaches down the humerus in the usual fashion, but is not actually divided by the radial nerve. In A and F the second part has reached right down the humerus and is pierced by the radial nerve. It is, however, very thin and attenuated, while the deltoides patagialis and anconæus are both unusually large. In E (fig. 4, II) the conditions are similar, but that part of the attenuated long division of the muscle which lies next the anconæus (D. 3) is partly fused with it, although it has a separate insertion. In C and *a* (fig. 4, III) the final stage has been reached. The distal parts of the long division of the muscle have apparently quite disappeared, but are represented actually by small slips which leave respectively the distal ends of the deltoides patagialis and the anconæus to be inserted on the distal end of the humerus on either side of the radial nerve. Thus all the eutaxic pigeons show extreme development of this muscle. In six of them it has passed beyond the development into stages of degeneration. It is interesting to notice that in the Passerines there is usually a similar complete division of the deltoid, but I do not know of the existence of stages of degeneration of the long division.

Fig. 4.



Deltoides muscle.

PAT. Delt. patagialis. S. Tendon of Supracoracoideus. D. Deltoides major. A. Anconæus scapularis.

I. *Columba livia.* II. *Columbula picui.* III. *Geopelia tranquilla.*

M. metapatagialis or *Expansor secundariorum.*—This curious slip, upon which so much stress was laid by Garrod, is obviously decaying among pigeons. In *Columba livia* it is extremely variable, nearly every condition from full formation to complete absence being present. Traces of it are more common than not among pigeons generally. In the eutaxic forms it is never well developed. Traces of it occur in *a*, B, C, and D; in the others, as in Passeres, it is completely absent.

At this point, I may sum up the evidence from the muscular structure of the wing in the eutaxic pigeons. They all exhibit high stages in the progressive changes to be found among pigeons, and in many of these changes they recall conditions to be found among the Passeres. I do not for a moment wish to suggest that there is any genetic relation between Pigeons and Passeres; but it appears to me that in many points the specialized pigeon-wing shows convergent resemblances to the specialized wing of Passeres. These convergences are peculiarly well marked among the eutaxic forms.

M. ambiens.—This muscle is one of the most interesting and variable structures among birds, and it is only natural to find that the conditions it presents among pigeons are variable and significant. It is impossible to doubt that the pigeons are among that great group of birds characterized by Garrod as Homalogonatæ, from the normal presence in them of an ambiens muscle. Among some Homalogonatous birds (as, for instance, Parrots, Herons, and Storks) the ambiens may be present or absent.

In a former paper (5) I showed that there may be found among Homalogonatous birds, apparently devoid of an ambiens, distinct vestiges of the former existence of that muscle. In another memoir (6) I was able to show that there occurred as individual variations in *Opisthocomus* almost every stage in the degeneration of the muscle, from complete presence to such reduced vestiges as I had described in Parrots and Herons. I do not think it open to doubt that the ambiens muscle is a normal and ancestral constituent of the musculature of pigeons, and that when it is degenerate or rudimentary or absent, such conditions are secondary. In the great majority of pigeons I have dissected it is present in the ordinary form. On the other hand, among the eutaxic pigeons it shows marked traces of reduction. In F alone is it present in the complete normal condition. In *a* and C it is present above the knee in an extremely reduced form; the usual channel through the fasciæ over the knee is absent and the slender tendon disappears. Below the knee, and quite unconnected with the upper part, there is an origin from the head of the fibula representing the usual accessory tendinous head, and from this slips go to the flexors of the toes. In D it is present, but very slender, above the knee, and does not cross the knee-joint, being completely absent below. In B and E it is quite absent above the knee, but below is represented by the fibrous rudiment from the fibula which I made known in Parrots and Herons. In A it is completely absent above and below the knee.

Thus the eutaxic pigeons show a strong tendency to degeneration in this muscle, which is generally present in a fairly well-developed form among diastataxic forms of pigeons. It is interesting to notice that in the eutaxic *Opisthocomus*, which in many respects resembles pigeons, the ambiens is degenerate.

M. peroneus profundus.—This muscle is very variable in birds, and is present in all pigeons; but in the eutaxic forms it is markedly degenerate.

Visceral Anatomy.

I have found no indications of very great importance from the point of view now under consideration. The oil-gland is absent in only one of them (C), but it is small in B and F. It is almost certain that the presence of large cæca is a characteristic of the more primitive forms of the gut in birds (7). In pigeons, generally, the cæca are on the wane, but in the great majority of forms they are definitely present as a pair of nipple-like structures. Among the eutaxic forms they are present in B, but extremely small and showing patches of dark pigment as are to be found frequently on degenerate organs. In C, according to Garrod, they are present; in the only specimen I have seen they were absent, so that it is probable that individual variation occurs. In the other five eutaxic forms they are totally absent. The gall-bladder is absent in all the eutaxic forms, and as it occurs in a comparatively large number of diastataxic forms, its absence may have some significance. In all the eutaxic forms, the gut shows the arrangement of coils and loops which I have described as typical for pigeons (7) in a strongly-marked form. In A, *a*, B, and F the middle loop, so characteristic of pigeons, is particularly long and shows the peculiar spiral twisting in of the parallel distal and proximal limbs in a strongly-marked fashion. So far as the viscera are concerned, it may be said with confidence that the eutaxic pigeons exhibit the typical pigeon-variations in a high degree.

Osteological Characters.

I have not yet proceeded so far with the collection and collation of osteological facts in pigeons as I have done in the case of the muscular anatomy, and I cannot speak with the same conviction as to primitive and ancestral characters, but there are a few definite points upon which the evidence seems to me more clear.

Anastomosis of Dorsal Vertebræ.—In pigeons, as in some other groups of birds, there is a marked tendency to anastomosis of some of the dorsal and posterior cervical vertebræ, with the result of giving a greater rigidity to the vertebral column. This anastomosis affects the vertebral centra, the neural arch, and the articular processes, and is the result of ossification of the ligaments, such as occasionally may be found in old specimens of almost any group. Typically, in pigeons three vertebræ, usually the three anterior dorsals, are anchylosed in this way; and I have not yet found in any diastataxic form a greater number of vertebræ affected. But among the eutaxic forms the fusion has proceeded further. In A, *a*, C, and F it affects four dorsal vertebræ, while in B, D, and E five are united. Similarly, the extent to which the ilia are increased by secondary ossification of the adjoining ligaments and membranes is on the whole more extensive in the eutaxic forms.

Another point of some little importance in pigeons, as in many other groups of birds, is the degeneration of the fibula. I do not think it can be doubted that a fully formed fibula is a primitive character, while degeneration implies secondary modification. This degeneration is usually accompanied by reduction of the deep or second peroneal muscle which springs from a varying area of the distal end of the fibula, and which shows special signs of degeneration among eutaxic pigeons. Beddard and Parsons have shown that the absence of this muscle among Parrots is a feature of systematic importance (8). In Pigeons generally the second peroneal is a strong well-developed muscle, and the ossification of the fibula extends almost to the extreme distal end of the tibia, where it is continued in a strong fibrous band. Among the eutaxic forms, the ossification is never so much as seven-eighths of the length of the tibia, and seldom so much. In A, *a*, B, C, and D it does not reach more than three quarters of the length of the tibia, and the whole bone is very degenerate, the characteristic fusion with the tibia towards the proximal end being specially well marked.

Supracoracoideal crest.—The supracoracoideus muscle (pectoralis secundus) is one which tends to become very highly developed among pigeons. It is well known that its insertion on a special ridge of the humerus is a peculiar feature of pigeon osteology. This ridge is specially well developed among the eutaxic forms, but it would be difficult to say more than that this special development of pigeon anatomy was well marked in them. On the other hand, there is a crest of origin for this muscle to which I cannot find that attention has been directed. In its fullest development it is a T-shaped crest, the stem of the T carrying out the line of the coracoid across the carina of the sternum at right angles to the long axis of that bony protuberance, and the cross-piece of the T lying parallel to the anterior edge of the carina, the lower limb running along the line on the carina which separates the insertion of the two pectoral muscles. This crest is extremely well developed in C, the ventral limb of the cross-piece extending nearly halfway down the carina (fig. 5). In all the eutaxic forms it is very well formed, while the extent of its development among diastataxic forms varies. It is just visible in *Goura* and *Calœnas*; it is well marked, so far as the stem of the T is concerned, in *Columba* and *Turtur*, and in pigeons generally it is noticeable, as in most Passeres. But in the eutaxic forms the stem is always very strong and the lower limb of the cross-piece well marked.

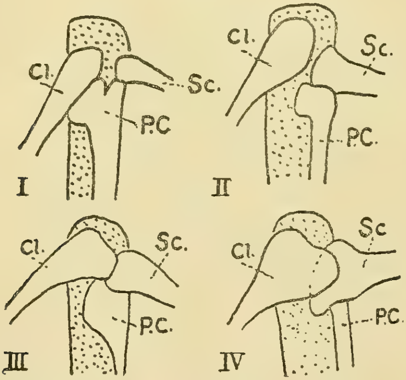
Fig. 5.

Starnœnas cyanocephala.—Carina of sternum, showing supracoracoideus crest.

Coraco-sternal articulation.—A primitive feature, familiar in reptiles, is that the coracoids should overlap at their junction with the sternum. This is well marked in some birds, and occurs occasionally among species of *Columba* and in individuals of *C. livia*. In birds generally the coracoids tend to be more and more separated at their sternal articulation. In most pigeons they either actually meet or are very close together indeed. Among the eutaxic forms they just meet in C and E; in the others they either do not touch at all or are well separated.

Angle of Scapula and Coracoid.—This angle varies with the development of certain wing-muscles, and on the whole varies inversely as the power of flight. While it is impossible to lay much stress upon it from the ordinary systematic point of view, it may at least be said that there is a close connection between wide angle and degenerate wings. The angle among pigeons varies considerably; among the eutaxic forms it is never more than 50 angular degrees, and generally is considerably less.

Fig. 6.



I. *Columba*. II. *Phlogœnas*. III. *Leucosarcia*. IV. *Corvus*.—Articulation at shoulder-girdle. The coracoid is dotted. *Cl.* Clavicle. *P.C.* Procoracoid. *Sc.* Scapula.

Procoracoid Process.—Fürbringer has investigated the procoracoid process and the relations of the scapula, coracoid, and clavicle with the greatest care, and has drawn a number of important conclusions from their conditions. It may be said generally that a large procoracoid articulating with the clavicle and a separation of clavicle and scapula are comparatively simple;

while in more specialized forms the procoracoid process becomes smaller, loses its connection with the clavicle, the latter developing an epicleideal plane which meets and may overlap the end of the scapula. In fig. 6 I, a comparatively primitive condition, as seen in *Columba*, and with minor details in most diastataxic pigeons, is represented. The procoracoid is large and articulates prominently with the clavicle, while the latter is not expanded at its end and is well separated from the scapula. In fig. 6 IV, the more advanced condition, as seen in a typical Passerine, is represented. The procoracoid is much reduced, and does not meet the clavicle. The clavicle is expanded at its end, and meets and overlaps the scapula. Among the eutaxic forms, the procoracoid is generally small and never meets the clavicle by a broad articulation, but is either free from it, as in B (fig. 6, II), *a*, C, and E; or just meets it above, as in A, D, and F (fig. 6, III), the junction being in a different place and due rather to the growth of the epicleideal plane than to size of the procoracoid. The clavicle among the eutaxic forms is either quite close to the scapula, on account of growth of the epicleideal plane, as in B (fig. 6, II), or actually meets it, as in the other eutaxic forms (fig. 6, III), while in all the diastataxic forms I have seen it remains separate.

Summary of Anatomical Argument.

When the anatomical differences between eutaxic forms and their diastataxic allies are compared, it appears that the eutaxic forms are on the average distinctly more specialized. If there is any general progress along special lines among pigeons, the eutaxic forms are well advanced. Their anatomical features appear to show that, if eutaxy be a derivative of diastataxy, it is at least a striking coincidence that in other respects eutaxic pigeons are more specialized than diastataxic forms. For my own part I am personally so much impressed by the evidence for the gradual modification of a whole group in the same direction, that I cannot avoid regarding the eutaxy of these pigeons as being simply a part of their general specialization.

Size and Eutaxy.—The eutaxic pigeons, like eutaxic birds generally, are small compared with their allies. A, *a*, D, and E are very small pigeons, B and C are moderately small, and F is the only fair-sized bird. They are certainly smaller than the sand-grouse, which would appear to be the nearest diastataxic allies of pigeons. But, unless one knew the size of the ancestral pigeon, it would be impossible to draw any strong argument from size; in a general way, it may be said that a large number of very primitive birds are large, while many of the most extremely specialized forms are minute, as among the Passeres.

Theory of the Origin of the Diastataxic Condition.

As my general argument involves the supposition that eutaxy is a derivative of diastataxy, it may be worth while to advance a speculation as to the reason why there should have occurred a gap in the wing of birds, and why that gap should be in a fixed position.

The first point upon which I wish to insist is that the quills are not different in kind but only in degree of development, as compared with other feathers. From a uniform covering certain individual feathers have become enlarged to serve the purpose of flight, instead of the more primitive purpose of protection. Precisely in the same way in the case of Elasmobranch fishes, from the general protective covering of toothed scales all over the body, certain individual scales or rows of scales become specially enlarged, and form series of exaggerated teeth, either at special points, as in the case of the dorsal spines of the spiny dogfish, or in rows along the dorsal surface of the tail, as in some skates, or in one or more rows along the edges of the jaws where the external skin folds in to form the stomatodeal lining of the mouth, when such rows are developed. It may fairly be taken for granted that birds had feathers or feather-like scales before they had quills, as quills are simply exaggerated feathers, and that the quills are simply rows of extremely developed feathers.

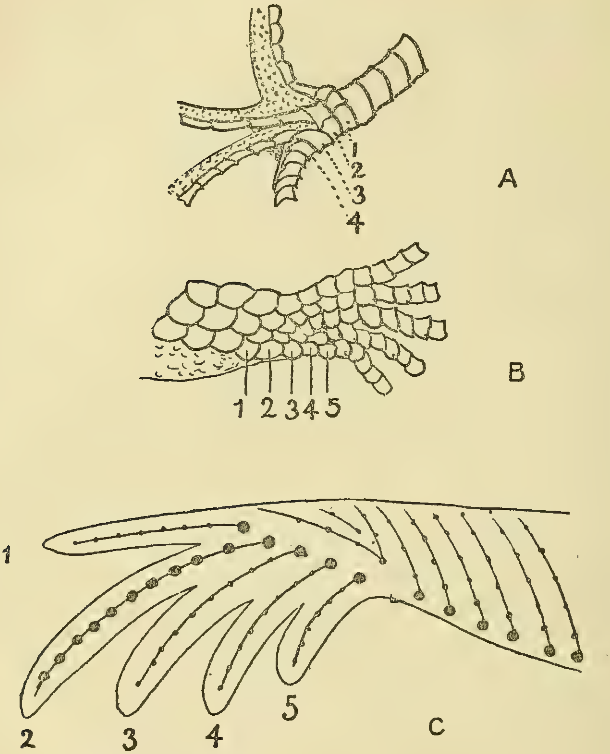
When rows of large structures follow body contours, as in the case of true teeth, caudal spines, or quills, the series appear to possess a longitudinal coherence and integrity which may be fallacious. If pins be placed vertically on diagonal lines crossing the surface of one of the irregular stuffed cushions familiar on old fashioned toilet-tables, the pins which happen to lie along the contour edge appear to have a special symmetry with regard to these contours, and could we imagine these pins to increase in length because of their position, it would be difficult to avoid supposing that the long contour pins were planted specially in a contour row. In the feathering of a wing two series of rows are evident, the intersections of the rows forming a diamond pattern, most conspicuous on the surface of a plucked wing. One series is horizontal, or at least more or less parallel to the contour of the ulnar edge. Of these horizontal series, the rows of quills and of major and second and third coverts are most obvious, partly because of the large size of the individual feathers, but these horizontal rows are much more difficult to trace outside above the larger feathered rows. The other series run rather diagonally to the ulnar edge and are starting upwards and with a forward slope from the quills. They are very beautifully seen in some of Mr. Pycraft's figures (9. plate xxiv.), but are obvious enough in most wings. These diagonal rows run round the surface of the wing posteriorly almost at right angles to its long axis, but anteriorly with an increasingly forward inclination, to which I shall presently refer. They resemble the general disposition of colour-markings or scales on a cylindrical surface which usually occur as hoops running round it; and it appears to me that the apparently longitudinal rows are composed of members of the transverse rows at different levels, being in fact simply the enlarged individuals of the transverse rows which come to lie on the ulnar edge.

In actual development in the wing of the chick, it is true that the two great horizontal rows which are to form the quills and the major coverts appear first as longitudinal rows. It is only when these become obvious, and when one or two other longitudinal rows appear from before backwards, that the diagonal rows begin to be marked. Later on these latter acquire increasing coherence until the adult stage is reached. I am not, however, prepared to attach great importance to this early ontogenetic appearance of the longitudinal rows as such. In the first place, considering what we know of the extraordinary accelerations and retardations that occur during larval development, it would appear to be pushing the recapitulation theory to a ridiculous point, to attempt to found a theory of the ancestral nature of the rows from the order of their ontogenetic appearance. Secondly, there is a very obvious reason for the early appearance of the quill-rows. These and the coverts are much larger than the other feathers; they take longer to grow and must begin first; they are more important to the future bird, and early provision must be made for them.

I suggest that the quills, although appearing to be a horizontal row, are really different members of diagonal transverse series.

There now remains to suggest an explanation of the origin of the gap. In a general way, morphologists have been inclined to regard simple series, as in the case of metameric repetitions, as more primitive than discrete and incoherent series; but in a number of cases, as for instance in the nephridia of earthworms, it would appear that the diffuse condition is simpler and more primitive than the orderly repetition found in the common earthworm. I think we have learned to be on our guard against taking for granted that an apparently simpler condition is in reality more ancestral, and that we should approach the problem of the diastataxic gap without any prejudice in favour of its being secondary. Whether it be secondary or primitive, we have to account not only for its existence but for its appearance in a definite place after five quills. If the primitive condition were eutaxic and the gap produced in a whole series of different birds by secondary lengthening of the wing, we should have to explain why this lengthening always occurred after five quills. If we think of the gap as being primitive, there is no difficulty whatever in supposing that convergent closing should have occurred independently in any number of groups, or even of species and genera; and I think it is not difficult to form some idea as to how a gap in that position might have come into existence in an ancestral wing. Consider an ancestral pentadactyle wing provided with scales or scale-like feathers. The most common arrangement of these, as may be seen by looking at the scales on any lizard or crocodile or on the feet of birds, is that longitudinal rows should run along the digits and diagonal transverse rows should surround the arm. Now these two series have to meet somewhere, and when different series of scales or markings meet, there must be a transition of some kind from one to the other. Sometimes one set of series gives way to the other; sometimes there is intercalated between the two a wedge-shaped set of rows, as Professor D'Arcy Thompson pointed out to me in the case of the markings on the zebra. In the foot of a bird (fig. 7, A) the transverse rows are represented by large single scutes in many cases, while a line of enlarged scutes may run down each digit. Where the digit-scutes come in contact with the other series, they may run down parallel with them and appear on the distal edge of the tarsus. In the arm of a lizard (fig. 7, B) the interference is more strikingly apparent, there being along the distal edge five scales which are in series with the digital rows, and there is an abrupt transition from these transverse rows to the modified digital rows. In fig. 7, C represents diagrammatically a simple mode of feather-distribution on a pentadactyle wing which would result in a gap. Rows run along the digits, and where these meet the transverse rows a wedge-shaped piece is intercalated, forming the transition. I

Fig. 7.



A. Foot of a Passerine bird. B. Hand of a Lizard. C. Diagram of scales or feathers on a hypothetical ancestral bird's wing. The quills of modern birds are represented by darker spots.

have put larger dots to represent the actual quill-series of modern birds. The primaries are the enlarged series of the index digit; the carpal remex belongs to the pollex series; the next four secondaries belong to the digital series of the four digits; then comes a diastataxic gap due to the alteration of curvature (as in the transition from the neck to the body series in a Burchell's zebra) being bridged over by a wedge; then follow the other secondaries, which are members at different levels of the succeeding diagonal rows. Naturally this supposition is entirely theoretical, but it is enough to show that the occurrence of a gap after five quills is a phenomenon which might have arisen in a very simple fashion.

So far as the underlying bones are concerned, the gap in my diagram occurs much more distally than in the adult ordinary bird. I do not think, however, that this presents the slightest difficulty. We know that ontogenetically and phylogenetically the wing of birds elongates. Actually in development the feather-papillæ shift along the wing. Superficial skin-areas generally are exceedingly primitive in their character, but may shift almost indefinitely in their topographical relation to underlying structures. In the human body, these changes of skin-area in topographical position have been worked out in relation to the phenomena of referred pain.

Eutaxy and Diastataxy in Aves generally.

I am not at present prepared to extend the argument from the Columbæ to birds in general at length. But I may point out that there is a general parallel to be found between the relations of eutaxy among Columbine forms and the relations of eutaxy among birds generally. In Columbine forms the majority are diastataxic, and the few eutaxic forms are isolated among their diastataxic congeners. Among the great groups of birds most are diastataxic. We may leave out of consideration the Struthious birds and the Spheniscidæ, as in these the wing is so greatly modified as to make any comparisons misleading, especially as we cannot be certain whether the modifications are from a high, or from a very low type of wing. As for the other eutaxic forms, the great majority of anatomists would agree that the Passeres were extremely specialized birds, and therefore forms in which, if diastataxy be primitive, one would not expect to find it. Similarly the Pici, the Cuculidæ, and *Opisthocomus* are birds in which one would not readily look for primitive features. *Opisthocomus* is an exceedingly peculiar and specialized form. Among the Ralline birds generally, the three eutaxic forms *Psophia*, *Dicholophus*, and *Rhinochetus* present many striking peculiarities which are not generally regarded as primitive, and anatomists generally have regarded them as modified forms of the diastataxic Gruidæ. There remains the great group of Gallinaceous birds, which in many respects, such as the alimentary canal and the completeness of the muscles, present primitive features and are yet eutaxic. On the other hand, they are specialized in the sternum and in the vertebral column. The Anseriformes, which are diastataxic, are quite as primitive in their muscular structure and less specialized in the sternum and vertebral column, while among them are to be found the Palamedeidæ, certainly archaic forms, and sometimes regarded as forming a link between the typical Anseriformes and the Galli. These are diastataxic, as primitive as the Galli in muscular anatomy, more primitive osteologically, and with alimentary canals displaying what appears to be an exceedingly primitive disposition. So far as a general survey goes, there is nothing against and a good deal in favour of supposing that diastataxy is architaxic in Aves generally.

The Alcedinidæ and the Cypselidæ are groups in which, as in the Columbæ, some members are eutaxic, while the others are diastataxic. I have not had an opportunity of dissecting a sufficient number of these forms to obtain an idea as to which condition of the wing is associated with greater specialization.

Summary.

The Columbæ, which have been regarded hitherto as a diastataxic group, have several members with the eutaxic condition. Comparison of the feathering in these forms makes it probable, or at least plausible, that the eutaxic condition has been attained by closing up of the gap, with first crowding, and then disappearance, of two of the three feathers occupying the primitive gap. Intermediate stages between true wide-gapped diastataxic forms and true eutaxic forms occur. Comparison of the anatomy of the eutaxic forms with that of the diastataxic forms shows that the former are on the whole more advanced in the general progressive modification of the whole group. It is easy to show that in a hypothetical pentadactyle wing a gap in specialized rows

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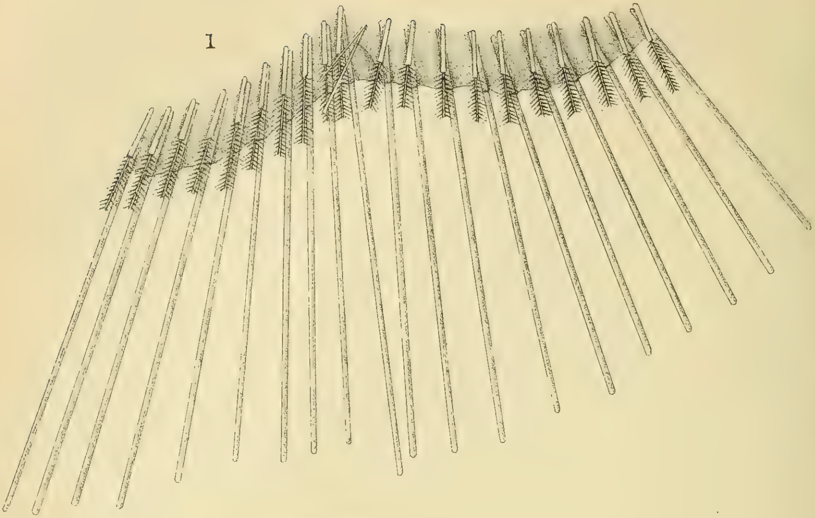

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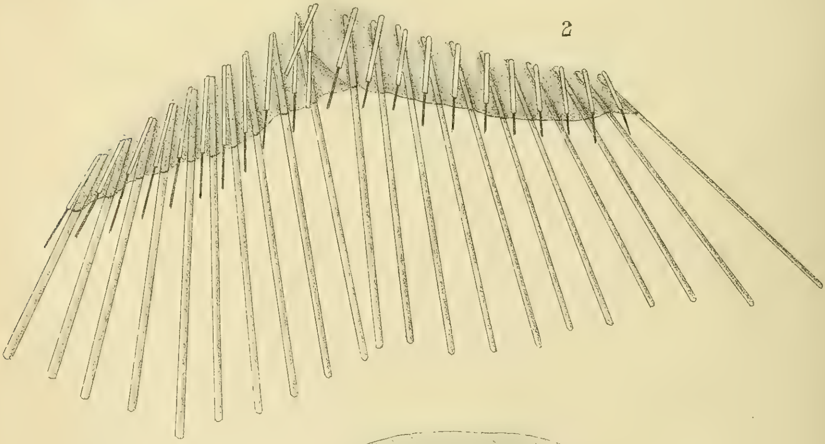

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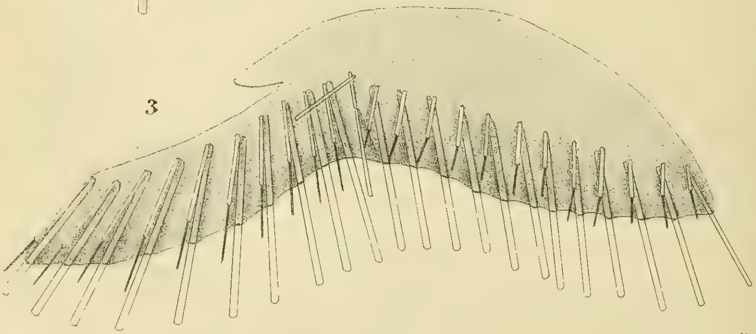

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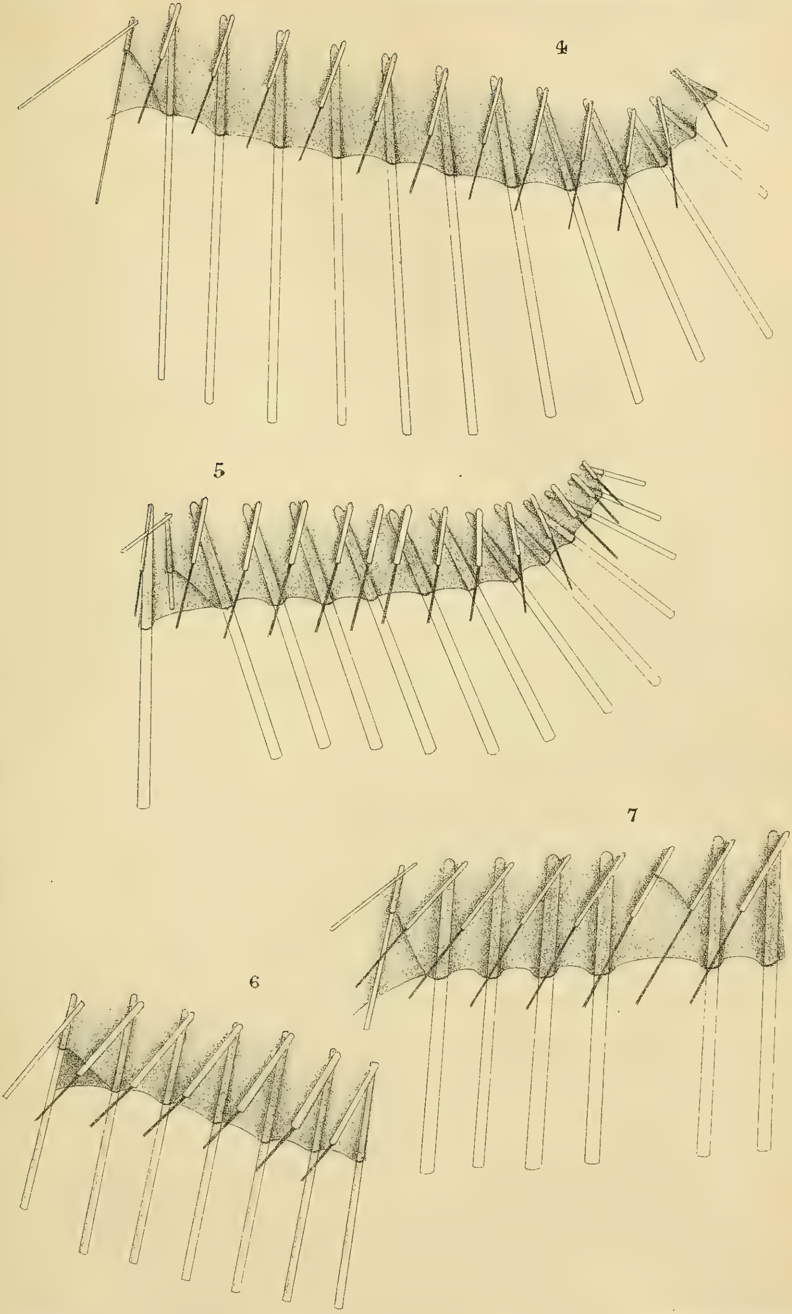
QUINTOCUBITALISM IN THE WING OF BIRDS.

Mitchell. Linn Soc. Journ. Zool. Vol. XXVII. Pl. 13.



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QUINTOCUBITALISM IN THE WING OF BIRDS.

of incipient quills might arise in the position required for the diastataxic gap. Among Aves there is a general correspondence with the conditions among Columbæ. The diastataxic condition of the wing is primitive among birds; it is the architaxic condition. By closing up of the ranks any architaxic wing may become eutaxic, and this change has been made by some whole groups and by individuals of other groups.

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(8) Beddard & Parsons.—"On certain Points in the Anatomy of the Parrots." P. Z. S. 1893, p. 507.

(9) Pycraft.—"A Contribution towards our Knowledge of the Morphology of the Owls." Trans. Linn. Soc., Zool. vol. vii. (1898) p. 223, pls. xxiv.–xxix.

EXPLANATION OF THE PLATES.

Plate 12.

Fig. 1. *Geopelia cuneata,* left wing: showing primaries and coverts, carpal remex and covert, and even series of secondaries and coverts; no gap, Eutaxic condition.

Fig. 2. *Leucosarcia picata,* left wing: showing primaries and coverts, carpal remex and covert, and even secondary series without gap. Eutaxic condition.

Fig. 3. *Geophaps plumifera,* left wing: showing the primaries and coverts, the carpal remex and covert, the secondaries and coverts without a gap, Eutaxic condition.

PLATE 13.

Fig. 4. *Columbula picui*, left wing; carpal covert and remex; series of coverts and secondaries: showing the eutaxic condition.

Fig. 5. *Geotrygon montana*, left wing; 1st primary; carpal remex and covert; series of secondaries and coverts: showing reduced diastataxic condition.

Fig. 6. *Starnœnas cyanocephala*, left wing; carpal remex and covert; six secondaries and coverts in even series. Eutaxic arrangement.

Fig. 7. *Turtur chinensis*, left wing; carpal covert and remex; four secondaries and coverts; diastataxic gap with covert; two secondaries with coverts.

Some Facts concerning the so-called "Aquintocubitalism" in the Bird's Wing. By W. P. PYCRAFT, A.L.S.*

[Read 16th March, 1899.]

(PLATES 14–16.)

CONTENTS.

Introductory Remarks.

THE feathers in the typical bird's wing, *e. g.*, the Common Fowl, are divisible into two groups—tectrices or coverts, and remiges or flight-feathers, commonly known as "quills."

The remiges form a single row of feathers running along the post-axial border of the wing from the tip of the index-digit inwards to the elbow-joint. Those of the hand constitute the primaries, those of the forearm the secondaries. With the primaries we have little or nothing to do in this connection; suffice it to say that they never, in the Carinatæ, exceed 12 in

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* *Cf.* Editorial footnote on p. 21

number. The number of the secondaries varies greatly from 9 to 37. Though the primaries are packed closely together at their bases, the secondaries are more or less widely spaced (Pl. **14**. fig. 5). The exigencies of flight demand this.

The tectrices are separable into several distinct series, forming the major, median, minor, and marginal coverts, to which may be added the *ala spuria*, the *hypopteron*, and *parapteron*. With these last we have nothing to do now. The tectrices clothe the dorsal and ventral surfaces of the wing. The major coverts are the most post-axial, and are seated in pairs on the bases of the remiges—two to each remex, one dorsal and one ventral—to which they are firmly attached. The median form the row next in front of the major coverts, both on the dorsal and ventral surface. There is never more than one row on the dorsal or ventral surface. The minor lie beyond the median coverts, and vary from 1 to 4–5 rows on both aspects of the wing. Beyond these are the marginal coverts; they occupy the pre-axial border of the wing, and help to clothe both the dorsal and ventral surfaces.

A reference to Pl. **14**. fig. 5 will make this much more clear than mere description. Questions concerning the overlap, variations in the number of rows of minor and marginal coverts, their length, the absence of more or fewer of these rows on the arm or manus in different groups, need not be discussed here. One point, however, is noteworthy. Sundevall (7), and later, and more correctly, Wray (8) pointed out that the major and median coverts of the ventral aspect of the wing turn their ventral surfaces downwards as do the remiges, and not *upwards* as do all the other coverts of the under surface. Wray's interpretation of this was, that these feathers had been slowly carried round from the dorsal surface of the wing, whilst the tectrices of the under surface were separately derived from the ventral surface of the body.

Eutaxic and Diastataxic Wings.

The Bird's wing may assume one of two forms, known hitherto as (1) the Quintocubital, and (2) the Aquintocubital (p. 238). The two may readily be distinguished. In the former, each pair of secondary major coverts embraces a remex between them; in the latter, the remex from between the 5th pair of coverts is apparently missing—hence the name "aquintocubital." The perfectly regular arrangement of the coverts in such a wing, and the presence of a more or less distinct gap between the 4th remex and that next succeeding it, seemed to justify the conclusion that a remex had been lost—that the wing had undergone a reduction of the original number of its remiges by the loss of the 5th quill. The aim of the present paper is to show that no such loss has taken place. The 5th remex has lost its original relations, but *not* its existence.

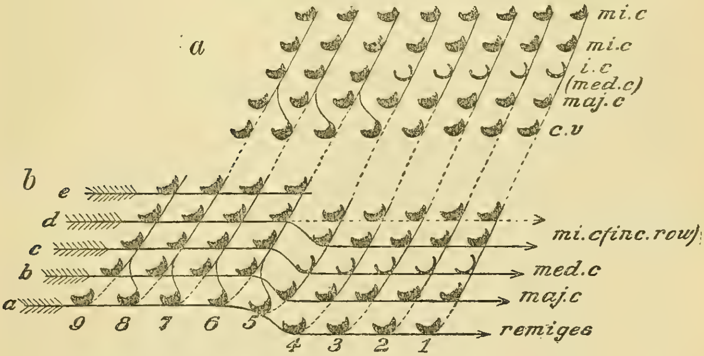
Before proceeding further, it will be well to say a few words concerning the terms which have been proposed as substitutes for the older and less exact " Quinto- " and " Aquinto-cubital." At the time this paper was read the names Stichoptylic for the former, and Apoptylic for the latter were used. These were suggested to me by Prof. E. Ray Lankester, and were certainly preferable to those which we both desired to supplant. But it will be remembered that Mr. P. Chalmers Mitchell, in the course of his paper dealing with this same question, suggested the names Eutaxic for the quintocubital or stichoptilic form, and Diastataxic for the aquintocubital or apoptilic. His names not only have priority over mine, or, rather, Prof. Lankester's (his paper having been read before mine), but they are, I think, actually preferable; hence, throughout this paper, I shall adopt the terminology proposed by him. Moreover, by doing this I shall be rendering a service to my readers, by saving them the labour of keeping in mind the values of some half-dozen names for what may be called the positive and negative of one and the same thing.

The Embryo Wing.

In all wings, the feather rudiments appear first along the post-axial border of the wing; those representing the remiges and their major coverts appearing simultaneously, and sometimes together with very faint traces of one or more of the pre-axial rows representing the median and minor coverts. At this stage, it is often not possible to say whether a wing will ultimately prove eu- or diasta-taxic. The change takes place, however, generally at the close of this phase of development. As the rudiments of the median and minor coverts become more distinct, it will be noticed that the papillæ representing the remiges 1–4 no longer form an unbroken series with those running from this point inwards, but that they have moved backwards and downwards; sometimes this is very marked, sometimes only very slightly so. The hitherto unbroken series now becomes more or less distinctly divided into two portions, thus :—· · · · · · . . . .; at the same time, it is noticeable that this shifting of the outer remiges backwards may also be accompanied by an outward movement towards the tip of the wing. Sometimes all four remiges participate in this outer movement, sometimes only the 1st or 1st and 2nd become notably disturbed.

The movement of the remiges is in all cases accompanied by a corresponding movement on the part of the coverts associated therewith, from the post- to the pre-axial border. The result, when the wing is viewed as a whole, seems to show that a process of "faulting" has taken place, the major, median, and one or more rows of minor coverts from 1 to 5 in each row having slipped backwards so as to break the connection with their several rows proximad of this point; each row—or, more correctly, the first 3 or 4 rows—now runs, not in a continuous line with that of its series, but between this and that immediately behind it (fig. 1, *b*). The disturbed rows, however, seem to readjust

Fig. 1.



Shifting of wing-coverts and remiges. *a*, before; *b*, after.

themselves very quickly so as once more to form continuous lines with the more proximal feathers; as, in the typical diastataxic wing, it will be found that, not counting the remiges, uniformity is regained at the 4th row, or rather a semblance of uniformity, inasmuch as this row is really made up of two rows. This is shown in the diagram (fig. 1, *b*). Here the 3rd row of these downwardly shifted coverts appears as an intercalary row, the 4th row becoming continuous with that of the

5th, thus affording at the same time evidence in favour of the view adopted in this paper, that all these coverts have shifted backwards. Pl. **15**. fig. 1 represents the wing of an embryo Pigeon showing this intercalary 3rd row very clearly.

Only one row of ventral coverts appears to participate in the general disturbance which we have traced on the dorsal surface in connection with this backward and downward motion of coverts 1–5 and remiges 1–4. This is well seen in fig. 3, Pl. **14**, representing a ventral view of the wing of an embryo *Machetes pugnax*.

Before passing on to consider what is, apparently, the only possible objection to the explanation of the phenomena here set forth, I would draw attention to the accompanying diagrams.

Fig. 1 *a* (p. 239) represents the arrangement of the cubital coverts and remiges in the eutaxic wing as far inwards as the 9th remex. Fig. 1 *b* shows the effect of a backward and outward shifting of remiges 1–4 and coverts 1–5 from the major coverts forwards; *i. e.*, a portion of each horizontal row of coverts from 1–5 from the major coverts forwards to the tectrices minores, thus converting the eu- into the diasta-taxic wing. The bending of the horizontal lines serves to indicate the amount of shifting which the remiges and coverts have undergone. The arrow "*d*" has been made to "dip" like the arrows *a*, *b*, *c*, so as to indicate the amount of shifting of each row; it has also, by means of a dotted line, been made to pass straight outwards to indicate the restoration of parallel series. But it must be remembered that these restored rows are composed of feathers belonging to two different rows. Thus coverts 1–5 of the 2nd row of minor coverts now become serial with the coverts of the 1st row from the 6th inwards, the coverts 1–5 of the 1st row having been cut off to form a series by themselves—the intercalary row. This intercalary row actually obtains in a more or less well-developed form in all diastataxic wings, and this diagram enables us to see how it may have come into existence. In so far as the diagram is concerned, it is perfectly true that the 1–5 coverts of the median row could equally well be regarded as an intercalary row. The size and position of these feathers in the adult probably account for their retention in the series to which they belong. The row (1–5) immediately in front are smaller and more easily isolated; hence these in the adult become the intercalary row.

The diagram just described (fig. 1, *a*, *b*), to show how the eu- may have been transformed into the diasta-taxic wing, can be readily constructed by the reader by laying over fig. 1 *a* a piece of transparent paper and marking over remiges 1–4 and coverts from 1–5 in each row. This being done, shift the paper backwards and slightly forwards so that the major coverts 1–5 come to lie parallel with the interspace between the remiges and major coverts proximal to 5, as has been done in fig. 1 *b*. This gives the two broken rows of coverts (major and median) and the intercalary row (3), which exactly agrees with actual wings (*e. g.*, Pl. 15. fig. 1).

Inasmuch as by this artificial mechanical shifting and rearrangement of the feathers of the anterior end of the dorsal aspect of the forearm, all the features of the diastataxic wing can be demonstrated, it may be reasonably contended that a strong degree of probability has been brought forward in support of the view that the phenomena of diastataxy are due to a backward and downward shifting of the remiges and their coverts.

Summary of the foregoing Remarks.

To summarize briefly, the contention of the present paper is:—

(1) That there is no evidence in support of the hypothesis that diastataxy is due to the absence of a remex.

(2) There is a very considerable amount of evidence to show that a process of shifting has taken place of the coverts and remiges at the distal end of the forearm. This has resulted in carrying remiges 1–4 and the first and each succeeding horizontal row of coverts from 1–5 backwards and slightly downwards and outwards. Thus the original relations between the 5th major covert and its remex have been disturbed, the covert having shifted away from its remex, which has now become associated with the 6th covert. Thus the 5th, together with its ventral covert, appears to have lost its remex.

(3) The cause of this shifting is still a matter for investigation; it is possibly due to a slight secondary lengthening of the forearm.

Evidence in support of the above Conclusions.

We will now proceed to review the evidence in support of the hypothesis just submitted.

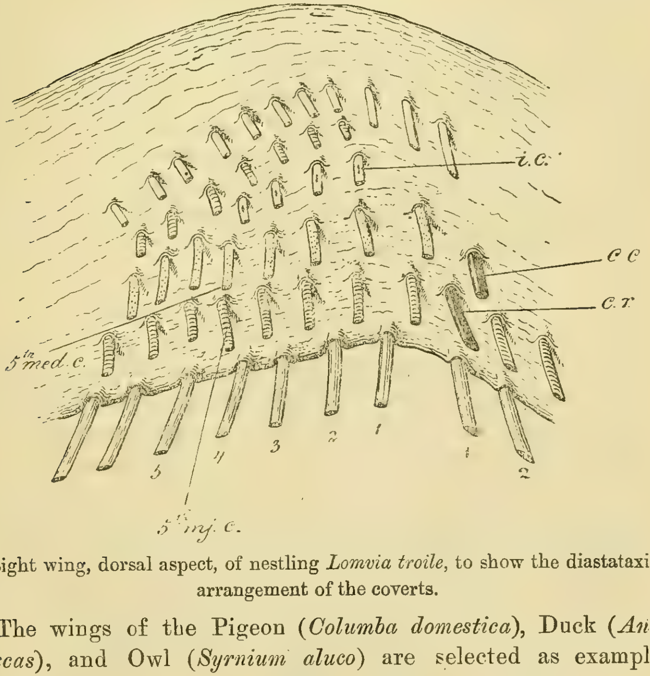
What follows has reference only to the developing remiges, and their coverts, of the forearm; those of the hand need not be taken into consideration in this connection.

In the eutaxic wing of the Common Fowl the earliest traces of feathers are those representing the remiges and their dorsal major coverts (Pl. **14**. fig. 4). These form a double row along the post-axial border of the wing, the major coverts lying opposite the interspaces of the remiges, the ventral row of major coverts and the dorsal median and minor coverts appearing somewhat later, and the marginal last of all (Pl. **14**. fig. 4). The arrangement of the median and minor follows that of the major coverts and remiges, so as to form a series of alternating rows, the feather rudiments of one row lying opposite the interspaces of the row in front of, and behind it. By the time the full complement of rows has been attained, however, this primitive arrangement in horizontal rows is somewhat masked, and the feather-papillæ appear rather to run in oblique rows sloping either from without inwards or *vice versa*, according to the view of the observer; but, as will be seen later on, when examining wings of other forms the obliquely-inward slope becomes finally adopted.

The wing of the Lapwing (*Vanellus cristatus*) (Pl. **14**. fig. 1) agrees with that of the first stage (described above) of the Common Fowl in having only two rows of feather rudiments along the forearm, and, like this, it is also eutaxic. That is to say, no shifting has as yet taken place. The fifth major covert is not yet divorced from its remex. In a much later stage (Pl. **14**. fig. 2) this severance has taken place: the wing is now diastataxic. Unfortunately, I have no intermediate stages between this and fig. 1. It is of interest to note, that the downward shifting in this case must have been but slight, as the intercalary is the 2nd and not the 3rd row of coverts, as was the case in the typical wing described on p. 239. Moreover, the feather rudiments seem to have travelled forward, inasmuch as the 1st cubital remex now lies on a level with a line drawn through the proximal end of the manus in front of the carpus; whilst in the younger stage the 1st remex lies proximad of this imaginary section.

The wing of the embryo Guillemot (*Lomvia troile*) (Pl. **15**. fig. 2) is one of the most valuable of the whole series now in my possession; earlier stages than this are much to be desired. Here the remiges and major, median, and two (with faint traces of more) rows of minor coverts are all represented, but, as yet, the wing is undoubtedly eutaxic, though soon after this stage it becomes diastataxic. A foreshadowing of this is plainly visible at the stage under discussion. A reference to Plate **15.** fig. 2 shows that the remiges 1–4 have already begun to move backwards through a small arc of a circle, the movement having been greatest at the distal end of the row, whilst the proximal end, represented by the 4th remex, has as yet scarcely moved at all. It may be expressed thus , the black line representing the original and the dotted line the new position. The disturbance is much more obvious in the row of papillæ immediately above the remiges—the rudimentary major coverts 1–5. These have become distinctly separated from the rest of the row proximad of this point. The disturbance of the rows preaxial to this of the major coverts is barely perceptible. There is yet no intercalary row. I have no stage between this and that of the nestling (woodcut, fig. 2).

Fig. 2.



Right wing, dorsal aspect, of nestling *Lomvia troile*, to show the diastataxic arrangement of the coverts.

The wings of the Pigeon (*Columba domestica*), Duck (*Anas boscas*), and Owl (*Syrnium aluco*) are selected as examples of typical embryonic diastataxic wings. In earlier stages of these we must seek for confirmation of the course of development outlined in the case of the Plover and Guillemot.

In the Pigeon's wing (Pl. **15.** fig. 1) the feather rudiments have arranged themselves in strongly marked transversely-oblique rows sloping inwards and presenting a strongly curved front towards the distal end of the wing. As yet, there are but faint traces of the marginal coverts. It is noteworthy that the transverse rows of coverts from 1–5 are more widely separated one from the other than is the case with the more proximal rows. The downward shifting of the anterior remiges and their coverts (1–5) is very marked. The intercalary row is the 3rd. This last is well seen in the wing of the nestling (Pl. **16.** fig. 1).

In the wing of the Duck (*Anas boscas* var. *domestica*), Pl. **15.** fig. 3, the intercalary is formed by the 3rd row of coverts, *i. e.* 1–5 of the minor coverts. There are faint traces of several more rows in addition to those in the figure. Compared with the adult wing, one very striking fact becomes apparent. It will be noticed that in the embryo wing (Pl. **15.** fig. 3) the 1st median covert—that lying immediately above the first cubital remex and its major covert—lies over the base of metacarpal II., whilst the 2nd median covert lies just below the angle between the carpus and the distal end of the ulna. In the adult this spot comes to be occupied by the 1st median covert, that is to say, it apparently supplants the 2nd and takes its place. From this it would seem that we have indeed evidence of an increased lengthening of the forearm which can be measured by the distance from the 2nd to the 1st median covert.

A possible Objection.

Diastataxy, as we have endeavoured to show, is due, not as was supposed, to the loss of the 5th cubital remex, but to the shifting of the remiges and coverts lying to the outer side of this. The ultimate fate, however, of the remex in question has so far only been hinted at. *Exactly* what takes place during this shifting is difficult to make out, and will only be possible after a larger series of embryos have been examined. This much, however, seems certain,—that all the covert-feathers of the wing from the 6th inwards have moved outwards, one place, in the form of a series of obliquely transverse rows. Thus the transverse row which originally belonged to the 6th remex now becomes associated with the 5th, that of the 7th remex with the 6th, and so on. A reference to the diagrams will make this clear.

At first sight, this outward movement seems to make rather a large demand upon the imagination, and to this extent to throw doubt on the interpretation of the facts recorded in this paper. The difficulty, however, is more imaginary than real. It simply means that the remiges in question become associated with transverse rows immediately in front instead of with those next behind. This must certainly happen in the case of the Guillemot's wing. In the Duck and Pigeon's wings (Pl. **15**. figs. 1 & 3) this forward movement has already taken place. The ventral major coverts from the 6th inwards are subjected to the same forward movement as those of the dorsal surface. Thus the 5th remex lies between the 6th pair of major coverts, 6th remex between the 7th pair, and so on. The position of the ventral coverts 1–5 in these figures will illustrate the downward—ventralward—shifting of the feathers in this region.

The Carpal Covert and Remex.

A fixed point of no small value in the present connection is that afforded by the two feathers known as the carpal covert and the carpal remex (Pl. **14**. fig. 2, *c.c.*, *c.r*); inasmuch as, since they occur in wings of both types, they serve as valuable landmarks, and show, moreover, that the disturbance is to be sought for proximad of this point, and thus help to confirm the contentions of this paper. The significance of these feathers has been discussed by Wray (**8**), the present writer (**5**), and by Degen (**1**), who bestowed on them the names Carpal covert and remex, from their position on the carpus. Although feeling by no means certain on this point, I think the probability is that the "remex" is really correctly so named, and that it represents a feather more or less completely dwarfed and in course of disappearance. Its office—as a remex—has not entirely ceased. It is probably being slowly crushed out of existence by reason of its position, which is in the angle of the wing caused by the folding of the hand on the forearm. The 1st cubital remex of the Gallinæ is, like its carpal remex, and for the same reason, undergoing a similar process of reduction.

Explanations of Diastataxy.

The first recorded reference to diastataxy is that of Gerbe (3), who describes it in the following words :—"Chez les Rapaces, les Pigeons, les Échassiers, les Palmipèdes, il y a atrophie complète de l'une des remiges secondaires, et cette atrophie, qui paraît être originelle, porte invariablement sur la cinquième. Ses satellites, c'est-à-dire, sa couverture supérieure et sa couverture inférieure, prennent un développement normal et occupent leur place respective, comme si elles accompagnaient la penne qui fait défaut.

"Ni les vrais Passereux, ni les Zygodactyles (les Perroquets exceptés) ne présentent cette singulière anomalie."

My friend and late colleague, Mr. E. S. Goodrich, the Aldrichian Demonstrator of Comparative Anatomy at Oxford, took part with me for some time, in this investigation, and also formulated a theory of his own to account for the conditions which have been described and figured in this paper, and in justice to him, as well as because of its intrinsic value, I propose to endeavour to describe his theory here.

Briefly, he holds that the phenomena of diastataxy are due to a bifurcation of a row of feather-papillæ, probably the second —major coverts—starting at what is now the 5th major covert. Thus a double row was formed representing the present major and median coverts 1–5. This theory does not demand either shifting of remiges or coverts. Supposing the shifting of the former be proved, the presence of this "intercalary row," as he termed what are now major coverts 1–5, is still more easily understood. They have appeared to fill up the space between the row immediately in front and the remiges behind. Bifurcation of this kind occurs in the scale-covered forearm of Reptiles for instance : or, again, in the form of additional rows of ossicles in the manus of Ichthyosaurs.

Yet another attempt to solve this mystery is that of Degen (1). Though none will grudge this writer the credit of having evolved a very ingenious hypothesis, few probably will be found willing to adopt it. Degen carries us back to an imaginary quadri-dactyle manus in which each digit supported a set of remiges and major coverts. In course of time the 4th digit became suppressed and its remiges, 3 in number, migrated inwards on to the ulna—ousting the cubital remiges 1–3. Next, the remiges of Digit II. moved inward on the ulna. Originally there were five of these, but the 5th, lying in the carpal angle between the bases of Metacarpals III. and IV., became suppressed,—just as occasionally happens in the case of the “carpal remex.” The coverts of this suppressed 5th remex were retained. Feathers 1–4 only remained to migrate on to the ulna. The 5th is now only indicated by its coverts,—hence the diastataxic wing. The carpal covert and remex of existing birds represents the short 1st remex and covert of Digit III., which has travelled inwards along Mc. III. to rest finally on the carpal joint at the base of Mc. II.

Exceptions.

The wings of all birds are either eu- or diasta-taxic. Moreover, there is no known exception to the rule that, though a genus may include both forms of wings, it will be found that the species constituting that genus will group themselves, invariably, into two sections—those with eu- and those with diasta-taxic wings; for, as yet, individual variation in this particular is unknown. Therefore, the wing of any given species being found to be diastataxic, it may be certainly predicted that every individual of that species will also be diastataxic, and *vice versa.*

Amongst the Carinatæ there are certain large groups every individual member of which, so far as is known, has diastataxic wings. These are:—

Pygopodes = Divers, Grebes.
Tubinares = Petrels, Albatrosses.
Herodiones = Herons, Storks.
Steganopodes = Cormorants, Gannets, Frigate-birds.
Phœnicopteres = Flamingoes.
Anseres = Swans, Ducks, Geese, Screamers.
Accipitres = Eagles, Hawks, Vultures, and Secretary-bird.
Ralli = Rails.
Limicolæ = Curlews, Plovers, Sandpipers, Auks, Gulls.
Pterocletes = Sand-Grouse.
Megapodes = Mound-builders.

To these may be added :—

Psittaci = Parrots.
Striges = Owls.
Caprimulgi = Nightjars and Oil-bird.

Similarly the following are eutaxic :—

Tinami = Tinamus.
Galli = *Crax*, *Phasianus*, *Gallus*.
Turnices = Hemipodes.
Opisthocomus = Hoatzin.
Coccyges = Cuckoos, Plantain-eaters.
Coraciæ = Rollers, Bee-eaters, Motmots.
Bucerotes = Hornbills and Hoopoes.
Trogones = Trogons.
Colii = Colies, or Mouse-birds.
Pici = Woodpeckers.
Passeres = *Eurylæmus*, *Pitta*, *Tyrannus*, *Menura*, *Atrichia*, *Corvus*.

The remainder of the Carinatæ contain more or fewer exceptions—both eu- and diasta-taxic forms :—

Grues = Cranes, Trumpeter, Seriema.
Columbæ = Pigeons.

The Grues may be considered as a diastataxic group, the exceptions being :—

Dicholophus = Seriema.
Psophia = Trumpeter.
Rhinochætus = Kagu.
Eurypyga = Sun-bittern.
Heliornis = Fin-foot.

These are all very aberrant types, whose systematic position is still a matter for investigation.

The Columbæ, like the Grues, are a diastataxic group, the only recorded exception being the genus *Columbula*.

The Coraciiform Alcedines (Kingfishers) and Macrochires (Swifts and Humming-birds) each contain genera the species comprising which include forms with both eu- and diasta-taxic wings. Thus amongst the Alcedines, in the genus *Ceryle*, *C. torquata*, *C. rudis*, *C. alcyon*, and *C. maxima* are diastataxic; the remaining species of the genus are eutaxic. In the genus *Halcyon*, *H. vagans*, *H. chloris*, and *H. sancta* are diastataxic. *D. gigas* appears to be the only diastataxic member of the genus *Dacelo*.

The Macrochires comprise the Swifts (Cypseli) and the Humming-birds (Trochili).

The Trochili are all eutaxic.

The Cypseli are mostly eutaxic, but contain at least two genera possessing both forms:—

Dendrochelidon mystacea is diastataxic.
Acanthyllis collaris ,,

No satisfactory explanation of these exceptions has yet been offered, though some sort of an attempt was made by the late Henry Seebohm (6). He suggested that some diastataxic species may have become eutaxic by elimination of the coverts belonging to the missing fifth remex, thus removing all traces of their former condition. From the facts already educed in the preceding pages of the present paper, this particular interpretation must now be regarded as probably discounted. Before anything like a final explanation can be hoped for, we must wait till more material is at hand. A large series of embryo and adult species of those genera containing both forms of wings will probably settle the question. For the present, perhaps, the few suggestions advanced on p. 252 may be acceptable.

Facts correlated with Diastataxy.

According to Seebohm (6):—

1. No eutaxic bird has a webbed foot.
2. Birds which have abnormal plantar tendons contain both eu- and diasta-taxic species *.
3. There are very few diastataxic birds without an ambiens; but there are *no* eutaxic families that contain birds both with and without it †.

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* Concerning 2 it may be remarked that this is equally true of birds having *normal* plantar tendons—Seebohm's term for plantar tendons in which the flexor perforans supplies each of the front toes.

† This depends upon the individual taxonomer—as to whether he eliminate the discordant elements.

4. Pelargomorphæ have normal plantars and are diastataxic.
5. Ægithomorphæ have normal plantars but are eutaxic.
6. Coraciomorphæ contain both diasta- and eutaxic forms. Of four diastataxic families two contain both eu- and diasta-taxic species.

According to Degen:—

> "Aquintocubitalism and Quintocubitalism seem to reflect on the presence or the absence of the 11th metacarpo-digital flight-feather." (All 11-primaried birds are diastataxic according to this author.)

According to Goodchild:—

> The diastataxic wing is characterized by a peculiar interruption or faulting of the coverts of the dorsal surface.

Degen's contention is disproved by the fact that, as shown by Gadow (2), the following, though diastataxic, have only 10 primaries:—*Scopus*, *Eurypyga*, *Rallus*, *Ocydromus*, *Himantornis*, Psittaci, some Cypselidæ, *Caprimulgus*, and *Megapodius*.

Again, many Cypselidæ, *Eurylæmus javanicus*, *Acanthyllis caudacuta*, and *Ceryla americana* have 11 primaries, but are eutaxic.

Goodchild's observation refers only to the external phenomena of the relative length of the feathers composing the different rows in this region of the wing. This "faulting" is not always visible in diastataxic wings, as is well seen in many Parrots for instance.

Some Degenerate Wings.

In the present connection it will be sufficient to survey this subject briefly. In the most perfect form of wing it will be noticed (Pl. **14**. fig. 5) that the manus is longer than the forearm, and that the angle which the primaries form with the skeleton changes more and more from within outwards; the innermost remex lying at a right angle to, and the outermost parallel with, the long axis of the wing. Thus it comes about that the wing-area of the hand is as great as, or greater than, that of the forearm. Correlated with the form of the wing is the nature of the flight. Thus, in the Swifts and Albatrosses the wing is ribbon-shaped—very narrow from the pre- to the post-axial border, and much produced outwards. In birds like the Heron, the wing is very broad, and the flight, though strong and capable of being sustained for long periods, is not so rapid.

It will be found that, the less the wing is used, the greater is the departure from this type. The manus shortens conspicuously, and the wing takes on a rounded form, making it difficult to distinguish primaries from secondaries in the outstretched wing. This is well seen in the wing of *Opisthocomus* (Pl. 16. fig. 2). Again, compare the wings of the Kagu, *Psophia*, *Ocydromus*, or the Common Water-Rail, with that of the more perfect Cranes; or the wings of *Coua*, *Phœnicophaës*, and *Crotophaga*, *Turacus*, and *Musophaga*, with that of the Common Cuckoo; of *Stringops* with that of other Parrots, and so on. In all, the wing-area of the hand is lessened, markedly so, and the relative length of the secondaries is increased, whilst the primaries and their coverts grow shorter from within outwards. On discussing this matter with my friend and colleague, Mr. Eugene Oates, he drew my attention to the fact that this shortening and widening of the wing obtains in two non-migratory Indian Ducks.

The wings of the Rhea, Ostrich, Cassowary, and Apteryx afford evidence of still greater retrogression, passing from a relatively large wing, such as that of *Rhea*, in which may be distinguished primaries, secondaries, and coverts*, to the vestiges, more and more complete, in the Apteryx, Cassowary, *Æpyornis*, Moa, and *Hesperornis*.

The wings, then, both of the Ratitæ and the Carinatæ, show that the reduction of the skeleton is soon followed by a reduction in the size, and then in the number of the remiges, and that this latter takes place at the extreme distal end of the primary and proximal end of the secondary series, where they become shorter and shorter and finally disappear.

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* The pterylosis of the wing of *Rhea* I hope to describe shortly. It differs markedly from that of all other wings in that the dorsal coverts and remiges of the forearm are clustered together in strongly-marked obliquely-transverse rows separated by deep furrows one from the other. Furthermore, there remains to be settled one or two points touching the nature and homology of the remiges, and the disposition of the feathers in the carpal region. The ventral surface of the wing is bare.

In connection with the cubital remiges, it is interesting to note that these, in the Common Fowl, are, in the nestling, functionally preceded by their major coverts. This appears to be the case also in the young Pigeon, as is well seen in Pl. 16. fig. 1.

The probable Origin of the Diastataxic Wing.

We may now turn our attention to a discussion on the probable origin of diastataxy.

The primitive wing, I take it, was eutaxic, and resembled that of the Common Fowl in that it was clothed by numerous rows of covert-feathers; that of the Picariæ and Passeres is a specialization of a more primitive type, the number of rows of coverts having been reduced. Although, in these, the forearm may have increased in length, the remiges have decreased in number and become more widely spaced, and have developed broader vanes. Thus an equally efficient wing has been obtained with less expenditure of material.

The diastataxic wing is a modification of the eutaxic, and is possibly due to an increase in the length of the wing accompanied by a corresponding increase in the number of the remiges. It would seem more natural to assume, therefore, that all diastataxic wings have been derived from a common source; and thus this feature may be regarded as a sure sign of affinity, more or less remote, enabling us to classify all birds into groups eu- and diastataxic.

The existence, however, of what we may term eutaxic genera amongst diastataxic families is certainly a serious difficulty in the way of this hypothesis. For instance, *Columbula* is the only known exception amongst the Pigeons, which are diastataxic, though other exceptional genera may turn up, and the numerous instances of diastataxy amongst the Kingfishers and Swifts. It might be pleaded that *Columbula* has re-acquired a eutaxial form, by reduction in the length of the wing, and a similar reduction in the number, accompanied by a readjustment of the feathers. Note the position, for instance, of the 5th and 8th remiges in the wings of *Columbula* and *Columba*. That this is problematical, however, is shown by the wing of *Ocydromus*, which, though very greatly reduced in size, still remains diastataxic, like the rest of the Rails. Again, it is probable that the Megapodes, which are diastataxic, are somewhat closely related to the Game-birds, which are eutaxic. Apart from internal anatomy, they present the following points in common:—The remiges, in the nestling, are well developed and functional before the pre-pennæ of the trunk are replaced by the definitive contour-feathers. The 1st cubital remex develops much later in life than the rest of the series, and is always much shorter than these. The Megapodes as we have just remarked, are diasta-, and the Game-birds eu-taxic. If the two are closely related, we might claim justification in holding that the arrested development of the 1st cubital remex was derived from a common source, and that diastataxy has been acquired by the Megapodes since then. If this interpretation be correct, it follows that we may hold it to be admitted that diastataxy may have arisen independently in different groups of birds,—a somewhat unlikely conclusion. The position into which we have drifted, then, may be stated as follows:—

The Class Aves, very early in the process of its differentiation, developed the phenomena of diastataxy, which has been retained by very different groups now regarded as only remotely allied. The presence of eutaxic forms in an undoubtedly diastataxic group, as in the case of *Columbula*, must be regarded as the result of a secondary re-arrangement of the wing-feathers, or as a reversion to the more primitive type of wing from which it was derived. Such admittedly aberrant eutaxic forms as *Psophia*, *Cariama*, *Heliornis*, must be regarded as more remotely allied to the diastataxic forms with which they are now associated than is generally believed. Diastataxy is probably an indication of consanguinity.

There are certainly difficulties in the way of acceptance of this view, perhaps the most formidable being the case of the Swifts and Kingfishers, the majority of which are eutaxic; some genera, moreover, containing both eu- and diasta-taxic forms. We have to face two alternatives:—

(1) That the group, whichever it may be, really belongs to the diastataxic stock, but that the majority of the species, like *Columbula*, have reverted to eutaxy; or,

(2) That diastataxy must be explained, in that and all other groups, as the result of the action of similar mechanical forces, upon a common type, and which may occur independently in different groups, and even different species of the same genus.

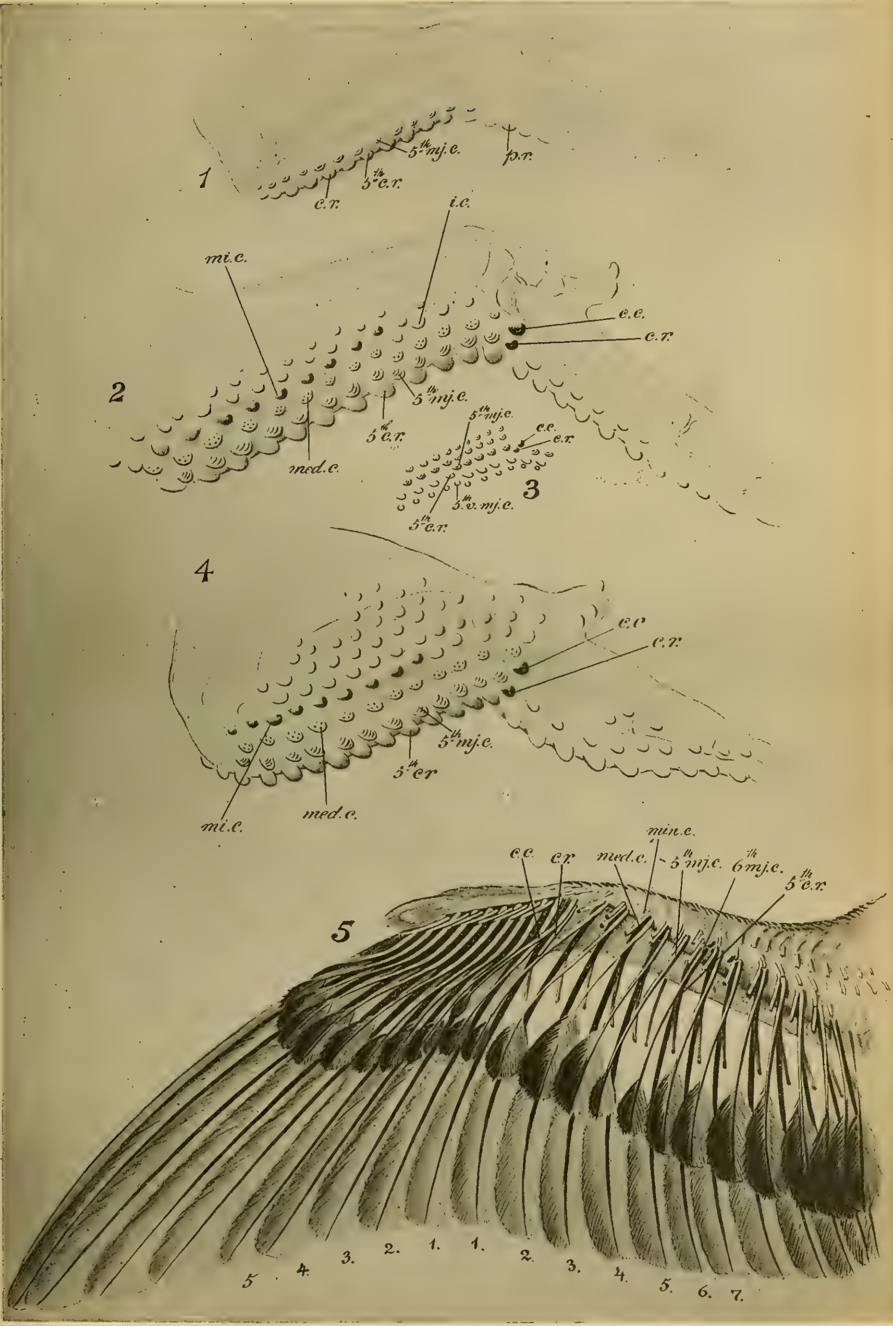
In spite of the objections which we may feel towards the first proposition, it seems more probable than the second, and more in harmony with the facts as a whole.

Diastataxy as a Factor in Classification.

If it be true that diastataxy is an indication of a more or less remote degree of consanguinity, as has just been hinted, or, in other words, if diastataxic forms are more nearly related one to the other than those which are not, we may find this character, used with discretion, no small help in systematic work. I say used with discretion advisedly; for it is incontrovertible that the nature of the evidence from other sources makes it absolutely impossible to use this character as a primary factor, wherewith to divide the Class Aves into two great groups, eu- and diastataxic. But the presence of diastataxy in a little coterie of forms, admittedly related, but hitherto indiscriminately mixed with eutaxic, will be a sufficient reason to justify our separating them out to form a group by themselevs, on the assumption that the character was inherited from a common source, and that they are therefore more closely related one to the other than to the neighbouring eutaxic forms. The presence of discordant elements in the shape of eutaxic forms amongst our now diastataxic groups—such as the Kingfishers, Swifts, and Pigeons—must be attributed to reversion or secondary readjustment of the feathers resulting once more in eutaxy. This is not as convincing as it should be; but it demands less of us than the alternative hypothesis, that diastataxy has been independently acquired wherever it occurs.

The result of the slight shifting here suggested is in no sense revolutionary in its tendencies. Amongst the Picarian forms it would bring together the Psittaci, the Striges, and the Caprimulgine forms associated therewith, the Swifts and Humming-birds and the Kingfishers—all diastataxic, drawn from the ranks of eutaxic forms to constitute a little coterie by themselves. The Megapodes would be cut off from the remainder of the Galline forms, which are eutaxic, just as *Heliornis*, *Psophia*, *Cariama*, *Rhinochetus*, and *Eurypyga* remain as every modern systematist has left them—as isolated and aberrant groups in the neighbourhood of the Grues. *Cariama* remaining as a sort of sign-post pointing the way, as Beddard has recently shown, from the Grues to the Accipitres.

This scheme is doubtless open to criticism; but this may be said of every other.



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DIASTATAXY (AQUINTOCUBITALISM).

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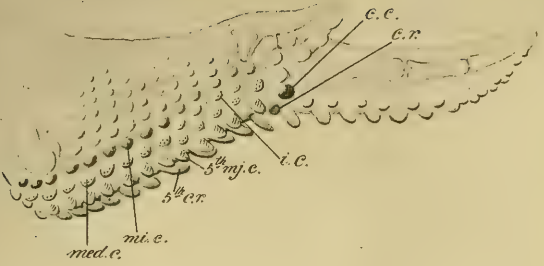

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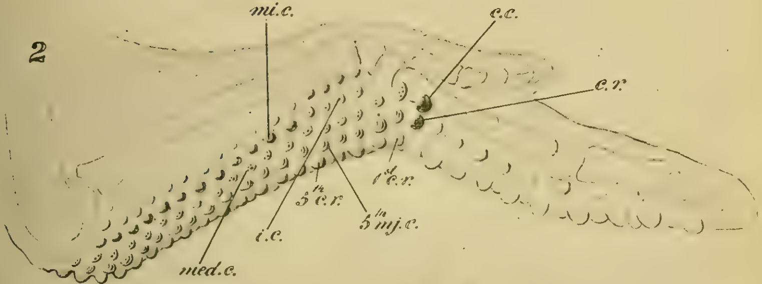

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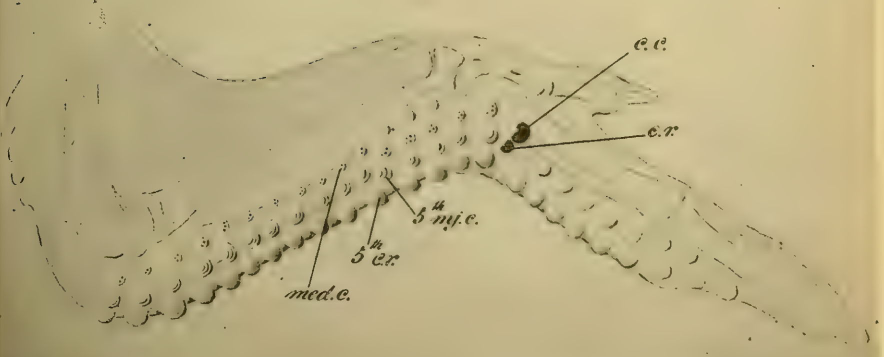

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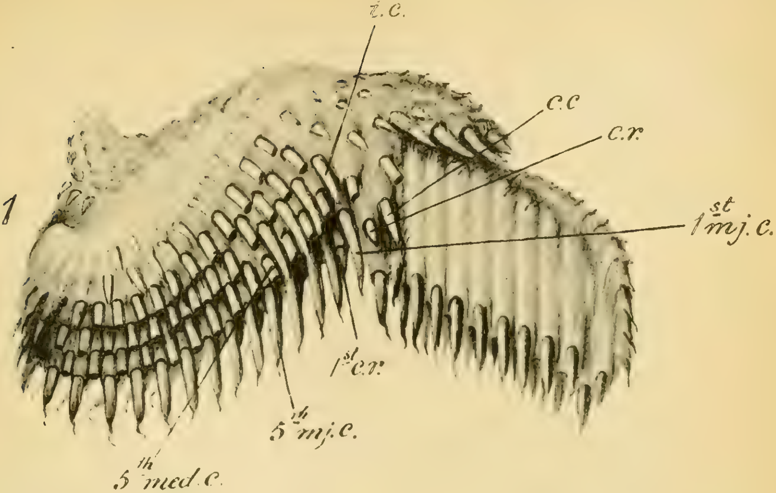

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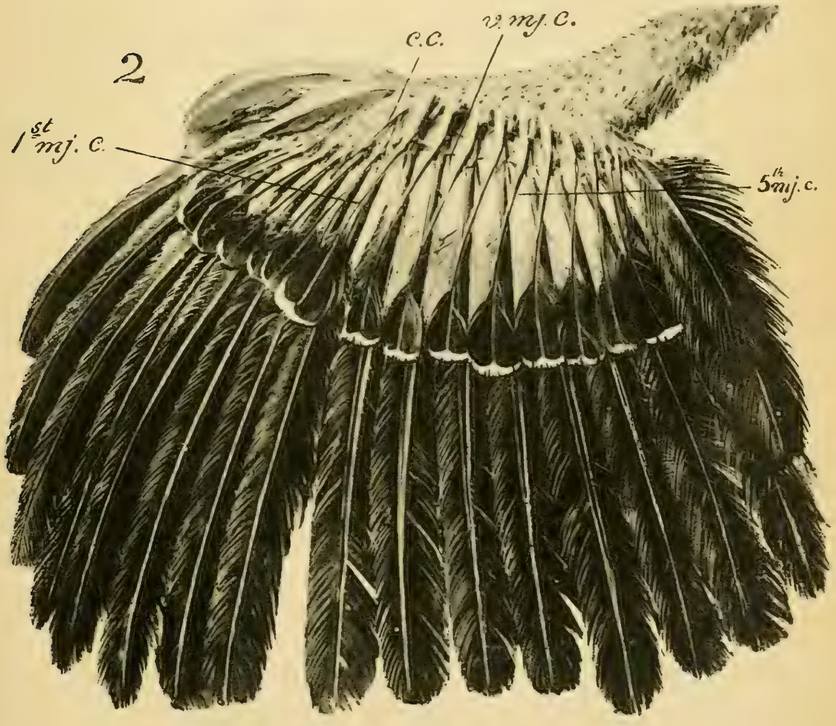

Pycraft del. Morgan & Kidd, Collo.

DIASTATAXY (AQUINTOCUBITALISM.)

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EPPLANATION OF THE PLATES.

Reference letters.

c.c. = carpal covert.
c.r. = carpal remex.
i.c. = intercalary coverts, intercalary row.
med.c. = median covert.
mj.c. = major covert.
v.mj.c. = ventral major covert.
min.c. = minor covert.
mi.c. = ,, ,,

Plate 14.

Fig. 1. Right wing, dorsal aspect, of an embryo *Vanellus cristatus*, showing the first appearance of the feather-papillæ representing the remiges and major coverts of the forearm,—and indistinctly of the primaries.

Fig. 2. The same in a more advanced stage of development. Several rows of coverts have now appeared, and "faulting" has already taken place. The wing is now diastataxic; in fig. 1 it is still eutaxic.

Fig. 3. Portion of the right wing, dorso-ventral aspect, of an embryo *Machetes pugnax*, showing position of ventral major coverts.

Fig. 4. Right wing, dorsal aspect, of an embryo *Gallus bankiva*, var. *domestica*. This is an eutaxic wing. The coverts have been marked as in the diastataxic forms for the purpose of comparison.

Fig. 5. Left wing, dorsal aspect, of an adult *Asio accipitrinus*, to show the typical, adult, diastataxic wing. Note the absence of a remex between the 5th pair of major coverts, and the marked gap between the 4th and 5th remiges.

Plate **15.**

Fig. 1. Right wing, dorsal aspect, of an embryo *Columba domestica*. This is markedly diastataxic. The shifting of the coverts is very distinct. Compare Pl. **16.** fig. 1.

Fig. 2. Right wing, dorsal aspect, of an embryo *Lomvia troile*, at present eutaxic; but a study of the coverts shows that a shifting has commenced, the result of which ultimately *reduces the wing to the typical diastataxic form*. Compare this with the figure on p. 243, which shows the condition of the wing in the downy nestling.

The figure immediately below is drawn from fig. 2 to show the effect of a slight increase in the shifting of the coverts transforming the wing from the eutaxic to the diastataxic type, as seen in fig. 1.

Fig. 3. Right wing, dorsal aspect, of an embryo *Anas boscas*, var. *domestica*, decidedly diastataxic. No earlier stages were procurable.

Plate **16.**

Fig. 1. Right wing, dorsal aspect, of a nestling *Columba domestica*. Note the intercalary row of coverts, and compare with fig. 1, Pl. **14.**; also the large size of the major coverts of the forearm as compared with the cubital remiges (1st *c.r.*), which have as yet only just begun to project beyond the surface of the wing.

Fig. 2. Right wing of adult *Opisthocomus*.

On the Discovery and Development of Rhabdite-"cells" in *Cephalodiscus dodecalophus*, McIntosh. By F. J. Cole, University College, Liverpool. (Communicated by Prof. G. B. Howes, Sec. Linn. Soc.)

[Read 6th April, 1899.]

(Plate **17.**)

A short while back Professor Herdman was kind enough to place in my hands some small pieces of *Cephalodiscus* for treatment and sectioning by modern microscopical methods. As interest in this unique form has been again aroused by the recent work of Masterman *, it was proposed to revise the whole anatomy of the polypide besides investigating the few points which a consideration of the literature showed to be unsettled.

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* Q. J. M. S. vol. xl., 1897; Trans. R. S. Edin. vol. xxxix. pt iii., 1898.

So far, the results are the bodies described in the present communication, a *possible* true sense-organ in the region of the gill-clefts, and a large and undoubted gland situated on the proboscis *. Descriptions of the two latter are left over for the present. Of the material at my disposal sections were cut in various planes and treated by various methods. The whole cœnœcium with the contained polypides was sectioned, as well as also individual polypides orientated by the dissecting-microscope in paraffin. The latter process, owing to the size of the individuals, is by no means difficult, so that it is not necessary to resort to Patten's method. So far as the purposes of the present paper are concerned, the only method of staining found to give really satisfactory results is Dr. Gustav Mann's excellent combination of methyl-blue-eosin †. The sections were stretched on a slide previously treated with Paul Mayer's albumen-fixative and covered with a film of water, and then stained on the slide according to the directions given by Dr. Mann. Successful preparations *that have not been over-stained* (when properly decolorized for the rhabdites the general tissues are almost unstained) show a perfect differentiation of the rhabdite-"cells," so that their structure is somewhat easily followed by examination with Zeiss's 1·5 mm. apochromatic lens in conjunction with the compensating eyepiece No. 12.

HISTORICAL.

As is well known, after the return of the 'Challenger' Expedition, the bottle containing the specimens of *Cephalodiscus* obtained in the Straits of Magellan was sent, with the collection of Tunicata, to Prof. Herdman. It then bore a label in the writing of the late Prof. Moseley, stating that the animal was a "compound Ascidian." Prof. Herdman examined it in the winter of 1879–80, and mounted some preparations in different ways (including the material referred to above), sufficient to determine that it did not fall strictly within the group Tunicata, and that its affinities were rather with what are now considered the other Protochordata. He returned the stock to Sir Wyville

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* This apparently is not the structure referred to by Harmer (Zool. Anz. 1897), and I am not yet in a position to state its relation to the proboscis-gland of *Balanoglossus*.

† Journ. Anat. & Phys., vol. xxix.

Thomson, with a statement that he did "not consider it a compound Ascidian, but rather an aberrant Polyzoan related to *Rhabdopleura*." As a result the animal was at once forwarded to the late Mr. George Busk, and after that to Prof. McIntosh, as stated by the latter in the 'Challenger' report on *Cephalodiscus* (p. 3). The material I have used is a few fragments made use of by Prof. Herdman in his first determination of the probable affinities of the animal.

As described by Professor M'Intosh in his 'Challenger' report, the branchial plumes "are nearly of uniform size, and consist of a thickish central stem, occasionally slightly crenate, and furnished with a series of longitudinal fibres; while distally each is terminated by a peculiar bulbous enlargement, which at first sight resembles the tip of certain hydroid tentacles (e. g. *Coryne* or *Syncoryne*) bristling with dart-cells and pigment. The rugose appearance, however, is due to large gland-cells containing granules and globules, which are arranged in a somewhat regular manner round a central cavity, and which present a deep yellowish tint in the preparations. This structure may perhaps be a further and special development of the somewhat large hypodermic granules of the tips of the pinnæ." Elsewhere McIntosh states that the bulbous enlargements of the plumose arms may secrete the "spinous processes or fimbriæ" on the surface of the cœnœcium. Although McIntosh did not succeed in elucidating the nature of the "large gland-cells," his description above, as far as it goes, and excepting perhaps the last statement, is quite correct.

Masterman's interpretation of the bulbous enlargements (which may be conveniently termed "rhabdite-batteries") is that they represent "a dozen large eyes of a very primitive compound type." As this conclusion is so directly opposed to the explanation given in this paper, it is perhaps as well that the evidence on which it is based were summarized. It is as follows:—

1. "If the parts be subjected to partial maceration the clear globules [inside the gland-" cells"] can be obtained free, and they remind one irresistibly of a crystalline refractive lens."

2. "All [the gland-'cells'] have fine pigment granules scattered throughout their interior, and a great number of them contain the crystalline lenses referred to."
3. The base of the "eye" is believed to have been "in some cases traced into the main nerve of the plume."
4. "The whole structure here described seems to indicate that these organs are rudimentary monostichous compound eyes, which bear a remarkable resemblance, both in appearance and structure, to the 'branchial organs' found in the sedentary Annelids, such as *Potamilla* and *Sabella* . . . . . It seems most reasonable to regard them tentatively as primitive eyes, though the presence of compound eyes in the Chordata is rather remarkable."

First, as regards matters of fact, I find myself unable to confirm the statement as to pigment in paragraph 2, the existence of a nucleus as shown in the figure, and also the belief as to the nerve-supply in paragraph 3. Further, fig. 30 in Masterman's paper is, I must confess, quite unlike anything I have seen. In all my sections the wall of the battery is considerably vacuolated, and I have never seen the cells closely opposed as shown in this figure (*cf.* my fig. 1).

Second, as to matters of interpretation, passing over the insufficient nature of the evidence on which Masterman bases so important a statement, the finer structure of the bodies in question as here described must, assuming the accuracy of the description, be held to negative the view which Masterman has stated.

In his later paper (*op. cit.* p. 521) Masterman, in referring to the blastogenesis of the plumes and pinnæ, says: "The plumes arise throughout in pairs. They first make their appearance as a papilla, which elongates to a finger-shaped process, the distal extremity of which becomes slightly swollen, and then bulbous. The epithelium of this bulbous extremity then becomes modified to form the eyes. The cuticle of certain of the epithelial cells becomes thickened, and soon the thickening protrudes into the cavity of the cell as a lens-like body. Later it is detached from the cuticle and lies freely in the protoplasm. Here it becomes rounded off to form the lens." In plate iv. figs. 75, 76, & 77, this process is illustrated, showing the nucleus of the "eye" at first peripheral in position, and afterwards thrust down to the basal extremity of the cell by the ingrowing cuticle. As I have not investigated the blastogenesis of the rhabdite-"cells,". I am not in a position to express an opinion as to the accuracy of the above statement. I can, however, assert that a true cuticle is *not* present on the free surface of the rhabdite-battery of the adult, although a peripheral deeply-staining membrane is often seen, but this is not a cuticle. That it would be noticed if present in my sections is shown by the fact that the axis of each branchial plume has a cuticle which is quite obvious, but with one exception, when it was traced on to the base of the battery, this is always seen to stop short of the knob of the battery. Indeed in some sections, which were kindly placed at my disposal by Prof. Howes, indications were not uncommon of a few rows of cells situated external to what I have supposed is the free surface of the battery, *i. e.* the surface bounded by the supposed cuticle. It is possible these may represent a true epidermis which has been lost by the maceration of the material, although it seems very improbable that it would have been lost in by far the greater majority of the batteries. The existence of such a layer is, however, rendered conceivable by the position frequently assumed by the immature rhabdite-"cells," and also by the usually ragged and seemingly artificial free border of the enlargements themselves.

DESCRIPTION OF THE RHABDITE-"CELLS."

The occurrence of the "cells" of the rhabdite-batteries on the branchial stems has been correctly described and figured by McIntosh, so that it is not necessary to recapitulate it here. A close examination of the rhabdite-"cells" in a number of specimens discloses two important and significant facts: (1) No two "cells" are ever exactly similar—hence they are "cells" in which a great amount of metabolism is going on; (2) there are two extremes of position—(*a*) near the basal cells of the battery, and (*b*) absolutely outside the battery and lying on its surface. These two extremes of position are bridged over by the necessary intermediate stages. These two observations alone justify us in concluding—(1) That the "cells" are engaged, and actively engaged, in secreting something, and are hence of a sort gland-cells; (2) that that something is a body which, to serve its purpose, must be cast on to the exterior. Similarly, the observations at once preclude the possibility of the "cells" being sense-organs of any sort. They are not excretory organs, as their position and structural relations imply, and they do not store up food-material like the sacculi of the Crinoids, as the products of the "cells" are (at least often) ejected on to the exterior. But since, on the other hand, the ultimate products of these bodies are a number of pointed or somewhat blunt rods, since the metabolism of the "cells" is always in the direction of the production of these rods, and since finally these rods can in some cases be seen in the various stages of being, by the rupture of the "cell," shot on to the exterior, the only structures with which the "cells" can be compared are clearly the rhabdite-cells of Turbellaria and Trematoda, and the less specialized bodies found in the integument of Nemerteans. They will have the same function doubtless as the rhabdite-cells in the latter groups, whatever that is, and they are produced in *Cephalodiscus* by the following series of changes.

It is first necessary to describe the structure of the wall of the battery itself (fig. 1). Such a description is necessarily based on the material as I found it, and is thus liable to a percentage of error due either to post-mortem changes or imperfect fixation or both. Figure 1 is a drawing of a portion of the wall of the battery which, after a prolonged search, seemed to have been most favourably preserved and cut accurately at right angles to the surface. The cavity of the battery (*10*) is lined by a series of occasionally nucleated fibres (*8*), which are doubtless the direct continuation of the longitudinal fibres of the stem described by McIntosh. Many of these fibres have snapped in fixation (*9*), giving the appearance under ordinary lenses of a row of large cilia projecting into the cavity. Situated on these fibres is a single row of large irregular cells (*4*), each containing at least one undoubted nucleus. In some preparations it can with certainty be made out, as shown in the figure, that the cells are continuous at the base, so that a perfectly continuous layer of protoplasm surrounds the longitudinal fibres (*5*). From this layer of protoplasm there occasionally passes a long filament (*7*) which lodges one or more nuclei, and passes straight upwards to anastomose with the free surface of the battery (*1*). Similar filaments, which are however much more numerous, and also lodge nuclei, pass from the basal cells themselves to the surface (*6*). Whether either one or both series of filaments represent the narrow interstitial cells described by Bürger as being wedged in between the "pseudo-rhabdites" of Nemerteans is a possibility which only perfectly preserved material can determine. The three interesting features therefore about the basal cells are:—(1) Their protoplasm is continuous proximally; (2) they are separated by distinct intervals from each other, and present an almost amœboid appearance; (3) they are connected by one or more nucleated filaments with the periphery of the battery. Lying in the spaces defined by the latter filaments are the rhabdite-"cells" themselves (*3*)—to be described below. The varying position and structure of these bodies may be noted here. The periphery of the battery is often defined by a fine membrane (*1*), which seems to rupture to admit the passage of the rhabdites, whilst underlying this is a stratum containing two or three rows of undoubted nuclei (*2*). What this layer is the condition of the material did not permit me to determine, but many of the nuclei in the particular section shown in the drawing were certainly situated on the filaments described above. It is possible that this layer with its nuclei represents the epidermis, or, together with the basal cells, the dermis.

Figure 2 shows what I conceive to be an early stage in the development of the rhabdites. The "cell" was projecting slightly from the surface of the battery (*1*), and contained two highly refractile rounded bodies—one being very much larger than the other. There can be little doubt, from their general appearance and waxy homogeneous structure, that these bodies are simply secretions of some sort, although of what nature I was unable to determine. This identification was at once independently suggested by the biologists to whom I showed the slides. Besides the larger secretions are two smaller aster secretions, which bear a superficial resemblance to centrosomes but which have not of course any relation to those problematical bodies. One of these asters is connected with the smaller secretion-sphere, which suggests that it may have originated by the fragmentation of that body. The asters are also shown in figs. 4, and 6 *a* & *b*. Beyond that they appear to pursue the same course of development as the rhabdites themselves, that is to say they are formed by the breaking up of an originally spherical secretion-mass, of which the earliest stage I have seen is shown in fig. 4, I have failed to ascertain where they come from or what ultimate rôle they fulfil. The presence, however, of other asters consisting simply of very fine rods with no central secretion-mass, as shown in figs. 2 and 6 *a*, seems to indicate that they perform the same function as the larger rods, although such explanation does not meet all the facts. They are of fairly frequent, but not of universal occurrence, and they are the only bodies in the rhabdite-"cells" which are of a fairly constant structure and position, and do not vary within wide limits. For the rest, the irregular outline or sac of the "cell" shown in fig. 2 contains a granular substance which seems to be either pure plasma or a more or less slight modification of that substance. It is to be noted that it is more densely granular at the two poles, the base, however, being more granular than the apex. Particular attention must be directed to the fact that in this "cell," as in all the others examined, there is no structure whatever that can with any justification be called a nucleus. I have hence in describing the bodies as rhabdite-cells placed the word cell in inverted commas.

Figure 3, drawn from a single field, illustrates three conditions well:—(1) the variation in position of the "cells"—*d* lying somewhat below the surface, *a* and *b* immediately beneath it, and *c* and *f* completely outside it; (2) the fragmentation of the secretion-mass as shown in *f*, *d*, *g*, and *b*; and (3) the splitting-up of the secretion-mass to form rhabdite-rods, as shown in all except *c*. In the latter we have only the secretion-sphere and a small vacuole—the most undifferentiated rhabdite body that has been seen. In *b*, however, the sphere has fragmented into two pieces—each piece lying apparently in a vacuole (an interesting feature also seen in the rhabdite-cells of certain Turbellaria), and just commencing to split up. Hence the serrated appearance of the periphery of the two pieces. In *g*, *d*, *e*, and *f*, successive stages in the splitting up of the secretion-mass are seen, whilst in *a* the splitting has proceeded so far that a number of rods have been formed connected by a central mass of hitherto undifferentiated secretion. The latter contains a small vacuole (see also fig. 4), whilst outside the clump of rods are two small secretion-masses, which may either be the two aster anlagen or fragments of the original secretion-sphere.

In figure 4 we have a condition intermediate between *f* and *a* of the preceding figure. The secretion-sphere lies in a large vacuole, and the splitting up, though somewhat far advanced, has yet not proceeded as far as in 3 *a*. The central vacuole has been already noticed. Above, at the apex of the "cell," is a bent plate of secretion which I have not seen in any other "cell," unless it is comparable to the rod in the same position seen in fig. 5. Below are two large asters of a comparatively simple type, and of the usual structure and position. As shown in figs. 3 *a* and 6 *b*, the split secretion-sphere does not always lie in a vacuole.

The rhabdite-"cell" shown in fig. 5 is lying practically outside the battery, the rhabdites have broken away from the central mass, leaving the latter lying in the middle of the "cell." At the base is another mass of secretion, formed doubtless by an antecedent fragmentation of the original sphere. At the apex is a thin transverse rod, perhaps comparable to the curved plate in fig. 4, which I have not seen in any other "cell." The "plasma" does not completely fill the latter. The rhabdites are here practically ready to be discharged, and to the left are seen several free rods formed by the discharge of an adjacent "cell."

Figure 6 shows two contiguous "cells" (lying immediately under the surface) from one field. In *b* we have a stage similar to that in 3 *a*, except that in the former two small asters are present, each lying in a clear space, whilst the splitting of the secretion-sphere has not proceeded so far. In 6 *a*, however, the splitting has resulted in the formation of two kinds of rhabdites —stout and fine. The latter are still adherent to the residue of the sphere and are the more numerous, whilst the former have broken off, may project through the wall of the "cell," and bear evident traces of their origin from such stages as those figured in 6 *b* and 3 *a*. The whole, together with a small aster of 4 rays, lies in a clear space in the "cell," two small asters being embedded in the "plasma."

The "cell" shown in fig. 7 is an almost isolated example of its kind, and no other exactly resembling it was seen *. Empty sacs, however, having faint longitudinal folds, which have been identified by others besides myself as similar bodies that have been discharged, are not uncommon. In the "cell" above, which lay immediately below the surface, the rhabdites were arranged in a definite axial bundle, no small asters were present, there were no clear spaces in the "plasma," and the whole of the secretion had been used up in the formation of the rhabdites—a condition not often seen. This stage may be described as the final one immediately prior to discharge.

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* Since writing I have observed others in Prof. Howes' material at the R. College of Science, Lond.

Finally it is necessary to mention another stage which was only of occasional occurrence in the material at my disposal, but which seems to be common in the sections of *Cephalodiscus* in the laboratory of the Royal College of Science. Here the rhabdite-" cells " are sharply divided into two parts, so as to present a strong superficial resemblance to certain of the pseudo-rhabdites described by Bürger in Nemerteans. The upper or apical portion contains a body which undoubtedly corresponds to the secretion-sphere and its products described above. The lower or basal portion is of a uniform, structureless and highly refractile appearance, as if this portion of the " cell " were filled with a homogeneous waxy secretion. I am unable to connect this stage with the others with certainty, but it seems to be an early stage in the formation of the rhabdites, and may possibly be the earliest yet seen in the material. Its occurrence was of too occasional a character in my material to enable me to study it as carefully as the other stages.

The question that now arises is from what source are the rhabdite-" cells " of *Cephalodiscus* derived. That they are portions of cells, and not complete cells in themselves, must be admitted, in view of the fact that they do not possess any structure that may be justifiably interpreted as a nucleus. On the other hand, their position and mode of occurrence is strongly suggestive of the view that they are disassociated portions of the basal cells (fig. 1, *4*) of the battery. These basal cells therefore, on this view, will be constantly giving rise to the so-called rhabdite-" cells," and the latter will as constantly be discharged on to the exterior. The term rhabdite-cell will hence belong properly to the bodies described in this paper + also the basal cells of the battery, since the two together are the morphological equivalent of the Turbellarian rhabdite-cell and its contents.

In order to justify the term I have applied to the structures here described, the following comparison is appended between these bodies and the cells in Turbellaria to which the term rhabdite-cell was first applied by Graff in 1882. Lang* in the Polyclads distinguishes two kinds: (1) Rhabdite-cells; and (2) " Schleimstäbchenzellen " or Pseudo-rhabdites. Of the former he says (pp. 51–52):—" Der Kern der Stäbchenzellen liegt stets am basalen Ende derselben; das freie distale Ende der Zellen ist mit Flimmerhaaren besetzt, wovon man sich durch Isoliren der

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* Fauna u. Flora d. Golfes v. Neapel, Monog. xi. pp. 51–55.

Stäbchenzellen des lebenden Thieres leicht überzeugen kann." The "Flimmerhaaren" I have not seen in *Cephalodiscus*, although it is possible that living material may disclose them. Lang's account of the development of the rhabdites is too long to be quoted *in extenso*, but may be summarized as follows:—Situated in between the mature rhabdite-cells here and there are much smaller cells each containing a nucleus. Lying close to the nucleus is a single small, round, homogeneous, highly refractile body. This body Lang regards as essentially a secretion. It grows and fragments to form a number of small balls, and each ball becoming lengthened and spindle-shaped, forms a rhabdite-rod—the whole of the rods becoming subsequently arranged to form a pyramidal bundle with the base opposed to the nucleus. The rhabdite-cells therefore contain a nucleus, plasma, and the rods. Lang and Graff are agreed that they are gland-cells, and that the rhabdites are their secretion.

The Pseudo-rhabdites of Lang have an uneven periphery. They are figured in some species as one or more tall columns of end to end secretion-fragments (Blöckchen) of an irregular shape, with the nucleus and plasma of the cell lying at its base and under the pseudo-rhabdites. In *Stylochus*, Lang says (pp. 53–54):—"Die einzelnen Blöckchen entsprechen ihrem optischen Verhalten nach sehr den Rhabditen, sie sind klar, homogen, stark lichtbrechend und verhalten sich Farbmitteln gegenüber ganz wie diese. Die Säulen, die sie bilden, erfüllen beinahe die ganze Epithelzelle, in der sie liegen, und lassen höchstens am basalen Theil, wo der Kern liegt, ein Klümpchen feinkörnigen Plasmas frei." Lang considers that the pseudo-rhabdites are fully comparable to the true rhabdites, and describes several stages intermediate between the *Stylochus*-type and the mature rhabdite-cell with its clump of rods.

Just as the pseudo-rhabdite must be regarded as a comparatively simple modification, in which the secretion has not undergone such differentiation as in the true rhabdite-cell, so do certain gland-cells in Nemertea represent a condition antecedent to the pseudo-rhabdite form. Hubrecht* describes and figures in *Cerebratulus* and *Eupolia* unicellular glands which he considers correspond precisely to the pseudo-rhabdites of Lang. They have in *Cerebratulus* highly refractile uniform contents, *not*, *however*,

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* 'Challenger' Reports, vol. xix. p. 61.

divided into blocks. Bürger* describes other homologous bodies Nemertea as flask-shaped gland-cells.

According to these descriptions there can be little doubt that the bodies described in this paper are similar, in all their essential points of structure and development, to the rhabdites, pseudo-rhabdites, &c. of Turbellaria and Nemertea. We have in fact a complete and gradually ascending series commencing with the comparatively simple cells in Nemertea, and terminating in the complex structures of *Cephalodiscus*. In *Cephalodiscus* they are more differentiated (1) as regards accessory secretions in the cells; (2) as regards the details of the development of the rhabdites; and (3), provided the view stated in this paper be correct, in the separation of the portion containing the secretion from the mother-cell, so that the two become quite distinct.

SUMMARY.

Cephalodiscus has a lophophore of 12 branchial plumes, each of which consists of a central stem or axis with its associated filaments. Each axis becomes enlarged at its distal or free extremity so as to form a conspicuous hollow bulb, the cavity of which is continuous with the cavity of the stem. As the rhabdite-cells are entirely confined to these bulbs, the latter may be conveniently termed rhabdite-batteries. Histologically, the wall of the battery is greatly vacuolated, and contains essentially two series of bodies: (1) a series of large nucleated basal cells; (2) above these a series of non-nucleated bodies lodged in the vacuoles and termed rhabdite-" cells." 1 and 2 together, however, are the equivalent of a rhabdite-cell of a Turbellarian, since 2 possesses no nucleus, and 1 contains no secretion. In fact 2 must be regarded as a disassociated portion of 1. The secretion of 2 is primitively a large homogeneous sphere. This may or may not become fragmented. Subsequently there often arise two small aster secretions of unknown origin, fate, and significance. The sphere of secretion afterwards splits peripherally so as to form, first a star-shaped structure, and then a number of stout free rods. The splitting usually leaves a residue, but the whole of the sphere may be used up in the formation of the rods. The rods have been observed arranged in a definite bundle parallel to the long axis of the " cell." The

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* Bronn's Thier-reichs, Bd. iv.

rods and sometimes the whole "cell" may be found lying outside the battery. No two cells are ever structurally idêntical, and their position varies from one in close proximity to the basal cells to one in which they lie completely outside the battery. Besides the secretion-spheres and their accessories, they contain a granular substance in varying quantity identified as plasma or a modification of that substance. In all essential respects they are comparable to the rhabdite-cells of the Turbellaria (and are hence of the same nature as the pseudo-rhabdites of Nemertea), since their prime object is to secrete rods and then to discharge them on to the exterior.

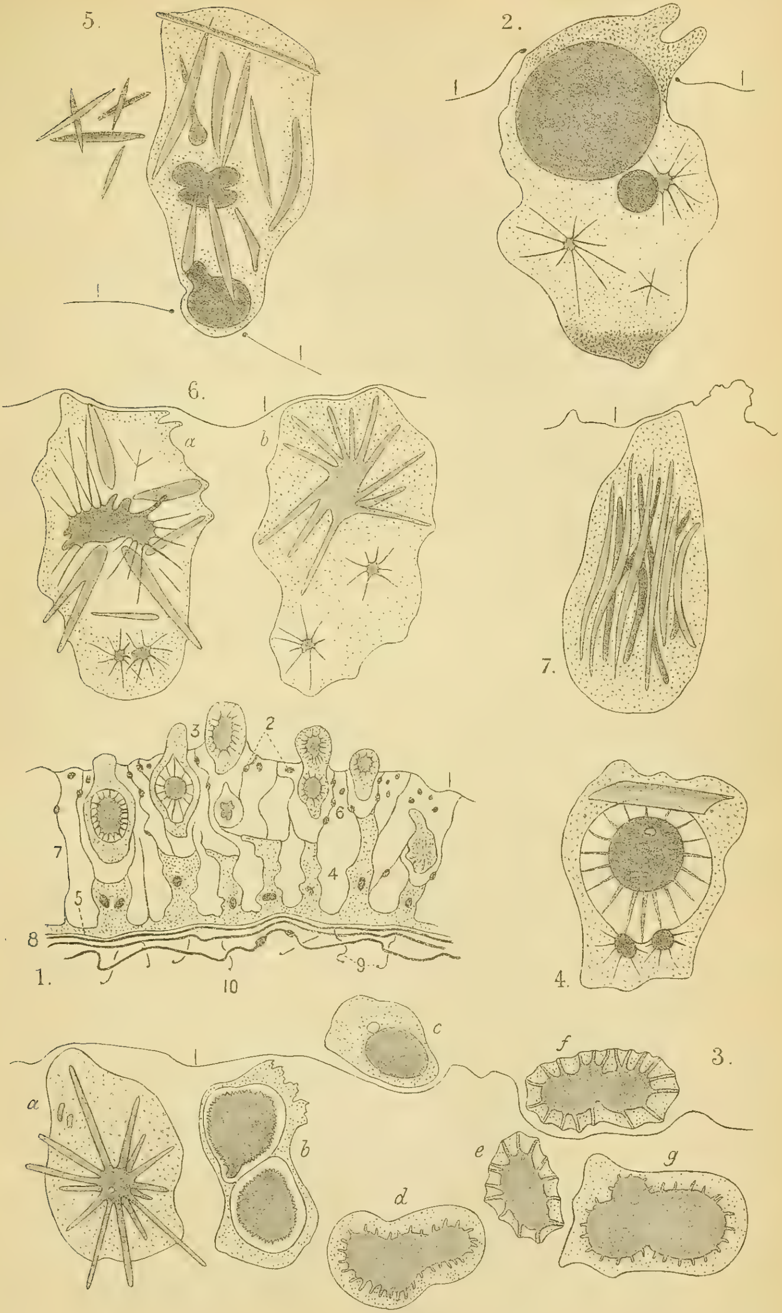
EXPLANATION OF PLATE 17.

All figures drawn with Zeiss's 1·5 mm. apochromatic lens with the oc. compens. 12.

Fig. 1. Portion of a median longitudinal section through the rhabdite-battery and stem of a branchial plume, showing the structure of a piece of the wall of the battery. Reduced.

1. Peripheral membrane.
2. Peripheral nuclei situated in the superficial layer of the wall of the battery.
3. Rhabdite-"cells" (semi-diagrammatic; note position).
4. Basal cells.
5. Stratum of protoplasm placing all the basal cells in communication proximally.
6. Nucleated filaments from basal cells to periphery.
7. ,, ,, from *5* to periphery.
8. Layer of longitudinal fibres (here appearing transverse).
9. Fibres of *8* snapped in fixation.
10. Cavity of rhabdite-battery (continuous with that of stem).

Figs. 2 to 7. Stages illustrating the development of the rhabdite-rods (arranged as far as possible in order). The "cells" are in all cases represented in the same position, *i. e.*, *1* is the peripheral membrane and above it is the exterior. The "cell" shown in fig. 5, therefore, lies practically outside the battery, and those of fig. 6 lie immediately under the surface.



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McFarlane & Erskine, Lith. Edinr.

RHABDITES IN CEPHALODISCUS.

The *Edwardsia*-stage of the Actinian *Lebrunia*, and the Formation of the Gastro-cœlomic Cavity.

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[Read 15th June, 1899.]

(Plates 18 & 19.)

Contents.

During the temporary establishment in November, 1898, of a marine biological laboratory at Bluefields *, Jamaica, in connection with the Institute of Jamaica, several specimens of a *Lebrunia* were found in the act of extruding larvæ. An examination of these, while in the living condition and when sectionized, discloses, amongst other characters, some very exceptional features in the development of the tentacles, and in the formation of the gastro-cœlomic cavity of the adult. I am also able to add, by way of comparison, a few facts in connection with the freshly-extruded larvæ of *Aulactinia stelloides*, McMurrich.

I. Systematic.

The specific determination of the first-mentioned Actinian calls for a few remarks. It is a small form which occurs in

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* Bluefields is the name given to a property, formerly a sugar estate, on the south-west coast of Jamaica, rendered classic to local naturalists as the residence of Philip Henry Gosse, F.R.S., during his collecting trip of eighteen months, from 1844–46. The principal features of its natural history, and those of Bluefields Bay, are most vividly portrayed in Gosse's work: 'A Naturalist's Sojourn in Jamaica' (London, 1851).

considerable numbers all round the island, at a depth of two or more feet, within crevices of coral-rock. In "The Actiniaria around Jamaica" (1898), I identified it as the *Hoplophoria coralligens* of H. V. Wilson (1890), transferring it at the same time to the genus *Lebrunia*.

The chief characteristic of this genus is the presence of four to eight dichotomously branched outgrowths (pseudo-tentacles) from the uppermost region of the column. They occur immediately external to the tentacles, and usually bear spheroidal batteries of nematocysts.

Dr. Wilson's species was founded upon a single specimen, about 2 mm. in diameter, discovered in a hole in the coral-rock on the Bahama reefs. There appears to be the closest external resemblance between the Jamaican and the Bahaman examples; and anatomical and histological examination supports this, even to the peculiar forms of the nematocysts, and an exceptional arrangement in separate bands of the endodermal muscle of the columnar outgrowths. Comparisons made with the Bahaman *Lebrunia* described by Prof. McMurrich (1889), and with the Jamaican representatives of the genus, also show a close agreement; hence, in the paper above mentioned, I stated (p. 457) that "it is possible that it may be but a young form of *L. neglecta*."

When I first came upon the Jamaican polyps specimens were sent to Prof. Wilson for his opinion as to their similarity with his species, and he obligingly writes as follows:—"In your preserved specimens the pseudo-tentacles have a noticeably different appearance from those of my single specimen. The white nettle-batteries so conspicuous in my specimen are not obvious in yours. I note though that you find them conspicuously outlined in the living animal. The pseudo-tentacles in your specimens are much larger and more flaccid than in mine. All slight and variable points of difference. I make no doubt they are the same provided your sectional study shows the internal anatomy and histology to be alike in your specimens and in mine."

Prof. McMurrich (1893, p. 133) has expressed the opinion that Wilson's species is identical with *Viatrix globulifera*, Duchassaing. But in the description and figures given by Duchassaing and Michelotti (1860) of this Guadaloupe species the columnar outgrowths are very numerous and vesicle-like, and the polyps float freely, characters never met with in the form under consideration.

Within the past year, Prof. A. E. Verrill (1898), without experience of either form, has cast doubts upon the identity of the Jamaican specimen with the true *Hoplophoria coralligens*, and also with the conclusion that it may be but a young form of *Lebrunia*.

From the above facts, however, no other conclusion than that it is identical with Wilson's species seems possible, and in the fuller description yet to be published I hope to show its agreement with the Jamaican *Lebrunia*. Meanwhile, it will be sufficient to refer to it as *Lebrunia coralligens* (H. V. Wilson).

The adult polyps are hermaphrodite. Ova and spermaria occur in considerable numbers closely associated in the same mesentery.

II. External Characters.

In living polyps the larvæ were to be seen through the somewhat transparent tissues of the parent moving about within the cœlenteron, and especially within the tentacular cavities. As many as five were contained within a single tentacle.

So far as could be observed, they possessed little or no motion of their own, but allowed themselves to be carried along by the circulation of the cœlenteric fluid. By a peculiar jerking action of the adult three or four larvæ at a time would be shot out through the mouth for some distance, and then sink to the bottom of the vessel. Here they would lie unattached for some time in any position, though usually on their side. Afterwards slow movements, both translatory and rotatory, would commence, but these at no stage became pronounced. Individuals might come to rest at apparently any point of their surface and again commence their swimming movements.

When first extruded the larvæ measured about 1 mm. in length and were of a pyriform shape (Pl. 18. fig. 1), divided by shallow grooves into eight, nearly equal, longitudinal regions. Sometimes they would take the form represented in fig. 2, or become short and cake-like as in fig. 3. Viewed along the edge, the colourless ectoderm was easily distinguished from the endoderm, the latter dark brown from the presence of numerous zooxanthellæ. In surface view eight longitudinal darker and lighter areas were clearly marked, the coloured areas corresponding with the mesenterial chambers, and the colourless with the line of origin of the mesenteries. The mouth was already indicated at the broader end as a slightly depressed, small, circular aperture; the aboral end was narrow and rounded (Pl. **18**. fig. 4).

The perioral ectoderm differed from the remainder of the outer layer in being dark brown in colour, owing to the inclusion of zooxanthellæ. Some of these apparently worked their way out from the ectodermal cells and adhered superficially, or, in other cases, became free. Their presence at various heights in this restricted region is also revealed in sections.

Contrary to the usual condition in the Actiniaria, the ciliation was uniform over the whole surface. The larvæ progressed with the narrower, aboral end foremost, and also attached themselves finally by this extremity. Even during the first day their power of adherence to the bottom and sides of the vessel was considerable, sufficient to resist a strong current of water from a pipette.

The description given applies to each of the larvæ extruded, all having apparently reached a similar stage of development. The subsequent growth, so far as followed, was likewise the same in each. No earlier stage could be seen through the transparent tissues of the adult, and when a polyp was cut in halves none floated out. It is evident, then, that in *Lebrunia*, as appears to be also the rule in many other Zoantharia, the ova are ripened and the embryos develop and are expelled in batches; for, were it otherwise, different stages would be represented within the gastro-cœlomic cavity at one and the same time.

Such, however, is not always the case. While at Port Antonio, on the north-east coast of Jamaica, working in the temporary Marine Laboratory established there in 1897, by the Johns Hopkins University, specimens of *Aulactinia stelloides*, McMur., were collected, and from these larvæ were also being set free. Here the individuals, each with an aboral tuft of longer, less mobile cilia, were thrown out from the internal cavity of the adult by the same jerking motion as in *Lebrunia*; but many different stages were represented in one parturition, and a like variety of phases could be observed through the partly transparent tissues. Minute planulæ, showing what seemed to be the beginning of an invagination, would appear along with larvæ possessed of eight, strongly marked ridges and furrows, and even, in a few cases, with as many as six or eight tentacles already developed. Only the younger stages here continued to swim about; the older straightway fixed themselves to the bottom of the vessel by means of a flattened basal disc.

Development of Tentacles.

Within the first twenty-four hours the larvæ of *Lebrunia* settled down, and indications of the future tentacles were presented by a slight bulging from each of the eight intermesenterial areas. These were at first rounded as in Pl. 18. fig. 4 *a*, but, on becoming larger, narrowed a little as in figs. 5 & 6.

From the first a distinction into two alternating groups of four was obvious, one series being slightly larger than the other, though all constituted only one cycle.

Many of the adult polyps are characterized by the occurrence of superficial, opaque white areas on the oral aspect of the tentacles, much more pronounced later on the columnar outgrowths. The opacity on the tentacles is found to appear at the earliest stages, at first on the four larger prominences and later on the four smaller.

For some time it was not possible to recognize any difference in size amongst the members of any one group of tentacles, the disc presenting a perfect tetrameral radial symmetry. Later, one tentacle became slightly larger than the rest. Following the conventional nomenclature proposed by Kölliker and now usually adopted, this will be the dorsal tentacle; or, in the more morphological terminology of Haddon (1889), the sulcular. The tentacle opposite will be the ventral, or sulcar, and the plane in which they are enclosed the dorso-ventral or sulculo-sulcar. In the further increase in size the dorso-lateral pair of tentacles, that is the tentacle on each side of the dorsal tentacle, remained a little behind the ventro-lateral pair—these four forming the smaller series in the earlier stage.

The larva thus changed from its primary condition of radial symmetry to a decided bilateral form, the sagittal plane passing through the large dorsal and the ventral tentacles.

At the expiration of two or three days the larvæ had reached the stage represented by fig. 7 (Pl. 18). The aboral end is now flattened and disc-like, and even slightly larger in diameter than the column; the latter has narrowed and become cylindrical, but still shows only eight alternating dark and light areas. The eight tentacles are finger-shaped, rounded at their free extremity, and able to move about, but, as in the adult, are incapable of retraction. The oral disc is flattened, its ectoderm still retains the zooxanthellæ, and the mouth is circular or oval-shaped.

The dorsal tentacle is a little stouter and longer than the others, and the originally smaller ventro-lateral tentacles are now practically of the same size as the three remaining members of the first series, *i. e.*, the ventral tentacle and the two median laterals. The dorso-laterals, however, have lagged considerably behind in their development. At their base they are also pushed out slightly further from the disc than the other six, which now are beginning to form a cycle by themselves.

The larvæ are clearly sensitive to the action of light. When settling they would select the under surface or a crevice in any fragment of coral-rock placed in the vessel, and if the fragment were turned over would detach themselves and move to some less exposed spot. The adults usually live associated in shady crevices, the pseudo-tentacles and tentacles protruding as a delicate fringe. During the ordeal of examination under the strong tropical light, the larvæ would slowly assume a more or less collapsed aspect, their healthy inflated appearance returning after being shaded for some time. This behaviour towards light I find also to be very general amongst adult Actiniaria and Madreporaria.

Several examples were kept alive for six or seven days, but none passed beyond the stage represented in fig. 7. No trace was presented of the pseudo-tentacles. The development of the larvæ after extrusion was at first very rapid, the stage last mentioned being reached within forty-eight hours. The only external alteration during the next four or five days was a slight increase in dimension of all the parts, without any indication of additional tentacles or mesenteries. Unfortunately, circumstances did not permit of further observation.

The chief external characters, other than that of size, in which the adults differ from the oldest larvæ are: (1) the presence of several cycles of entacmæous tentacles, arranged in the formula 6, 6, 12, 24, 48, the members of any cycle being equal; and (2) the six (normally) large branching "pseudo-tentacles,' arising from the most distal region of the column and bearing spheroidal batteries of nematocysts. The mouth, instead of being circular, is very long and narrow.

From what we already know of the development of other Zoantharia, the hexameral character of the adult tentacles is in most cases derived from the readjustment of primary tentacles of different sizes and origin. Thus, already in the larvæ the first cycle of six is indicated, constituted of the four larger of the eight primary tentacles and two of the smaller. The remaining two will probably form one of the pairs of the second cycle of six tentacles alternating with the first, in which case it is obvious that the second cycle will be composed of individuals of a very different order of development.

As regards the tentacles, then, *Lebrunia coralligens* passes through three very distinct stages:—(1) a tetrameral radial symmetry, with four large and four small tentacles; (2) a bilateral symmetry of the same parts, six tentacles being nearly equal and forming one cycle, and two remaining smaller and outside the others; (3) the approximate hexameral radial symmetry of the adult, with numerous alternating entacmæous cycles.

The simultaneous appearance and tetrameral radial arrangement of the tentacles here described in the first stage is in marked contrast with what is known of the tentacular development of the Zoantharia generally.

Comparatively few observations on the order of appearance of the tentacles have, however, been recorded. One of the fullest and best is the well-known account given by Prof. de Lacaze-Duthiers of the growth of *Actinia equina*, and supplemented by observations on other species. Not having the original monograph for reference, for what follows I am dependent upon the many figures and details reproduced by Prof. E. L. Mark in his "Selections from Embryological Monographs" (1884), and by Prof. A. C. Haddon in the concluding portion of his "Revision of the British Actiniæ" (1889). From these it appears that the dorsal tentacle is the first to arise, and for a long time this predominates over the others. The octoradiate stage quickly supervenes, the median lateral tentacles being the next largest to the dorsal, and the ventral protuberance one of the smallest. The great difference in size between the dorsal and ventral tentacles gives a strongly bilateral character to the larva, exceeding that ever exhibited by *Lebrunia*. The latter seems more closely to resemble *Bunodes verrucosa* (*B. gemmacea*), in which Lacaze-Duthiers found the octoradiate stage to be of longer duration.

The succeeding stages, showing the manner in which from tentacles of heterogeneous origin the hexameral cycles of the adult are obtained, do not now concern us, except to say that in all probability *Lebrunia* passes through similar phases.

Aulactinia larvæ afford somewhat similar results. I obtained freshly-extruded examples with only six tentacles developed, one smaller and one larger tentacle on each side of the dorso-ventral tentacles. Others, again, show eight tentacles; of the new pair one arises on each side of the dorsal tentacle.

Among the Cerianthidæ McMurrich (1891 *a*) and E. van Beneden (1891), in the same year, have confirmed the previous observations of Agassiz and Kowalewsky, that the first six tentacles arise in lateral pairs, and that then a single median tentacle—the sulcar—appears. No radial phase is ever assumed in any of these earliest stages yet described. Prof. G. von Koch (1897, p. 759), however, in the numerous larvæ of *Caryophyllia cyathus* which he had under observation, found the first twelve tentacles to appear apparently at one and the same time, six larger alternating with six smaller, just as in the adult. In one case they developed in pairs, the dorso-ventral pair appearing first.

The relation of the different tentacles to the internal mesenterial spaces is described later (p. 297).

III. Internal Anatomy and Histology.

In all about thirty extruded larvæ were obtained, and reared to different stages within the course of a week. Among a number of adults collected in 1896, at the Port Royal Cays, a polyp with its interior crowded with preserved larvæ was also detected. Cutting this across upwards of thirty examples floated out freely, or were easily separated from among the tissues. These were devoid of tentacles, and internally all presented precisely the same stage of development—a stage, it will be seen later, slightly in advance of that exhibited by the youngest of the expelled larvæ. In speaking, therefore, of early and late larvæ, I refer to phases reached in the development, independently of whether the examples were or were not extruded. Practically all the material was utilized for purposes of study.

Succinctly the general facts of the anatomy and histology are as follows:—

The ectoderm is a thick layer with the constituent elements—ciliated supporting cells, nematocysts in all stages of development, gland-cells, and nerve-elements—well differentiated. The supporting lamella contains isolated cells, and a definite, though very weak, musculature is already formed on its inner surface, its fibres arranged in a circular manner.

Eight mesenteries are present and extend the whole length of the larva; in the upper stomodæal region they are all perfect and arranged tetramerally *.

The stomodæum at first is a very short, strongly ciliated, rounded tube, without any external aperture. Internally it communicates with four radiating canals, which are connected with two sinuses, and these terminate in a system of inter-

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* Such a stage in which only eight perfect mesenteries are present, and in which no further numerical increase takes place for some time, has been found to be very constant in the development of the Zoantharia. The mesenteries are those of the first four pairs, and consist of two lateral pairs and two median pairs—the directives. The retractor muscles on the two lateral pairs occur on the face of the mesenteries turned towards one pair of the directives, which, following the terminology of Haddon, is the sulcar or ventral. The other pair of directives is the sulcular or dorsal, and in these the retractor muscles are likewise on the face directed towards the sulcar aspect of the polyp.

The pair of lateral mesenteries next the sulcar end—sulco-lateral—are the first to appear in the embryo; then, in the majority of cases, the lateral pair next the sulcular end—sulculo-lateral; the sulcar directives constitute the third pair, and the sulcular the fourth in the order of development.

Lacaze-Duthiers first recognized the octoradiate condition as one of the resting stages in the development of the Actiniæ. Haddon (1889) described it as the third stage of mesenterial development, at the same time realizing its phylogenetic importance and similarity to the permanent condition in the *Edwardsiæ*; McMurrich (1889) obtained it in *Aulactinia stelloides*, and later in others, and applied the term "Edwardsia-stage," an apt designation since adopted by all writers on the subject. The researches of these authors, and of H. V. Wilson, Boveri, van Beneden, G. von Koch, and others, demonstrate that the phase is repeated in the ontogeny of such diverse groups as the Ceriantheæ, Zoantheæ, Hexactiniæ, and the Madreporaria.

mesenterial and mesenterial spaces. The spaces throughout have a distinct ciliated limiting layer, in continuity with the lining of the stomodæum. Otherwise the whole of the interior is filled with a vacuolated, undifferentiated tissue, provided with nuclei and zooxanthellæ, but devoid of yolk. Such a larva may therefore be regarded as a nearly solid mass of cells.

Between the earliest larvæ and the latest, changes of great significance have been effected, in addition to those involved in the production of the tentacles.

The middle vacuolated tissue has broken down and a gastrocœlomic cavity of the usual Cœlenterate type is in process of formation; into this the stomodæum, now provided with an oral aperture, depends and opens directly. The primary spaces are in process of giving rise to the mesenterial chambers of the adult.

One pair of the original eight mesenteries—the sulco-lateral—remains connected with the stomodæum longer than the rest, and each of the pair bears mesenterial filaments in direct continuity with the stomodæal lining. Only the median streak is as yet developed.

Of the many expelled larvæ secured, only two or three retain the solid phase in its perfect condition, with the stomodæum and its diverticula intact. The remainder, including the specimens preserved within the body of the adult, have passed into the second stage in which the middle tissue is becoming disorganized.

The different structures will now be described in greater detail.

1. *Ectoderm.*

The ectoderm is an exceptionally broad layer, uniformly ciliated throughout, with its free margin very pronounced in sections stained in borax-carmine or hæmatoxylin (Pl. 18. fig. 8). This latter character is due to the occurrence of a very delicate rectangular enlargement at the base of each cilium; the closeness of these and the readiness with which they take up colouring-matter produce a strong delimitation from the rest of the layer. The Hertwigs (1879, Taf. iii. figs. 5–8) figure a similar appearance at the edge of the ciliated ectoderm of the external surface and stomodæum of *Anthea cereus*.

Most of the nuclei of the various cellular constituents are arranged in a broad zone a little within the periphery, but a few appear in the deeper regions and as far as the mesoglœa. A peripheral zone of the ectoderm is nearly colourless, being constituted mainly of the distal portions of the extremely long supporting cells, unicellular glands with clear contents, and a few gland-cells with fine granular contents. These last stand out very distinctly in sections stained with indigo-carmine. The nuclei of the principal zone are oval and closely arranged, staining not nearly so intensely as those of the stomodæum and mesenterial filaments. The inner nuclei are rounded and much more scattered; some approach the supporting lamella, and others appear partly or even entirely included within it. The mesoglœa of the adult polyps contains numerous isolated cells equally distributed throughout, and there is little doubt that these are derived both from the ectoderm and the endoderm. For in the larvæ nuclei in similar positions to those of the ectoderm already referred to also appear on the internal side, and the thin lamella of the mesenteries also displays included cells. Both in longitudinal and transverse sections a very delicate layer of nerve-fibrils can be distinguished next the mesoglœa, much more obvious at the narrower end (Pl. 19. fig. 21). Maceration-preparations of such delicate material in the preserved condition did not yield good results, but I was able in some instances to distinguish the usual nerve-fibrils of the sensory cells.

No distinct evidence of muscular fibrils occurs on the ectodermal side, but in longitudinal sections such can be recognized on the inner border of the mesoglœa of all but the youngest larvæ (fig. 21).

The nematocysts are of two kinds. A long narrow form extends almost across the layer and is distributed throughout the ectoderm, even as far as the aboral region. They particularly crowd the tentacular area. On maceration, a very small oval form is also obtained, often with the nucleus of the cnidoblast still connected. These are not early stages of the larger variety, as the developing forms of these latter are very conspicuous objects.

The large nematocysts are extremely thin-walled, nearly transparent, and usually only a central, nearly straight, more highly refractive axis can be distinguished, extending from one end to near the other. In some conditions the presence of a very delicate, closely spiral thread can be observed in addition. Nearly all my preparations reveal the curious fact that, in the process of sectionizing, many of the nematocysts become dislodged from the ectoderm, and dragged to what would be the margin of the paraffin block, without causing any apparent injury to the other elements.

Here and there throughout the layer, more numerously in the tentacular region, occur nematocysts in various stages of development. They are at once recognized by their homogeneous and deeply-staining character. In this respect they contrast strongly with the mature forms, the walls of which are not affected by borax-carmine, though they become slightly blue in indigo-carmine. Most of the nematocysts originate in the deeper parts of the layer, and, at first, are a little concave or irregular in outline, and arranged obliquely or even tangentially to the surface. When mature they extend as far as the external surface and are disposed vertically. Both the wall and the axis take up the stain in the nearly ripe condition, and in transverse sections of earlier stages the contents are homogeneous in the middle but granular towards the margin.

Around the aboral end the ectoderm is of a very different character from elsewhere (Pl. **19**. fig. 21). The periphery is crowded with small nematocysts, provided with a very distinct spiral thread; large, pyriform, deeply-staining bodies, perhaps glandular, occur more internally, and towards the supporting lamella the nervous layer is exceptionally well-developed. Such a special development of the protective, sensory, and probably glandular elements of the layer is, no doubt, in some way associated with the fact that in the free active stage this end of the larva is foremost, and that it is by this that it ultimately attaches itself. McMurrich (1891, p. 317, pl. xiii. fig. 13) describes and figures a somewhat similar exaggerated development of the nervous layer in the embryo of *Rhodactis*.

As already mentioned amongst the external characters, and contrary to the usual condition in adult Zoantharia, the ectoderm contains zooxanthellæ, restricted, however, to the central area of the oral disc. In the oldest larvæ they occur throughout the thickness of the discal ectoderm, but none remain in the adult polyps.

Compared in other respects with the ectoderm of the adult, there is a great increase in the latter in the proportion of unicellular mucous glands with nearly clear contents; cilia are not obvious in material preserved in the same manner and at the same time as the larvæ; and practically no increase in thickness of the layer has taken place. A weak ectodermal musculature occurs on the tentacles, oral disc, and uppermost part of the adult column.

The nematocysts of the columnar outgrowths (pseudotentacles) in the adult are of a different kind from those already described, being oval and much shorter, with a loose, irregular spiral thread.

2. *The Archenteron and Formation of the Œsophagus.*

It is remarkable that in all the larvæ taken from the preserved adult there is no external aperture (Pl. **19.** fig. 21). This is also the case with the extruded larvæ at the time they are set free (fig. 15), but a mouth is established very early after as a result of an infolding of the discal ectoderm. From this it would seem that the structure in *Lebrunia*, hitherto spoken of as the stomodæum, must, prior to its communication with the exterior, be regarded as an endodermal-lined archenteron, for there are important morphological differences between its earliest and latest conditions.

If the discovery of earlier stages should prove that at the blastula-stage of development a primary archenteric invagination is established, then its external opening—the blastopore—has become closed, and only later another aperture is produced, over evidently the same spot, and this persists as the mouth. The entire tube thus formed, partly from the archenteron and partly from the secondary invagination, persists as the œsophagus of the adult.

Fortunately, a fairly complete series of preparations has been obtained showing the different stages in this latter transformation. In the non-extruded larvæ (fig. 21) the blind archenteron is easily distinguished by means of its deeply-staining lining; outwardly it extends as far as the external ectoderm, its narrow lumen recognizable all the way. The supporting lamella is seen to be invaginated for a considerable distance, but does not extend transversely. The ectodermal cells immediately over the archenteron are rather loosely arranged, and zooxanthellæ occur amongst them. It appears as if all that is needed to bring about the adult condition is for the archenteron to extend itself a little, and thus set up a communication with the exterior.

Vertical sections of one of the freshly-expelled larvæ prove that this is apparently not the case, but that to form the adult oral aperture and œsophagus a distinct invagination of the superficial ectoderm takes place. This is very distinctly shown in the actual sections represented in Pl. 18. figs. 9 to 11, taken from a series of vertical sections through the archenteric region of an extruded larva, before disintegration of the central tissue has commenced. In the particular larva the transverse, separating tissue of the invagination has evidently just broken through, establishing communication, but the lateral walls still indicate how the whole process has been carried out.

Fig. 9 is from a tangential section through the wall of the archenteron and the invaginated region above. The ectoderm directed inwardly differs much in character from that beyond; zooxanthellæ are absent, and a greater number of deeply-staining nuclei cause it to stand out very distinctly. A straight, ciliated edge indicates the free surface of the floor of the ectoderm; while a middle region below, nearly devoid of nuclei, represents where the lower surface of the invaginated end has come into contact with the expanded upper end of the archenteron.

The free margin of the wall of the latter, bordering on the flattened archenteric or cœlomic chamber, is also very strongly ciliated. The floor of this chamber is at this stage entire and sharply defined; the limiting layer is ciliated and contains abundant nuclei, which easily distinguish it from the vacuolated tissue below and around. To the right the floor is continued further into the diverticular system (*cf.* left side of fig. 15, Pl. 19).

Fig. 10 (Pl. 18) is from another tangential section, but nearer the lumen than the former. An external aperture is now presented, the outer ectoderm being seen as an inturned layer. The floor of the invagination is dome-shaped and extends some distance laterally. The area of its union with the roof of the archenteric cavity can even yet be distinguished owing to its diminished number of nuclei. The central cœlomic space is still flattened, but the preparation does not permit of the lateral extensions being followed.

Fig. 11 represents a section through the actual lumen. The central tissue, consisting of the floor of the ectodermal invagination and the roof of the archenteron, is now absorbed or broken down. The floor of the invagination is still represented laterally by the very marked indentation on each side, the actual point of union of the two layers being in the neighbourhood of the lower edge. Neither in this section nor in any of the later stages can the actual union of the invaginated ectoderm and the archenteric endoderm be recognized by any histological difference. The lumen throughout is now much wider than hitherto, but soon narrows again.

In all the other extruded polyps of which I possess vertical sections the stage reached is later than the above; the stomodæum has straight walls, and no indication is afforded of any double origin of its lining.

Strictly, then, only the upper, ectodermal-lined region of the gastric funnel in *Lebrunia* is homologous with the stomodæum or fore-gut of the Enterocœla; the lower region, lined with archenteric endoderm, is equivalent to a portion of the mesenteron or mid-gut of the higher Metazoa. While such conditions as those revealed in fig. 21 (Pl. 19), where the archenteric endoderm is in absolute continuity with the filamental tissue, strongly suggest that the mesenterial filaments along the free edge of the mesenteries are but the banded continuations of the enteron.

On account of the seeming double origin of the gullet in *Lebrunia*, the term œsophagus is preferable to the term stomodæum usually employed in Actinozoan literature for this structure. The former, as used in the Enterocœla, implies merely the first portion of the adult gastric canal, without any reference to the embryonic origin of its lining, though usually it possesses both an ectodermal and an endodermal portion; while the latter is the term employed to designate the extent of the invaginated ectodermal lining of the gastric canal. The justification for the employment of stomodæum in the adult Actinozoon rests upon the fact that, in general, the lining of the gullet is wholly derived from a primary ectodermal inturning, but it is obvious, from the details just given, that this may not always be the case.

We may thus summarize the formation of the oral aperture and œsophagus:—An invagination of the external ectoderm takes place directly over the outer extremity of the archenteric tube, and at the same time the layer undergoes a considerable histological alteration. Its floor presses upon the blind end of the archenteron, and the result is a mutual flattening, leading to a convexity in the former and a considerable lateral extension in each. The two ends ultimately break down in the middle, and a communication between the interior and exterior is thereby established. The lateral walls of the invaginated ectoderm and of the archenteric endoderm form the lining of the adult œsophagus.

Once the œsophagus is fully established, the lumen at first is extremely small, and circular in transverse section. Even in the older larvæ the outline may be circular in some places, but oval in others, the longer axis always corresponding with the sulco-sulcular axis of the mesenteries. No histological change suggestive of a gonidial groove ever takes place at either end, a condition not to be expected, as gonidial grooves are not present in the adult.

The lining is more strongly ciliated than that of the columnar ectoderm; indeed, it is the most strongly ciliated layer of the whole larva. As in the column a small, deeply-staining enlargement occurs at the base of each cilium.

The nuclear zone is very pronounced; the nuclei are oval, closely arranged, and stain a brilliant red in carmine. Clear gland-cells appear to be absent, but granular gland-cells occur here and there, and long, narrow nematocysts similar to those of the column. The mesoglœa is extremely thin. Only in some of the most favourable sections of the older larvæ can suggestions of a nervous layer be observed, though this is very pronounced in the adult.

Aborally the œsophagus opens directly into the gastro-cœlomic cavity. In perfectly horizontal sections the sulcar and sulcular ends terminate at about the same level. At the inner extremity a slight reflection of the strongly-nucleated lining takes place all round, so that in transverse sections at this point the latter appears cut through twice (Pl. **19**. fig. 18). The reflected portion is more or less connected with the mesenterial filaments at their origin; it is further discussed under the section Mesenterial Filaments.

In the adult polyp the œsophagus is greatly elongated transversely, so that it stretches nearly across the cœlenteron, the directive mesenteries being much shorter than the four lateral pairs. Gonidial grooves are absent. An exceptionally well-developed nervous layer occurs, without any accompaniment of muscular fibres, and granular gland-cells are numerous.

3. *Larval Cœlomic Spaces and Formation of the Gastro-cœlomic Cavity.*

Transverse sections through the upper archenteric region of the youngest larvæ, before any disorganization of the internal tissue has commenced, reveal very narrow, isolated, slit-like spaces within the intermesenterial, parenchymatous tissue, one near the middle of each face of a mesentery (Pl. 18. fig. 12, *d*, *e*, *f*). A little lower the two within each chamber become connected by a transverse channel, and still lower only a single median cavity occurs in each radial division (fig. 12, *g*, *h*, *c*), the lateral boundaries always remaining close to the face of the two enclosing mesenteries.

Approaching the inner termination of the archenteron, where three pairs of the mesenteries have become free, each cavity broadens somewhat, and communication is established between the five chambers on the dorsal or sulcular side of the sulco-lateral mesenteries, and also between the three on the ventral or sulcar side, two distinct sinuses being thus formed (fig. 13). The successive steps in the sinus formation, following the disappearance of the centripetal parts of the mesenteries, are shown in fig. 12, in connection with the intermesenterial spaces *b*, *a*, *h*. In this particular instance the sulcar mesenteries are the first to lose their connection with the archenteron and permit of communication.

Fig. 13 represents the arrangement of the various cavities at the inner end of the archenteron. It delineates the details observed in several sections of a polyp which happened to be cut slightly obliquely to the vertical axis. The archenteric tube terminates in four canals, one of which communicates with the sulcar sinus and three with the sulcular sinus. Were the sulco-lateral pair of mesenteries developed only to the same extent as the others, it is obvious that a complete circumferential sinus would be established.

For a short distance below, the two sinuses remain distinct, but later become sub-divided into eight V-shaped chambers, associated with the free edges of the mesenteries.

The various stages leading to this are represented in fig. 14, taken from a single oblique section in which the upper part is more aboral than the lower. Traces of the two sinuses are still seen in the latter region, and on the right side the last evidence of the sulcar canal; while, in the upper half of the figure, the V-shaped canals, embracing the free edge of the mesenteries, are distinct. This latter condition holds for all the mesenteries as far as their lower termination.

A vertical section, such as would be obtained along the line *x–y* in fig. 12, is represented in fig. 15 (Pl. 19), taken from one of the youngest larvæ. The archenteron opens into a shallow central chamber, from which two canals radiate, one to the left and the other to the right. Histologically the floor of the chamber differs considerably from the undifferentiated tissue below, more nearly resembling the endodermal lining of the archenteron. Vertical sections of one early larva show this chambered region very distinctly; some (figs. 10, 11) with the right side terminating blindly, and others (fig. 9) with a canal-like continuation. The precise outline of the diverticulum to the left in fig. 15 is largely deduced from the various transverse sections, as only isolated parts are recognizable in the actual vertical preparations.

The boundary of all the canals and spaces is regular and smooth, and cilia can be distinguished, not, however, so thickly disposed as in the archenteron. Everywhere at its origin the limiting layer is in continuity with the archenteric lining, and throughout bears a close resemblance to it. The cells constituting it are more or less separable from the rounded, vacuolated cells below, being columnar and filled with finely granular, protoplasmic contents; oval nuclei are much more numerous than elsewhere, and are arranged in a somewhat regular layer.

Throughout the best-preserved larvæ the margins stand out prominently in sections stained in borax-carmine, owing to the greater abundance of nuclei which readily take up the stain.

In sections the vacuolated tissue, both central and peripheral, most closely recalls the parenchymatous tissue of plants. The cells are somewhat polygonal in outline, their boundaries being extremely thin, and the contents have almost entirely disappeared. Here and there a nucleus occurs applied to the walls, and zooxanthellæ are distributed throughout. No objects at all suggestive of yolk-granules are present in any of the stages. The tissue probably shares in the formation of the muscular system, for in connection with it delicate fibrils are recognizable on the column-wall (fig. 21) and mesenteries (fig. 16).

The limiting cells next the supporting lamella of the column-wall are not arranged in any definite layer, and appear to differ in no respect from those more central.

Nuclei sometimes occur here more abundantly than elsewhere, and often in a similar manner along the two faces of the mesenteries. They are probably connected with the formation of the mesoglœa, and some seem to become included within it.

To recapitulate: The archenteron terminates internally in a small central cavity, from which four canals radiate and open into two circumferential sinuses, extending slightly above and below. In the middle archenteric region of the larvæ the sinuses subdivide into eight distinct chambers, one for each radial division, and ultimately each of these terminates in two cornua, sixteen in all. Below the archenteric region the sinuses terminate in eight V-shaped canals, each of which is formed, as it were, by the union of two cornua from adjacent mesenterial spaces. Owing to this the lower terminal chambers are mesenterial in position, while the upper must necessarily be intermesenterial. A ciliated limiting layer closely resembling in structure, and in absolute continuity with, the archenteric endoderm is throughout easily distinguished from the general mass of undifferentiated tissue. This system of spaces I regard as a larval cœlome or body-cavity arising in connection with an archenteron, but not cut off from it.

Instead of representing a definite and independent system of larval cœlomic diverticula, it may be urged that the spaces are merely the initial clefts in the disorganization of the solid interior, to be completed later. Against this I would point out that the canals and spaces all exhibit the distinct limiting layer, very different from anything to be associated with disintegrating tissue; and that in the intermediate larvæ, where the process can be followed, the breaking down of the cells commences just below the internal opening of the archenteron, attacking first the central mass. It is not until very late that any alteration takes place in the more proximal and distal spaces. And further, there is evidence that the greater part of the limiting layer becomes the unilaminar epithelium of the adult cavity. It is not disintegrated.

The internal appearances of the various regions of a later larva, one in which the disorganization of the central tissue is in progress, though the mouth is not formed, are represented in Pl. **19.** figs. 16–21. The first five are taken from actual sections of one of the non-extruded polyps, while fig. 21 is constructed so as to represent what would be obtained along the lines I–*x*, *x*–I in fig. 19. As a matter of fact, however, fig. 21 was obtained almost entirely from a single vertical section. The sections from which figs. 16–20 are taken would be along the lines 1–1, 2–2, 3–3, 4–4, 5–5 respectively of fig. 21.

Fig. 16 passes through the upper region of the archenteron, just below the sections showing the sixteen separate slit-like cornua. The spaces are very regular and crescent-shaped. Fig. 17 approaches the inner termination of the archenteron, only the sulco-lateral pair of mesenteries being still attached to the latter. The sulcular and sulcar sinuses are established, but neither here nor lower is there any trace of the archenteron dividing into canals. Four regions are indicated on its cœlomic epithelium, in which the deeply-staining tissue in continuity with the archenteric lining is becoming concentrated. The two in the sulcar sinus are distinct, but the sulcular pair are nearly united, though more distinct in sections above.

The appearance of the terminal walls of the tube alone is represented in fig. 18. The deeply-staining endoderm is cut through twice as a result of its reflection (*cf.* fig. 21, 3—3). The reflected moiety is now separated into two parts by the connection of the sulco-lateral mesenteries, which are seen to extend as far as the actual termination. The same tissue, developed to a much less degree, can also be traced along the margin of the mesenterial epithelium.

The next figure (fig. 19) is from a section below the archenteron, and shows the larger, filament-bearing, sulco-lateral mesenteries, and relics of the disorganized central tissue, in the gastrocœlomic cavity now in progress of formation. Comparing this with figures 9–11 of the earlier stage, it will be seen that the portion to disintegrate is that central to the two sinuses, including both the limiting layer and the enclosed mass of parenchymatous tissue.

The peripheral portion has not yet commenced the changes resulting in the unilaminar epithelium of the adult; it is still many cells in thickness, and its margin is strongly ciliated and nucleated.

In sections for some distance below the middle of the larva the mesenteries are all of the same size, and there is a large central cavity, but towards the aboral region the cavity is again nearly obliterated. The details here represented indicate the stages followed during the progress of disintegration. The vertical section in fig. 21 will assist in making the relations described a little clearer.

From these details it is evident that the only actual disintegration as yet is that involving the central tissue internal to the two circumferential sinuses, and extending to the aboral region and some distance within the œsophageal region. In the expelled larvæ the process, like that of the formation of the oral aperture, was set up immediately after liberation, and must have proceeded rapidly; for in only three specimens was I able to obtain the stage in which the centre is still solid and the diverticula distinct throughout. On the other hand, it is well on the way in the non-extruded larvæ, which are still devoid of any external opening.

Remains of the primary solid condition continue to be represented for some time peripherally, by an enormously thickened ridge of parenchymatous tissue, connected with the columnar boundary of each radial chamber, and also by the ridge of similar tissue on each face of the first pair of mesenteries (fig. 19). And in none of the polyps has the disorganization proceeded so far that the central cavity extends to the aboral region; but the process has progressed further at the oral extremity, whence the hollow tentacles arise.

All the preparations reveal, from the beginning, only a thin epithelium on the three pairs of shorter mesenteries, except towards their connection with the column and with the archenteron, where the layer joins that of the column-wall.

As growth continues the columnar intermesenterial ridges must also become further diminished until the unilaminar epithelium characteristic of the adult polyp is obtained throughout, but the larvæ only present stages towards such a condition. There is every indication that it is the limiting layer of the larval spaces, and not the vacuolated tissue, which persists and constitutes the lining of the adult cavity. In fig. 19, *e*, *f*, *g*, *h*, the limiting-layer appears, as it were, creeping round the ridges still remaining, and thus separating them for disintegration.

The original cœlomic spaces in connection with each radial division, whether above or below the œsophageal region, enlarge as the vacuolated tissue disappears and as the polyps increase in size, and ultimately become the endocœles and exocœles of the adult. These latter are thus shown to have their origin in primary spaces connected with an archenteron, exactly as occurs in the formation of the cœlome in the higher Metazoa, except that partial disorganization supervening, the spaces are never cut off from the central chamber.

In all the larvæ free zooxanthellæ and fragments of the disorganized tissue occur in the gastro-cœlomic cavity. It seems likely that these are ultimately expelled through the mouth of the polyp. I did not observe such in *Lebrunia*; but in *Aulactinia* and other embryos of about the same stage I have watched extrusions of this character going on from the interior; small irregular masses of mucus-like matter, mixed with what seemed to be yolk-particles and zooxanthellæ, would at times be passed out through the oral aperture.

The mesenterial filaments along the free edge of the mesenteries probably represent a divided digestive tube. In which case the space central to the mesenteries, the result of the disintegration, will be gastric, and the peripheral portion of the internal cavity will be cœlomic. Hence the term "gastro-cœlomic" more nearly expresses the true morphological conception of the whole of the internal cavity of the Scyphozoa than either "cœlenteron" or "gastro-vascular cavity."

It follows that the entire imperfectly-chambered internal cavity of the adult *Lebrunia* is ontogenetically both cœlomic and gastric, and is a secondary formation having its origin in two very different phenomena:—Firstly, in a primary system of radiating, archenteric diverticula or cœlomic spaces; and secondly, in the disintegration of a primary, undifferentiated tissue. The former gives rise to the mesenterial chambers, distinct from one another in the œsophageal region, but imperfect below; the latter gives origin to the space (gastric) central to the free edge of the mesenteries, and results in the imperfect character of the mesenterial chambers below the œsophagus. The greater part of the limiting layer of the spaces persists as the unilaminar epithelium of the gastro-cœlomic cavity of the adult.

4. *Mesenteries.*

Eight mesenteries are present in each stage examined, all perfect in the upper œsophageal region; but only two, the sulcolateral pair, remain united as far as the lower edge of the œsophagus. All may extend to the aboral termination of the internal cavity, but the sulcular directives sometimes cease a little in advance of the others. The four pairs subdivide the upper œsophageal region into eight chambers, four larger alternating with four slightly smaller, arranged so as to present a perfectly tetrameral, radial symmetry (Pl. 19. fig. 16), in correspondence with that of the tentacles on their first appearance. As the three pairs become free the transverse sections assume a distinctly bilateral symmetry. In their free condition the sulcolaterals continue for a short distance still larger than the rest, but below all the eight are practically equal, and very short in their centripetal extent.

It is remarkable that no increase in the number of mesenteries takes place between the earliest and the latest larvæ, representing a period of about five days. This is in harmony with the numerical condition of the tentacles, but the development of the mesenteries precedes that of the tentacles in all known cases.

In some examples the two sulcar directives, in the proximal region, become united along their free edges.

The mesoglœa of the mesenteries is usually broad at its origin in the column-wall, but is extremely thin beyond. In the earliest stages traces of muscular elements are indicated only in the basilar region, but later, transverse sections of very delicate longitudinal fibrils are seen along one face, just sufficiently well-developed to enable the paired arrangement of the mesenteries to be established (fig. 16). This follows the usual order, which is the same as that in *Edwardsia*, namely, the retractor muscles on the directives are on the faces of the mesenteries turned away from one another, while in the two lateral pairs they are on the faces turned towards one of the pair of directives which, by this means, if by no other, can be distinguished as the sulcar directives.

5. *Mesenterial Filaments.*

Mesenterial filaments are apparently undeveloped in the youngest larvæ, in which the whole of the vacuolated tissue is intact. In the earliest stages, however, in which disorganization is in progress, a filament occurs on the first pair of mesenteries, the sulco-lateral. These mesenteries, as already described, remain connected with the œsophagus as far as its lower termination, are much larger than the three other pairs, and are very prominent objects in transverse sections below the œsophagus (Pl. 19. figs. 19, 21).

Of the filament only the middle Drüsenstreif or glandular streak is yet formed. This structure stands out very conspicuously in sections stained in carmine, by reason of the deeply-staining character of its numerous close, oval nuclei, while the free surface is also strongly ciliated. Long, narrow nematocysts, similar to those in the superficial ectoderm and œsophageal lining, occur here and there in different stages of development, and occasionally granular gland-cells can be distinguished.

The filamental tissue extends for some distance down the edge of the mesenteries, but ceases before the aboral termination is reached. Although probably a matter of no particular significance, the filament during these early stages is found to be rarely equally developed on each of the two mesenteries, and generally terminates on one at a level different from that of the other.

In one larva sectionized transversely, the sulcular and sulculo-lateral mesenteries, in addition to the sulco-laterals, remain connected with the œsophagus as far as its aboral ending, and throughout their middle free course are proportionately larger than in other larvæ and also than the sulcar directives. The epithelium on each face is swollen a little, and towards the free edge stains more intensely than elsewhere, indicating that mesenterial filaments are in process of development.

While in the oldest extruded larvæ, and in all the non-extruded specimens (fig. 21), the filamental tissue is in absolute continuity with the similarly deeply-staining lining of the œsophagus or archenteron, a break occurs in earlier stages of the first series, where disintegration has just been set up.

A distinct bridge of unmodified tissue is seen to intervene between the œsophageal lining and the portion of the filament already developed below. This is clearly shown in fig. 22, representing the centripetal, swollen portion of the sulco-lateral pair of mesenteries of an extruded larva of intermediate age. The section is taken transversely a little below the gullet. At this level the mesentery to the left presents the beginnings of a filament at its free edge, easily distinguished by the oval, deeply-staining, closely-arranged nuclei and fringe of cilia; the mesentery to the right possesses only unmodified epithelium. Only a few sections lower, however, the filament begins to appear on the right mesentery also, and still lower is nearly as strongly developed on both, as shown in fig. 19, taken from a non-extruded larva. Such a separation between the filaments and œsophageal lining occurs in several larvæ of which I possess transverse sections, and also in one longitudinal series.

Any hiatus, however, is of a very temporary character. For in other early stages the filamental tissue already starts directly from the point at which the mesentery severs its connection with the œsophagus, at first very feebly developed, but becoming stronger below. Later, it is fully developed along the whole of its extent.

In this connection the outward and upward continuation of the archenteric or œsophageal lining which takes place at the aboral termination of the œsophagus must be referred to (figs. 17, 18, 21). Prof. H. V. Wilson (1888) found very pronounced reflections in the early stages of the development of the coral *Manicina areolata.* These push away the endoderm of the cœlenteric surface of the stomodæum, and Wilson considers them to be there concerned with the formation of the filaments, except those belonging to the first pair of mesenteries. These originated as direct downgrowths along the column-wall, to the mesoglœa of which the stomodæum at an early stage is apposed.

Prof. McMurrich (1891, p. 320, pl. xiii. fig. 17) also describes and figures a reflection at one end of the stomodæum of the larva of *Rhodactis Sancti-Thomæ.*

In several cases I obtain an appearance closely resembling that given by McMurrich; and on following it down, section by section, the deeply-staining tissue is seen to enlarge until ultimately it extends all round the œsophagus, with the exception of the two points from which the first pair of mesenteries are given off (fig. 18). At these it passes along the edge of the mesenteries.

When the sections are perfectly horizontal the reflection at first is equally developed all round, except at the two points mentioned, and is continued above in four distinct bands (fig. 17). The extent of the reflection in the non-extruded larvæ (fig. 21) should be compared with the condition before and after disintegration in the others (figs. 11, 22).

The sections of *Lebrunia* prove that such a condition as that figured by McMurrich—the stomodæum open at one end and the lips partly turned back, and with a free portion of the lining reflected outside the opposite end—is probably due to an obliquity in the sections to the vertical axis of the larva, but it would, of course, also be brought about if the stomodæum terminated at one end earlier than at the other.

The reflection has the significance of constituting the point of continuity between the œsophageal lining and the mesenterial filaments, and occurs also in the adult condition of most Zoantharia.

At the present time one of the most important problems in Actinozoan morphology concerns the origin, from one or other of the two embryonic layers, of the mesenterial filaments. The facts observed in every case are as follows:—Histologically the lining of the œsophagus very closely, though perhaps never completely, resembles the mesenterial filaments; and in the perfect mesenteries of all adult polyps the two are in absolute continuity. In so far as the filaments resemble the stomodæal lining do they differ from the ordinary epithelium of the gastro-cœlomic cavity; everywhere they offer a very strong histological contrast to the latter.

Embryological evidence is here of the greatest value. From this standpoint the question has been approached by Prof. E. B. Wilson (1884) for the Alcyonaria, by Prof. H. V. Wilson for the Madreporaria (1888), and by Prof. McMurrich (1891) and others for the Actiniaria. In his paper on "The Mesenterial Filaments of the Alcyonaria," the first mentioned investigator arrives at the conclusion that the filaments of the two dorsal mesenteries in that group are ectodermal derivatives, that is, downgrowths of the lining of the stomodæum, and are homologous with the Flimmerstreifen or ciliated streaks of the Actiniaria; while the six ventral filaments are endodermal in origin, and correspond with the Drüsenstreifen of the Actiniarian filament.

The former E. B. Wilson proves to be specially circulatory in function, while the latter are digestive. Studying the West-Indian coral *Manicina*, in which only the Drüsenstreif is developed, H. V. Wilson found that the filament of the first pair of mesenteries arises as a downgrowth of the stomodæal ectoderm, and the later ones from upward reflections of the same layer. He homologizes the simple Madreporarian filament with the whole of the trilobed Actinian filament. From his researches on *Aulactinia* and *Rhodactis* McMurrich is inclined to agree with E. B. Wilson, and to regard the Drüsenstreif as endodermal and the Flimmerstreifen as ectodermal in origin. The sections of *Aulactinia* revealed a bridge of unmodified endodermal tissue between the early filament and the stomodæal ectoderm, but the results with *Rhodactis* were not so conclusive, although representing earlier stages.

In this strictly limited aspect of the problem the evidence from *Lebrunia* at first sight appears incontrovertible. In having the four pairs of mesenteries already developed, along with a nearly solid interior, the larvæ present conditions very different from those studied by the previous investigators. As already described, no filament is discernible before the gastro-vascular cavity of the adult has begun to be established. And for the next early larvæ, the first portion of the free mesentery in the case of the sulco-lateral pair of mesenteries possesses only unmodified endoderm at its free edge, while a filament is well developed below. It is on evidence precisely of this character that E. B. Wilson and McMurrich affirm the endodermal origin, in the former case, of the six ventral filaments of the Alcyonaria, and, in the latter, of the median streak of the Actiniaria.

Regarding as I do the lower region of the œsophagus in *Lebrunia* as a portion of the archenteron and therefore its lining as endoderm, the significance of its primary relationship with the mesenterial filaments becomes altered from that understood by the writers just mentioned.

From such conditions as those revealed in fig. 21, before any ectodermal invagination appears, it is clear that the archenteric endoderm and the filamental tissue are morphologically one and the same.

I venture to think that in *Lebrunia* the temporary discontinuity in the extruded larvæ between the œsophageal lining and the developing filaments is a condition of no morphological importance, perhaps due only to the readjustment of the relations between the œsophagus and mesenteries consequent upon the disorganization of the central tissue and the formation of the oral aperture. Any subsequent discontinuity in such a larva as that from which fig. 21 is taken would clearly have no bearing on the morphological value of the filaments.

From the details revealed by the larva of *Lebrunia*, I consider that we are justified in regarding the simple filament of the Madreporaria and Alcyonaria, and the glandular streak of the trilobed filament of the Actiniaria, as representing a continuation of the enteron; a relationship already suggested by other workers (p. 307).

The fact that no such break in continuity as that referred to has ever been observed between the œsophageal epithelium and the lateral or ciliated streaks of the trilobed Actiniarian filament, has led E. B. Wilson and McMurrich to regard these as ectodermal downgrowths from the stomodæal walls, and in this they are followed by most writers on the Actinozoa. My results, however, incline me to the opinion of H. V. Wilson, namely, that the simple Madreporarian filament is homologous with the complex Actinian filament.

Ontogenetically the Flimmerstreifen appear later than the Drüsenstreif, and, at any rate in *Lebrunia*, after the continuity of the latter with the œsophagus has been established. They are always highly specialized structures in that the constituents are wholly columnar ciliated cells, without an admixture of gland-cells and cnidoblasts, thus differing histologically from the œsophageal lining or median streak of the filament. There is little doubt that they are, like the dorsal filaments of the Alcyonaria, special circulatory organs. Usually they are most strongly developed in colonial Actiniaria, such as the Zoanthidæ. The so-called "Reflected Ectoderm" of Haddon (1891, p. 619) met with in this family must, in all probability, be looked upon as a strongly developed portion of the ciliated streak.

To anticipate results yet to be published, I find that along the two sides of the simple filament of the West-Indian species of *Madrepora* a very characteristic structure is developed, in no way histologically distinguishable from the Flimmerstreifen of the Actiniæ.

Such an occurrence in a Perforate coral, in which the circulatory system is very extensive and complex, seems to afford strong evidence for regarding the single filament as the homologue of the whole of the trilobed filament, and consequently for its origin as a whole from one and the same embryonic layer.

In the adult *Lebrunia* the ciliated streaks are strongly developed and continuous with the lining of the œsophagus at its inner termination.

IV. RELATIONS OF THE TENTACLES AND MESENTERIES.

The origin of the different tentacles in relation to the mesenterial chambers discloses some unexpected conditions. And firstly a comparison may be instituted between the time of appearance of the tentacles as external organs of the polyp, and the stage reached in the development of the internal mesenteries and their corresponding chambers.

Though the first eight mesenteries in all Zoantharia yet investigated develop successively in pairs, the early tentacles rarely do so. Lacaze-Duthiers, in his classic investigations already referred to, found the tentacles to appear in *Actinia equina* during the stage in which eight mesenteries were present, one from each mesenterial chamber, as is also the case in *Lebrunia*. Von Koch (1897) apparently found twelve tentacles to appear simultaneously in *Caryophyllia cyathus*, at a stage when twelve mesenteries were developed, eight only of which were perfect. In Haddon's newly-hatched larvæ of *Euphyllia* no tentacles, however, were developed, although six pairs of mesenteries were present, three pairs of which possessed filaments.

On the other hand, both McMurrich and van Beneden found that in the Cerianthid *Arachnactis* the appearance in pairs of the tentacles follows closely upon that of the formation of the mesenterial chambers. But, in consequence of the stomodæum extending right across the cœlenteron, from wall to wall, at the stage of development characterized by the presence of two, or perhaps three, pairs of lateral tentacles, there exists no trace of any median chambers, and it is only when these have been formed that a median tentacle appears. In this case it is the ventral tentacle; a median dorsal never occurs, the region being one of apparently continuous growth in pairs of the tentacles and mesenteries.

From the few examples given there is evidently little or no connection to be expected between the stage of internal development and the appearance of the tentacles.

In viviparous polyps the formation of the tentacles rarely takes place until the larvæ are set free, whereas the internal development may have proceeded to almost any degree, though apparently not often beyond the *Edwardsia*-stage. Yet in newly-hatched larvæ of *Aulactinia* I found examples with six tentacles already protruding.

The relation of the axis of symmetry of the tentacles in their bilateral stage with that of the mesenteries may now be considered.

In *Actinia equina* Lacaze-Duthiers found the first and largest tentacle to arise from the sulcular endocœle, a smaller and opposite from the sulcar endocœle, and the three lateral pairs, varying somewhat in size, from the lateral mesenterial chambers. The sagittal axis of the tentacles, therefore, is the same as the axis of symmetry of the paired mesenteries, a relationship which would naturally be expected. The longer axis of the stomodæum is also in the same plane. The figures of McMurrich and van Beneden show that in *Arachnactis* the plane of symmetry of the tentacles and of the mesenteric chambers likewise coincide, and von Koch represents the same relations for *Caryophyllia cyathus*.

In one late larva of *Lebrunia*, in which a complete series of transverse sections enabled these relationships to be followed from one end to the other, a different relationship was encountered. This is represented in Pl. 19. figs. 23–25.

The first section (fig. 23), passing through the basal tentacular region, exhibits the relative sizes of the tentacles such as has already been described among the external characters for the bilateral stage. Sections in advance of this leave no doubt as to the correctness of the dorso-ventral relations here indicated. The longer axis of the oval stomodæum is in a plane at right angles to that of the median axis of the tentacles. Fig. 24, taken from a section through the middle stomodæal region, reveals the same bilateral arrangement of the tentacles, but the dorso-lateral tentacles (*f*, *h*) are now comparatively larger than before on account of their relatively lower origin in the polyp.

Under a high magnification the very delicate retractor-muscle fibres on the mesenteries can be made out, enabling the two pairs of directives (III., III.; IV., IV.) to be determined. These are found to be arranged about an axis (*a–e*) at right angles to the median axis of the tentacles (*g–c*). I have represented the cut ends of the muscular fibrils in the figure, although they could not be discerned at such a low magnification as that given.

The next figure is from a section a little below the stomodæal region, and, although no trace of any tentacles occurs, the section follows the others in regular sequence without any disturbance of the axes. The larva was sectionized in one continuous ribbon and mounted accordingly. As in the previous figure, the sulco-sulcular plane of the larva (*a–e*) is at right angles to what would be the median plane of the tentacles (*g–e*); in other words, the two median lateral tentacles communicate the one with the sulcar (*a*) and the other with the sulcular endocœle (*e*), while the two tentacles in the dorso-ventral plane communicate each with a median mesenterial space (*c*, *g*).

Another condition is disclosed by the slightly flattened larva from which figs. 26–28 are taken. The series indicates that on the left side the small tentacle next the large dorsal tentacle (*f*) communicates with the sulcular endocœle (*e*), and the small tentacle (*a*) on the right side, next the ventral (*b*), communicates with the sulcar endocœle (*a*), so that the median axis of the tentacles (*f–b*) is in a plane oblique to the sulco-sulcular axis of the mesenteries (*a–e*). Here, again, the longer axis of the œsophagus is in the same plane as the sulco-sulcular plane of the mesenteries.

A third larva was in the same condition as the first example described—the median axis of the tentacles at right angles to the axis of symmetry of the mesenteries. And, yet again, a fourth example, traced later, revealed the same oblique relationships as the second here recorded.

In every case the longer axis of the œsophagus coincided with the axis of symmetry of the pairs of mesenteries, not with that of the tentacles.

It is very evident, therefore, from these four cases, that the symmetry of the two sets of organs—tentacles and mesenteries—is independent in the bilateral stage of the larva. It may perhaps be explained as a result of the late formation of the cœlenteric cavity, of the assumption of the bilateral stage of the tentacles before any decided internal bilateral symmetry has been established in the upper tentacular region, the nearly solid interior having no influence on the method of grouping of the tentacular outgrowths.

Where, as in *Arachnactis*, the outgrowth of the tentacles closely follows the production of mesenterial spaces, it is obvious that the two must be directly related, and that the external symmetry will be moulded upon the internal. Also in the species studied by Lacaze-Duthiers and others, where the cœlenteric chambers were formed in advance of the tentacles, the internal symmetry first assumed would be likely to impress itself upon the external organs arising later.

The irregularity in *Lebrunia* is probably rectified in the subsequent rearrangement of the tentacles in hexamerous cycles, for, in the numerous adult specimens I have examined, the tentacles, œsophageal axis, and mesenteries exhibit the relationships usual in the Hexactiniæ.

V. Conclusions.

From the foregoing account it is obvious that the larva of *Lebrunia coralligens* presents us with very unexpected conditions in Scyphozoan development; and this not alone in any one particular organ, but in almost every essential structure. The early tetrameral symmetry, followed by a bilateral phase, and that again by the hexamerous adult; the system of ciliated cœlomic spaces connected with a closed archenteron, all embedded in a mass of undifferentiated tissue; the formation of the œsophagus by the breaking down of the floor of an ectodermal invagination in association with an archenteric tube; and the origin of the adult gastro-cœlomic cavity from a primary cœlome and disintegration of the tissues, are all unique characteristics.

The species seems to retain to a late period certain ancestral characters which in other forms are either passed over or disappear very early, so that other features dependent upon their presence are never exhibited. Thus, were the vacuolated tissue insufficiently developed, or to disappear early, we should have no clear evidence of a distinct larval cœlome.

Some of the facts observed in the early larvæ appear to obtain their full significance only from a comparison with the tetrameral Scyphomedusæ. Commenting upon the connection of this group with the Zoantharia Haddon, ten years ago (1889), wrote:—"The relationship of the Hydra-tuba and Scyphostoma stages of the Scyphomedusæ (Acalephæ) to the Zoantharia is now generally admitted, indeed a group (Tæniolatæ) has been erected by Professor E. Hæckel to include them both. Later Professor A. Götte has similarly proposed the term Scyphozoa for the same assemblage, but including the Ctenophora, as opposed to the remaining Cœlenterata or Hydrozoa. The Scyphostoma have an œsophagus lined by ectoderm (Stomodæum), four glandular mesenteries, the edges of which are true craspeda, and serve to digest food; in their upper portion nematocysts are present. The four tentacles are afterwards increased to eight, and finally to sixteen. It is especially noteworthy that at first there are only two tentacles: probably this is a reminiscence of a remote ancestor. The widespread occurrence of a symmetry of four amongst the larvæ of the Scyphozoa is very suggestive."

Discussing the Phylogeny of the Actinozoa McMurrich (1891 *a*, p. 149), two years later, also remarked:—"As regards the relations of the Actinozoa to other Cœlenterates, there is little to be said; the majority of authors who have committed themselves upon the subject, agree in tracing the Actinozoan stem back to a form similar to the *Scyphistoma*. The evidence we have seems to point in that direction; but it must be acknowledged that it is exceedingly scanty, and there are many points of difference between any *Scyphistoma* of which we have a description and the simplest Actinozoa. It seems probable, however, that the Actinozoa are to be traced back to an ancestor possessing only four mesenteries. The occurrence of an octameral symmetry in the simplest Actinozoa seems to point in that direction, as well as the fact that, in the development of the Hexactiniæ, the stage with four mesenteries seems to mark an epoch, much less distinct, however, than that indicated at the close of the *Edwardsia* stage."

The tetrameral symmetry of the *Lebrunia* larva, perfect as regards the tentacles, and the mesenteries and cœlomic diverticula of the upper archenteric region, seems to be explicable only on such a throwing back of the ancestry of the Zoantharia. The two alternating series of four tentacles exactly recall the eight-armed stage passed through by most Scyphostoma, and the arrangement of the four canals, with the circumferential sinus terminating in eight divisions bifurcated at the end, resembles a gastro-vascular system such as that of the Ephyra.

Though in the particular case of *Lebrunia* the eight tentacles develop simultaneously, it does not follow that they may not have had an ancestry in which they arose in pairs, as happens in the Scyphostoma. For there is evidence that such fundamental structures as the primary mesenteries develop successively in pairs, as is the case in all other Zoantharia. The two constituting the fourth pair (sulcular directives) in most cases disappear at the aboral end before the others, and in every case the first pair (sulco-lateral) are larger than the others, and are the only ones which bear mesenterial filaments.

The results appear to justify to a greater degree than has before been possible Hæckel's and Götte's union of the Scyphomedusæ and Actinozoa under the term Tæniolatæ or Scyphozoa; a relationship first rendered probable by the discovery of the ectodermal character of the stomodæal lining of the former, and the presence of mesenteries and gastric filaments. The strong objection founded on the tetrameral character of the Scyphomedusæ, as compared with the hexameral nature of the Actiniaria, disappears on the demonstration that the larvæ of the latter may pass through a tetrameral stage, directly comparable with that permanent in the former.

Further, where the transition from one stage to the other can be followed in the ontogeny of a single form, we have another to the many objections against the separation of the Tetracorallia or Rugosa from the Hexacorallia. There can be no fundamental distinction on the ground of symmetry alone.

The very marked arrest of the mesenterial and tentacular development in *Lebrunia* at a tetrameral or octameral stage, and the fact that such occurs to a greater or less degree in apparently all other Zoantharia (*Edwardsia*-stage), suggest this as either a permanent stage or as a starting-point for various modifications, and emphasizes with how little reliability adult structure can be accepted as evidence of phylogenetic relationship.

The Rugosa and Alcyonaria retain approximately a tetrameral or octameral type of symmetry, while the Hexacorallia and Actiniaria, by the further addition of two lateral pairs of mesenteries, give rise to another—the hexameral. Even amongst the Hexactiniæ, however, octameral or tetrameral examples may occur; occasionally in such a form as *Aiptasia annulata*, but apparently always in most species of the genus *Corynactis* (Duerden, 1898, p. 649).

McMurrich (1891, p. 311) is inclined to regard the differences of arrangement of the retractor muscles of the mesenteries, such as one sees in the directives of the Alcyonaria and in the Zoantharia, as of secondary importance, in comparison with the order of development and number of mesenteries.

Undoubtedly the character of greatest concern is the occurrence in an Actinian of what appears to be a system of primitive cœlomic spaces connected with a closed archenteron, within an otherwise solid interior. And it remains to be seen what support there is for the views already advanced in regard to such.

Until the earlier stages of the embryo have been obtained, it is impossible to determine the manner in which the conditions have arisen, and therefore to homologize them with certainty with what occurs in other groups. It will be necessary to ascertain whether an actual primary invagination takes place before or after the appearance of the supporting lamella, and if the spaces themselves are primitively formed as evaginations of this, the limiting layer being a direct continuation of its walls; or, whether the spaces originate independently as splittings within the solid tissue, their limiting layer then arising as a modification of the marginal cells, and later entering into communication with the internal end of the archenteron.

The evidence obtainable from the development of other Scyphozoa assists but little in the elucidation of the actual facts presented by *Lebrunia* at the stages under consideration. From the fertilized ovum a blastosphere results, and, according to the accounts of some observers, the two-layered planula is formed by invagination, and, according to others, by delamination. Reviewing all the known cases, McMurrich (1891), in the light of his own results with *Metridium*, comes to the conclusion that, with the probable exceptions of *Pelagia* and *Nausithoë*, in every case the endoderm in the Scyphozoa is produced by delamination; that the results of Kowalewski with *Actinia* (sp.?) and *Cerianthus*, of Jourdan with *Actinia equina*, as also of Hæckel with the Alcyonarian *Monoxenia*, in that they ascribe the production of the gastrula, and consequently of the endoderm, to invagination, are a misinterpretation of the appearances.

In the course of development a primitive mouth or blastopore appears to be always formed, and in some instances becomes closed; but in any case the permanent mouth and stomodæum are considered to arise by a later infolding of the ectoderm.

At the conclusion of the delamination in *Metridium* McMurrich (1891, p. 308) observed a slight depression at the posterior pole of the larva, which soon after breaks through, a communication of the interior cavity with the exterior being thus established. His latest stages of this species did not permit of his ascertaining the manner of formation of the stomodæum. A primary mouth, with a later invagination of the two-layered wall to form the stomodæum, is figured by Kowalewsky for *Actinia* (sp.?) and *Cerianthus*, and by Jourdan for *Actinia equina* and apparently for the coral *Balanophyllia* (1884, 'Embryological Monographs,' pls. xi.–xiii.).

In *Aurelia*, Götte found that after the planula settled down an ectodermic invagination is formed, its lower end breaking through, thus establishing a communication of the interior with the exterior and constituting the œsophagus. First two and then four diverticula or gastric pouches of the general cavity are formed and arranged around the œsophagus, and a reflection of the lining of the latter also appears to take place.

I believe it will ultimately be found that the early stages in the development of *Lebrunia* will be better understood by a comparison with what occurs in the Scyphomedusæ than by what happens in the Actinozoa.

In *Lebrunia*, we are confronted with the facts that a stomodæal-like funnel already exists in association with a considerable mesenterial development, and that up to the time of liberation of the larvæ no oral aperture is present, but that this is formed shortly after extrusion.

Can we then, in face of what is already known in Scyphozoan embryology, assume that the first mentioned structure is an endodermal-lined archenteron, the blastopore of which has become and is still closed, and that the later invagination is the one corresponding with that which gives rise to the mouth and ectodermal stomodæum in all other known Scyphozoan larvæ?

Until the study of earlier stages can settle the question absolutely I can come to no other conclusion, and, of course, the correctness or otherwise of the explanation of many of the other peculiar features is determined thereby. The view has the merit of placing the conditions in strict harmony with what occurs in many Enterocœla.

The limiting layer of the larval cœlomic spaces in continuity with the lining of the archenteron must be considered as the equivalent of the wall of the cœlomic pouches or cœlomic splittings of the higher Metazoa. Here it is usually regarded as mesoderm or mesothelium, the latter term being employed in order to distinguish it from the mesoderm—" mesenchyme "—arising by immigration.

The tendency, however, is to regard still as endoderm the walls of all the outgrowths from the archenteron and their derivatives. Thus in the latest important work on the morphology of the Echinoderms, Dr. H. L. Clark (1898) describes as mesoderm only the tissue of mesenchymal origin, and this plays a very insignificant part in the adult structures. Under endoderm he includes all the derivatives of the archenteron and its hydroenterocœl, embracing amongst other structures the lining of the digestive tract with most of the œsophagus; all the muscles of the body-wall and gut; the peritoneal lining of the body-cavity and epithelial covering for the various organs contained in it, as well as the genital organs and their ducts.

Homologizing the limiting layer of the cœlomic pouches in *Lebrunia* with the peritoneal epithelium of the body-cavity of the higher Metazoa, we may, with Clark, still regard it as endoderm, or, following the more usually accepted terminology, speak of it as mesoderm; and, as in all the Enterocœla, it gives origin to the principal muscular system and the gonads. The portion adjacent to the column-wall and that covering the two faces of the mesenteries would correspond with the somatic, and the remainder with the splanchnic layer of the higher Metazoa, and it is the former which remains as the epithelial lining of the major part of the adult mesenteric chambers. Below the œsophageal region it is the splanchnic layer which disappears during disintegration, but above, this constitutes the cœlomic lining of the gullet.

What, then, of the vacuolated mass of tissue which probably entirely disappears in the adult? It is the tissue within which the cœlomic spaces are formed. To continue the comparison with the Tripoblastica, may we not regard it as the equivalent of the "mesenchyme" of the higher Metazoa? It is evident that in *Lebrunia* it is little more than a larval "packing-tissue," disappearing as the adult Scyphozoan characteristics are taken on. As already mentioned, however, it probably shares in the formation of the muscular system.

Even though beyond the œsophagus no separate digestive tract with closed walls remains in the adult, there seems little doubt that the mesenterial filaments are to be looked upon as representing an endodermal-lined digestive gut, continuity with the œsophagus being either original or established at a very early stage. As the primary distinctness of the cœlomic pouches has broken down at an exceptionally early stage, so the walls of the enteron come to be represented only by thickened ridges along the free edge of the septa of the cœlome. Or the same result may thus be conversely stated, and perhaps with greater morphological truth, that as the lower portion of the enteron beyond the point at which diverticula are given off is not formed early enough, so the mesenchyme and cœlomic epithelia, which on their part are developed and would have surrounded it, become disintegrated, leading to the imperfect condition of the cœlomic chambers in the adult. It only remains to conceive of the adult mesenteries uniting along their lateral edges and we should have a closed gut as in the higher Metazoa, lined above by the invaginated ectoderm and below by the archenteric endoderm. The mesenterial chambers thus distinct from one another would constitute a true cœlome or body-cavity, exactly as in the œsophageal region and in the Enterocœla. As it is, the Scyphozoa are distinguished by having the lower portion of the enteric system in separate longitudinal bands, its cavity in communication laterally and below with the chambered body-cavity.

Were the explanations here offered to be confirmed, the occurrence in the Scyphozoa of an archenteron with distinct radiating cœlomic diverticula would be recorded for the first time, but the broad relationships of the group with the higher Metazoa thereby implied have been already surmised by various workers.

Prof. E. B. Wilson (1884), in his paper on "The Mesenterial Filaments of the Alcyonaria," devotes a section to the relations of the Anthozoa to the Enterocœla. Having established, both experimentally and histologically, that the digestive functions of the Alcyonaria are confined to the six ventral mesenterial filaments, he regards the latter as the representatives of the alimentary canal of higher animals, and suggests that "they are not only physiologically but also morphologically the equivalents of the enteron of the Enterocœla"; and continuing, affirms that "morphologically we may regard the radial chambers as diverticula from the primitive enteron."

Van Beneden (1891), from his study of the development of the larval Cerianthid *Arachnactis*, likewise comes to the same conclusion in reference to the mesenteric chambers of the Anthozoa and the cœlomic diverticula of the higher animals. He devotes special attention to a comparison of the origin and arrangement of the mesenteries and their chambers in the Cerianthidæ with paired cœlomic diverticula of the segmented Metazoa.

According to a preliminary notice appearing in 'Nature,' March 2, received when this contribution was nearly completed, Mr. J. Stanley Gardiner, studying a supposed new species of the coral *Cœnopsammia* from Lifu, has also come to practically the same conclusion as Prof. E. B. Wilson in regard to the enteron and mesenterial filaments. The notice contains the pertinent sentence: "It was further contended that the stomodæum together with the mesenterial filaments is homologous with the whole gut of the Triploblastica, and that the so-called endoderm is homologous with the mesoderm. The Actinozoon polyp then must be regarded as a Triploblastic form."

In the larva of *Lebrunia* we appear to have the actual embryological proof of these surmises, founded mostly upon a consideration of the adult anatomy. And it is clearly such a problem as can only be established on embryological grounds.

Whether the larval spaces are derived originally as paired or radiating evaginations of the terminal region of an archenteron, and their walls are then to be regarded as mesothelium or endoderm, or whether they originate as splittings within the solid undifferentiated cell-mass, matters but little. Both processes occur in the higher animals: in some the cœlome originates from endodermic diverticula, *e. g.* Echinodermata, *Amphioxus*; in others from mesoblastic splitting, *e. g.* nearly all Vertebrates.

The main point sought to be established is that the larval spaces of *Lebrunia* represent a paired cœlome embryologically equivalent to that of the higher Metazoa, and, consequently, that the chambers of the adult are the same. For there is no doubt as to the manner in which these latter arise from the primary spaces.

It remains to discuss what support there is otherwise for such a change in conception of the layers and internal cavity of the Scyphozoa.

Prof. J. P. McMurrich, in his most valuable series of "Contributions on the Morphology of the Actinozoa," devotes Part II. (1891) to the development of the Hexactiniæ, and therein describes an almost complete series of stages from the egg to the adult, taking his examples from the genera *Metridium*, *Rhodactis*, and *Aulactinia*. In reviewing all the known cases of early development, he concludes, as already mentioned, that the so-called endoderm of the Actinozoa is derived from the hollow blastula by the process of delamination, not by invagination, the extent of its cellular development being mainly dependent upon the amount of yolk present.

Following partly the results of Metschnikoff, McMurrich regards the process of delamination as a modified form of the more primitive process of immigration. In groups higher than the Cœlenterata the products of immigration, whether from the ectoderm or endoderm or from both, are regarded as mesodermic (*ex.* the "mesenchyme" of Echinoderms). There is little doubt that the internal parenchymatous tissue of the *Lebrunia* larva has arisen by delamination in the same way as in other Actinozoa: hence, if an independent endoderm, as from an archenteric invagination, can be established, there seems no reason why the first-mentioned tissue should not be regarded as the homologue of the mesoderm of higher Metazoa. May we not in *Lebrunia* have "mesenchyme" arising by delamination (in migration), and "mesothelium" (endoderm) from an archenteric invagination, as in the Echinoderms?

To the solid larval stage in the Actinozoa, where segmentation is completed and before the formation of the stomodæum, McMurrich (p. 310) applies the term "Sterrula."

In many Alcyonaria, and apparently in some Madreporaria (*Manicina* and *Balanophyllia*), this is a solid mass of more or less definite cells; whereas in *Metridium*, so far as McMurrich's embryos allowed the study to be continued, the sterrula was provided with only a comparatively narrow layer of endoderm, the remainder of the cavity being filled with yolk-granules. In the solid sterrula of the Alcyonaria the middle cellular tissue early begins to disorganize as the growth of the larva proceeds, giving rise, of course, to the usual cœlenterate gastro-cœlomic cavity with a unilaminar epithelium; while in the other cases it seems that the cœlenteron is produced by the absorption of the yolk, or some of the latter may be extruded through the mouth of the embryo.

The earliest larva of *Lebrunia* I possess has passed beyond the sterrula stage, the mesenteries and the archenteron being already formed. It is in the late stage to which the solid cellular tissue persists, that the species appears to differ from other examples yet recorded. And it would appear to be this entire retention of the central tissue, as compared with its early disappearance or absence in other Scyphozoa, which may enable the morphological conceptions of the other systems to be obtained in such a way as is known for no other species.

Is there any evidence that such a system of diverticula occurs at any stage in other Actinozoa? For it can scarcely be supposed that such an apparently fundamental phenomenon is restricted to an isolated type.

Few Zoantharia larvæ of exactly the same stage as the earliest *Lebrunia* have been minutely described. In some respects, as in the stage reached in the development of the mesenteries, the *Lebrunia* larva is far advanced; but in others—the persistence of the vacuolated tissue and non-formation of oral aperture—it is somewhat early in its development. McMurrich (1891) found in the youngest embryos of *Rhodactis Sancti-Thomæ* that the so-called endoderm-cells completely fill the central cavity, and show little or no arrangement into a definite layer. At the stage, however, where only two mesenteries are present, a well-marked central cavity already existed below the upper region of the body, though the endoderm above was yet solid, no intermesenterial cavities having appeared. In this species then the solid endoderm begins to disorganize at a much earlier stage than in *Lebrunia*, in fact before the mesenteries, with which the spaces are associated, are formed. McMurrich's earliest stages of *Aulactinia* possessed eight perfect mesenteries, the first only being provided with mesenterial filaments. They therefore correspond with the oldest stage in *Lebrunia.* The endoderm, however, had already arranged itself into a somewhat definite layer, but lying scattered about in the body-cavity of the embryo were numerous, somewhat large, cellular elements and yolk-granules.

The Zoanthid larva which van Beneden (1890) identified as closely related to Semper's larva presents three pairs of complete mesenteries and four incomplete pairs, and a very thick endoderm, with small cœlenteric spaces within the stomodæal region. Below, however, a considerable gastro-vascular cavity is formed. The same author (1891) found the larvæ of the Cerianthid *Arachnactis*, at the stage with only one pair of mesenteries and two pairs of tentacles, to possess a cœlenteron fully formed with an endodermal lining of only a single layer of cells. Prof. G. von Koch observed a central cavity in *Gorgonia* and in *Caryophyllia cyathus* (1897) before the formation of any mesenteries or the production of an oral aperture and stomodæum.

In the newly-hatched larva of *Euphyllia rugosa*, Haddon (1890) found three of the twelve pairs of mesenteries already bearing filaments, and alternating with the mesenteries were "large ridge-like vesicular outgrowths from the endoderm." There can be little doubt that, as in *Lebrunia*, these latter are the detached survivors of a more or less solid vacuolated tissue in the earlier stages of the larvæ. Prof. E. L. Mark ("Selections from Embryological Monographs," pl. xii. fig. 32) figures similar inter-mesenterial protrusions, thoroughly vacuolated, in *Edwardsia.* The appearances should be compared with fig. 19 and with the left side of fig. 20 (Pl. **19**) in the present paper. The phenomena are remarkably alike. On plate xiii. fig. 15 of the same publication, Prof. Mark reproduces the transverse section of the larva of *Balanophyllia regia* given by E. Jourdan, in which the embryo is still solid, though the central portion is indicated as yolk. Six mesenteries are here shown and the internal yolk seems clearly separated from the endoderm, which latter is still many cells in thickness. The conditions appear to be somewhat comparable with those in fig. 14 (Pl. **18**) of *Lebrunia.* I regret exceedingly that, not having Jourdan's original memoir for reference, I can do no more than merely draw attention to the possibility of larval cœlomic spaces being present in such a case. The thick vacuolated endoderm persistent in *Euphyllia* and *Edwardsia* just mentioned recalls so strongly the conditions in the late larvæ of *Lebrunia*, that it seems not improbable similar diverticula may also have occurred in these species at an earlier stage in their development.

It is evident from all this, that in most Scyphozoa the formation of the gastro-cœlomic cavity of the adult takes place at a much earlier stage than in *Lebrunia*, so that probably no complete and distinct larval cœlomic system is ever formed. This in no way disproves the view here presented. All that can be asserted from the *résumé* just given is that the disorganization to form the secondary body-cavity usually originates at such an early stage that no opportunity exists for the primary enteric and cœlomic system to establish itself. From such conditions as those revealed by *Lebrunia* in fig. 15 (Pl. 19), there seems no reason why at some time a species may not be found in which the archenteron is prolonged centrally beyond the origin of the diverticula, in which case we should have a temporary digestive cavity with closed walls. In this connection one is tempted to recall the ramified digestive tract described by Bourne (1887) as occurring in *Euphyllia*.

The larva of *Lebrunia* is in many respects of an exceptional character. If the interpretation of its tetrameral primary tentacles be correct, it shows that phylogenetically it is, in regard to these organs, at a stage earlier than other Zoantharian larvæ yet described, and perhaps the same may be said of much of its internal condition. No doubt the two sets of phenomena are in some way interdependent.

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EXPLANATION OF THE PLATES.

Reference figures and letters.

The Roman numerals I. to IV. are throughout opposite the four pairs of mesenteries, and also represent respectively the order in which they usually appear in the development of the Zoantharia.

I. I. Sulco-lateral pair.
II. II. Sulculo-lateral pair.
III. III. Sulcar pair of directive mesenteries.
IV. IV. Sulcular pair of directive mesenteries.

The letters *a–h* correspond with the mesenterial chambers: *a*, sulcar endocœle; *b*, left sulco-lateral chamber; *c*, left median lateral chamber; *d*, left sulculo-lateral chamber = sulcular exocœle; *e*, sulcular endocœle; *f*, right sulculo-lateral chamber = sulcular exocœle; *g*, right median lateral chamber; *h*, right sulco lateral chamber. Both for the mesenteries and the chambers the terminology here adopted must necessarily become slightly altered as other mesenteries appear.

arc.w., wall of archenteron.
cl.gl.c., clear gland-cells.
cœ.s., cœlomic space.
d.nem., developing nematocyst.
ect., ectoderm.
ect.f., floor of ectodermal invagination.
gr.gl.c., granular gland-cells.
l.nem., large nematocyst.
l.lay., limiting layer.
mes.fil., mesenterial filament.
mus.l., muscular layer.
ner.l., nerve-layer.
œs., œsophagus.
or., oral aperture.
s.nem., small nematocyst.
sp.l., supporting lamella.
sup.c., supporting cells.
vc.t., vacuolated tissue.
zoox., zooxanthellæ.

PLATE **18.**

Figs. 1–7 are not drawn to any scale; 1–6 are representations of the living larvæ as seen under a low power of the microscope, and 7 as seen with a hand-lens. All the others are from sections, and were drawn with the assistance of a camera.

Fig. 1. The usual form of the freshly-extruded, free-swimming larva.

Fig. 2. A form occasionally assumed.

Fig. 3. The contracted cake-like condition.

Fig. 4. Oral aspect of a free-swimming larva a few hours after extrusion.

Fig. 4 *a*. Lateral aspect of a larva a few hours after extrusion. The tentacular protuberances are beginning to appear.

Fig. 5. Oral aspect of free-swimming larva.

Fig. 6. The same seen from the side.

Fig. 7. A larva three or four days old. (See Plate **19.**)

Fig. 8. Vertical section through the middle region of the column-wall of a non-extruded larva in which the central tissue has already become disorganized. × 450.

Figs. 9–11. Vertical sections through the archenteric region of a larva very shortly after liberation, showing the formation of the oral aperture and œsophagus. × 320.

Fig. 9. Tangential section near the periphery of the archenteric wall. The flattened inturned ectoderm is in close contact with the flattened archenteric wall below. The upper narrow slit indicates the upper outer surface of the floor of the former, and the broad slit below is the central cœlomic space, to the right continued peripherally and below.

Fig. 10. Tangential section near the centre. The actual oral aperture appears; the floor of the invaginated ectoderm is convex and produced laterally.

Fig. 11. Radial section. The floor of the invagination and the roof of the archenteron are here broken through and complete communication is established between the interior and exterior. The invaginated ectoderm forms the greater part of the œsophageal wall, but the innermost portion is derived from the archenteric endoderm. The union between the two is indistinguishable, but from other sections it is clear that it occurs about halfway below the lateral indentations.

Figs. 12–14. Transverse sections of a freshly-extruded larva before disorganization is set up. × 250.

Fig. 12. Through the upper archenteric region. The section is taken slightly obliquely to the vertical axis and serves to represent the various

appearances of the cœlomic spaces. *d, e, f, g,* present the successive appearances from above downwards, showing how the single mesenterial space ends in two distinct cornua. Between *a, b* the separating mesentery has broken down and the two chambers are in communication one with the other, and a little lower also with the space in *h*.

Fig. 13. The figure is made up of the appearances presented by several oblique sections through the region of the termination of the archenteron. Four radiating canals communicate with the two cœlomic sinuses, the latter separated by the first pair of mesenteries—sulco-lateral, developed to a greater extent than the three other pairs. The limiting layer of the sinuses is both somatic and splanchnic.

Fig. 14. A little below the archenteric region. The middle of the larva is filled with vacuolated tissue; towards the upper side the cœlomic canals are completely separated one from the other, while on the lower side the last traces of the connections are seen, and to the right the last trace of the sulcar canal.

PLATE 19.

Fig. 15. Vertical radial section of a freshly-extruded larva such as would be obtained along the line x, y in fig. 12. × 120.

Figs. 16–20. Successive transverse sections through one of the non-extruded larvæ where disorganization of the central tissue is in progress. The sections are such as would be obtained along the lines 1–1, 2–2, 3–3, 4–4, 5–5, respectively in fig. 21. × 120.

Fig. 16. Section through the upper archenteric region. The mesenterial chambers are founded on a radial plan, four large and four small.

Fig. 17. Section towards the termination of the archenteron. In the ventral or sulcar sinus the splanchnic portion of the central tissue shows two separate regions of more deeply-staining tissue continuous with the archenteric lining and with the limiting layer, while in the sulcular sinus the reflected ectoderm is an almost continuous limiting layer.

Fig. 18. Section nearer the termination of the archenteron than in the last figure. Owing to its reflection the lining of the archenteron is cut through twice. The lumen of the archenteron is very small and circular. × 320.

Fig. 19. Section below the archenteron. The splanchnic portion of the limiting layer and the tissue enclosed by it have become disorganized, and only loose fragments remain. The somatic layer and the vacuolated tissue between it and the supporting lamella are as yet unchanged.

Fig. 20. Section towards the aboral region. Stages in the disorganization of the central tissue are represented.

Fig. 21. Vertical section through a larva of the same stage, such as would be obtained along the lines I–*x*, *x*–I in fig. 19. The section passing through the pair of mesenterial filaments shows their continuity with the lining of the archenteron.

Fig. 22. Transverse section through the free edge of the sulco-lateral pair of mesenteries of a larva one or two days old, taken a little below the œsophagus. The mesentery to the left shows the beginning of the formation of the mesenterial filaments, while that to the right is as yet unaltered. A few sections lower the filament appears strongly developed on each. × 320.

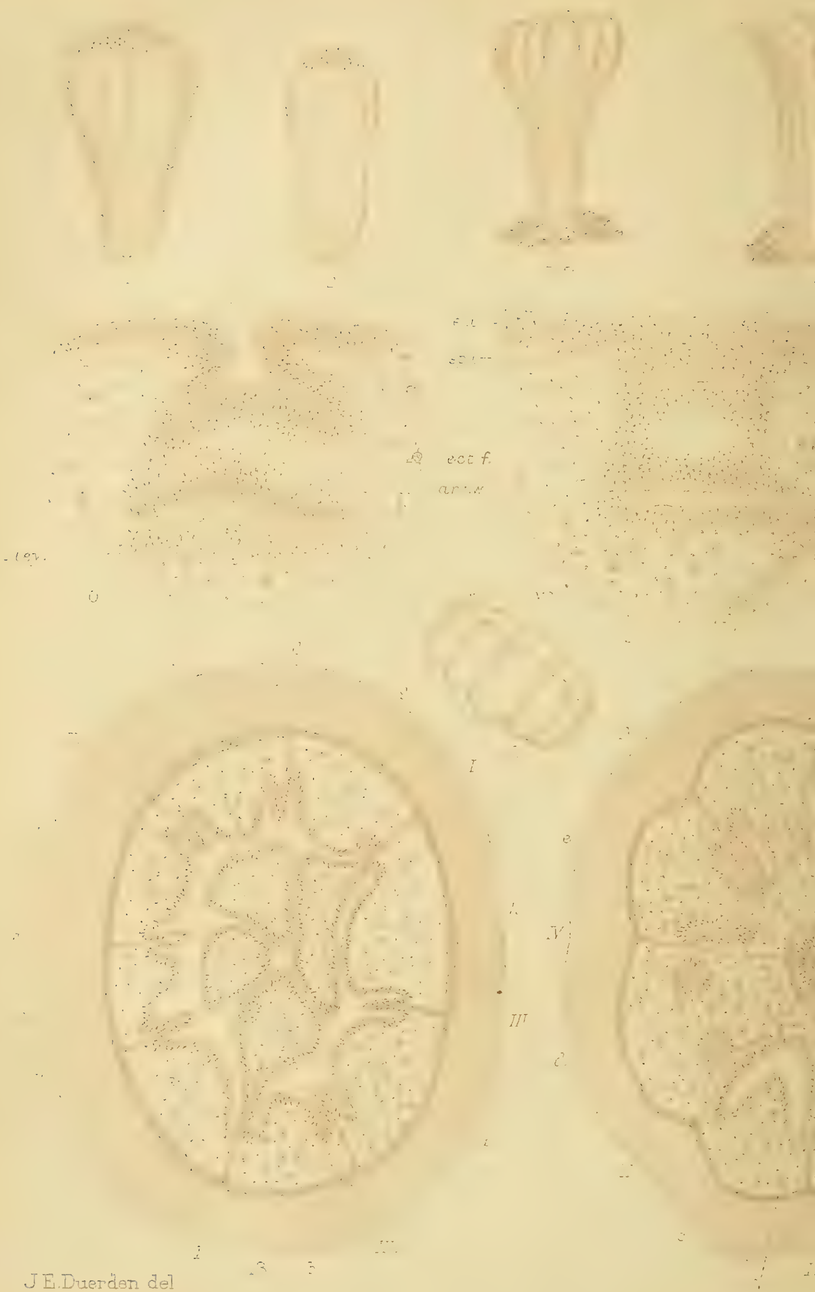
Figs. 23–25. Transverse sections selected at different levels from a complete series through a larva several days old, showing the relation of the plane of symmetry of the tentacles to the sulco-sulcular plane of the larva. × 50.

Fig. 23. Section through the tentacular region and the œsophagus. The tentacles towards their origin are in the same bilateral relation as in fig. 7. The mesenterial chambers are further developed than in any previous section represented. The larger axis of the œsophagus is at right angles to the dorso-ventral axis of the tentacles.

Fig. 24. Section towards the lower end of the œsophagus representing still the same relations. The sulco-sulcular axis of the mesenteries (*a*–*e*) and the longer diameter of the œsophagus are at right angles to the axis of symmetry of the tentacles (*g*–*c*).

Fig. 25. Section below the œsophageal region and the tentacular prominences. The axes are in the same relation as in the two previous figures. The axis of symmetry of the mesenteries is at right angles to that corresponding with the dorso-ventral axis of the tentacles.

Figs. 26–28. Transverse sections through a slightly compressed larva of about the same age as the former. The series show that the sulco-sulcular plane of the larva (*a*–*c*) is oblique to the dorso-ventral plane of the tentacles (*f*, *b*). × 50.



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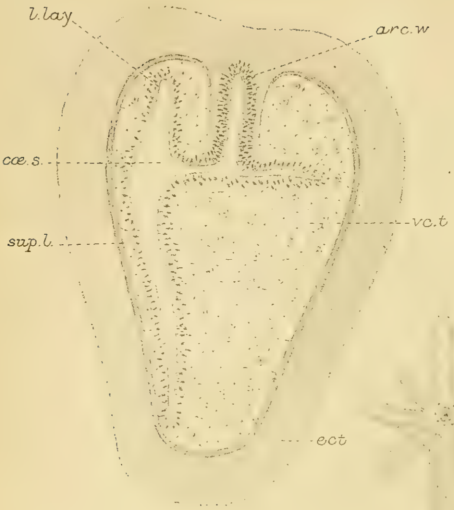

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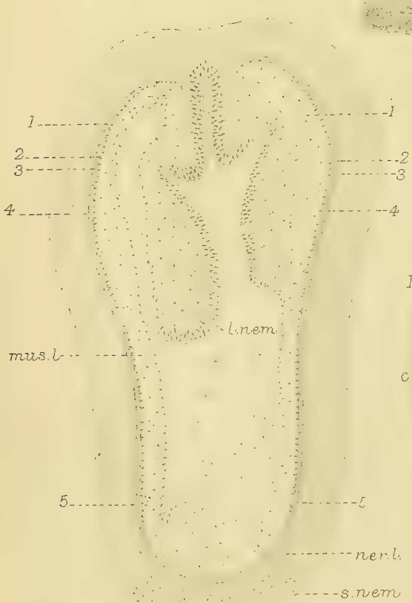

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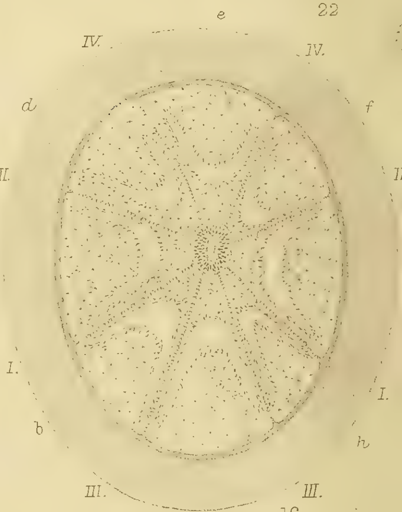

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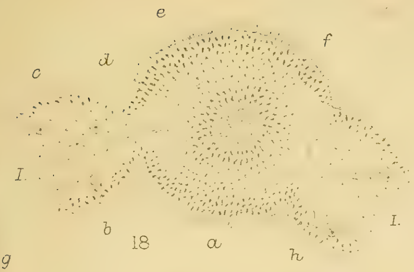

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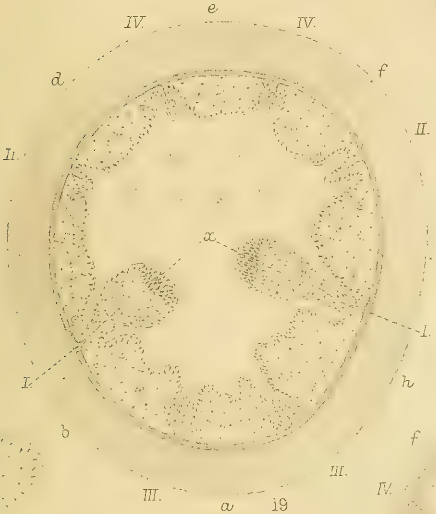

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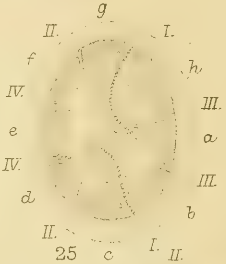

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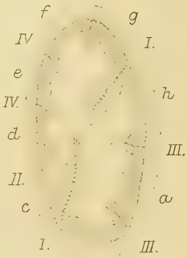

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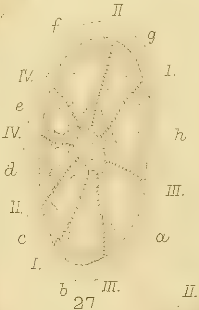

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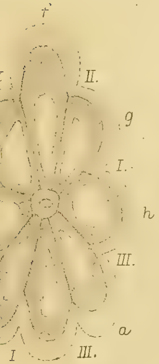

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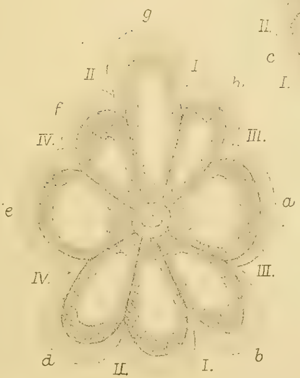

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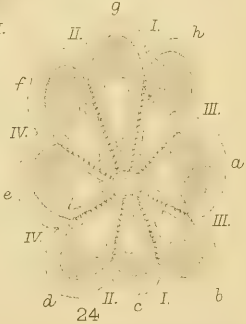

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West, Newman imp.

E OF LEBRUNIA.

J. E. Duerden del.
A. R. Hammond lith.

West, Newman imp.

THE EDWARDSIA STAGE OF LEBRUNIA.

The Position of *Anomalurus* as indicated by its Myology.

By F. G. PARSONS, F.R.C.S., F.L.S., Lecturer on Comparative Anatomy at St. Thomas's Hospital and Hunterian Professor at the Royal College of Surgeons.

[Read 4th May, 1899.]

FOR several years I have been anxious to dissect the muscular system of *Anomalurus*, and to compare it with that of other rodents; I am therefore especially grateful to Professor Howes for kindly placing at my disposal a young specimen which originally came from the Congo. Personally I hold that muscles, if judiciously used, are capable of giving a great deal of information about the relationship of animals, because they do not readily adapt themselves to changed conditions of life. This opinion is the result of a systematic survey of the muscles of several orders of mammals, a survey which has occupied me for several years; and although, in the opinion of many anatomists, muscles are very unstable structures, I would submit that both in Dobson's hands, and to a lesser degree in my own, a certain amount of definite assistance has been afforded systematists by them in classifying animals whose position had previously been doubtful.

Anomalurus gives a very good opportunity for testing the resources of myology, since its position is so uncertain. A study of Oldfield Thomas's paper "On the Genera of Rodents"* will show how many different positions have been assigned this animal, and one can therefore enter upon the task of finding out what its muscles have to tell with a perfectly free and unbiassed mind.

It may be asked why I have elected to prefer the muscles to any of the other systems of the body as an index of relationship. It is chiefly a matter of convenience for comparison. The nervous, vascular, or alimentary systems may well have many secrets to tell, but in order to understand them it is necessary that the details of these parts in a large and representative series of other rodents should be recorded and collated. This work I have already done for the muscles †, and I am therefore able to describe these structures in *Anomalurus* more briefly than I should otherwise feel justified in doing, premising that those muscles which are not mentioned are fairly stable in all rodents and, in my opinion, of little or no value for classificatory purposes.

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* P. Z. S. 1896, pp. 1012–1028.

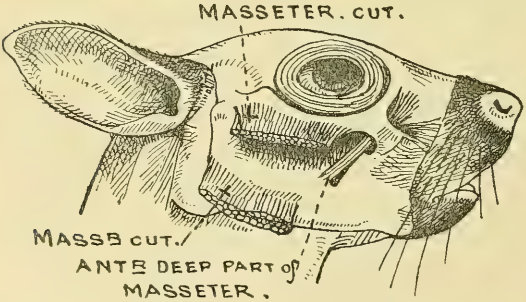
† P. Z. S. 1894, p. 251, & 1896, p. 159.

Muscles of the Head and Neck.

Temporal.—This muscle is quite small, as is usual in rodents. The three parts described by Kunstler *—parietal, temporal, and zygomatic—are present, but not very clearly defined. The muscles of opposite sides do not nearly meet in the mid-line; but it must be remembered that the specimen is that of a very young animal, and there is reason to believe that, with the growth of the teeth, the masticatory muscles become more developed and the temporal occupies more of the side of the cranium.

Masseter.—This is a muscle of great interest. In previous papers † I have pointed out that the hystricomorphine and sciuromorphine types of masseter are quite distinct, and it is well known that this difference causes a complete alteration in the shape of the skull. In most squirrel-like rodents no part of the masseter passes through the infraorbital foramen, but a special bundle, which has been spoken of as the sciuromorphine anterior deep part, occupies a nearly vertical groove in front of the zygomatic process of the maxilla. In the porcupine-like rodents a considerable part of the masseter, called the hystricomorphine anterior deep portion, passes through the greatly enlarged infraorbital foramen; while the mouse-like rodents show the transition between these two arrangements, and often, as in the case of the Hamster (*Cricetus frumen-*

Fig. 1.



The Masseter of *Anomalurus.*

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* Annales des Sciences Naturelles, sér. 7, t. iv. p. 150.

† P. Z. S. 1894, p. 251, and 1896, p. 159.

tarius)*, both the sciuromorphine and hystricomorphine anterior deep parts of the muscle are found in the same individual.

Anomalurus differs from all the sciuromorphine rodents I have hitherto examined in having a small anterior deep portion of the masseter passing through the infraorbital foramen, as in many of the Myomorpha, and this arrangement I cannot help regarding as a myomorphine tendency on the part of the animal.

Depressor mandibulæ (Digastric).—The great difference between the Sciuromorpha and Myomorpha on the one hand, and the Hystricomorpha on the other, is that in the former suborders this muscle is really digastric, and the tendons of opposite sides are connected across the middle line by a fibrous arcade with its convexity forward; from this convexity the anterior bellies spring in such a manner that the mesial borders of the two are in contact in the middle line, and the anterior attachments of these anterior bellies are close to the symphysis menti†. In the Hystricomorpha, on the other hand, the muscle does not deserve the name of digastric—the division between the anterior and posterior bellies is only indicated by a few tendinous fibres on its surface, there is no tendinous arcade, and the anterior attachment is some distance from the symphysis‡. *Anomalurus* agrees entirely with the first-mentioned arrangement.

Transversus mandibulæ.—This muscle connects the two halves of the mandible, just behind the symphysis, lying deep to the depressor mandibulæ and superficial to the mylohyoid; it is present in all the Myomorpha and Sciuromorpha except *Castor*. In *Anomalurus* it is well developed.

Sterno-cleido Mastoid.—The sterno-mastoid and cleido-occipital elements of this compound muscle are present in *Anomalurus*, the former running from the presternum to the base of the paroccipital process, the latter from the inner half of the clavicle to the curved line of the occipital bone; as is always the case in rodents, the spinal accessory nerve passes deep to both parts. In many rodents the cleido-occipital portion is often overlapped by the clavicular fibres of the trapezius, but this arrangement is not confined to any one suborder, and it does not exist in *Anomalurus*; but I do not at present regard the sterno-cleido mastoid as of much value from a classificatory point of view.

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* See figs. 2 & 3, P. Z. S. 1896, pp. 161, 162.

† See fig. 1, P. Z. S. 1894, p. 255.

‡ See fig. 9, Journ. of Anat. & Physiol. vol. xxxii. p. 439.

Omo-hyoid.—This muscle I have hitherto found in every specimen of sciuromorphine and myomorphine rodent which I have dissected, but it is absent in many of the Hystricomorpha and in the Lagomorpha. In *Anomalurus* it is absent, and, if this should prove constant, it will be a mark of distinction between that animal and other sciuromorphine rodents.

The *Omo-trachelian* (*Levator claviculæ*) rises from the anterior arch and transverse process of the atlas and is inserted into the acromion and metacromion; these are its usual attachments in Sciuromorpha and Myomorpha, though in the Hystricomorpha and Lagomorpha it often rises from the basioccipital.

Rhomboidei.—The rhomboideus capitis in *Anomalurus* forms a continuous sheet with the cervical and thoracic parts of the muscle: this is generally the case in the Sciuromorpha, but in the Myomorpha the rhomboideus capitis is usually a distinct muscle.

Splenii.—The splenius capitis is always well developed in rodents, and in *Anomalurus* it has the usual arrangement; the splenius colli, on the other hand, is a rare muscle, and *Anomalurus* differs from most other rodents in having it well marked.

Trachelo-mastoid is present as in most rodents.

Scaleni.—A scalene muscle passing ventral to the subclavian artery and brachial plexus is never found in the Sciuromorpha, very rarely in the Myomorpha, but often in the Hystricomorpha and Lagomorpha. *Anomalurus* has no scalenus ventralis or anticus, as this muscle is usually called; it has, however, a scalenus longus passing to the anterior four ribs and, dorsad to that, a scalenus brevis inserted into the first rib.

Muscles of the Anterior Extremity.

The Pectoral Muscles.—I propose to adopt the same method of dividing this group that I have found to work fairly well in other rodents *. (α) The superficial manubrial fibres: these also rise slightly from the clavicle and pass superficially to all the other fibres to be inserted lowest of all, opposite the lower part of the insertion of the deltoid. (β) The greater portion of the muscle rises from the whole length of the manubrium and gladiolus and passes, deep to the last, to be inserted into the pectoral ridge. (γ) The abdominal fibres, or Pectoralis quartus, rise from the linea alba as far back as the umbilicus and are inserted into

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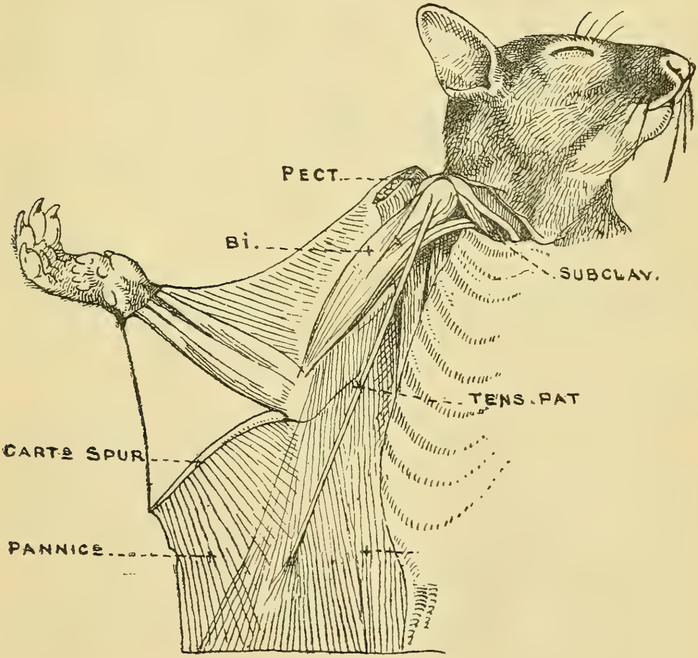
* P. Z. S. 1894, p. 259.

the neck of the humerus. (c) The deep portion, or Pectoralis minor, rises from the 3rd, 4th, and 5th costal cartilages at their junction with the sternum, and is inserted into the head of the humerus and capsule of the shoulder.

Subclavius.—This muscle is well developed, and is inserted into the posterior border of the outer third of the clavicle. This is the arrangement which is always present in sciuromorphine rodents. In the Hystricomorpha the subclavius is continued on to the spine of the scapula, covering the supraspinatus, and the whole muscle is called the sterno-scapularis. In the Myomorpha the arrangement is usually as in the Sciuromorpha.

The *Deltoid*, *Teretes*, *Supraspinatus*, *Infraspinatus*, and *Subscapularis* have the typical sciuromorphine arrangement and resemble the same muscles in *Sciurus*.

Fig. 2.



Muscles of Patagium and Arm.
Pect., Pectoralis; Bi., Biceps; Subclav., Subclavius; Tens. Pat., Coraco-patagialis.

Flexor Longus Cubiti (Biceps).—This muscle has both heads well developed, it is inserted into the radius.

Flexor Brevis Cubiti (Coraco-brachialis).—The frequency with which all three parts of this muscle are present seems to be one of the characteristics of sciuromorphine rodents, and *Anomalurus* is no exception to this rule. The three parts are closely blended near their origin, and the upper part or rotator humeri is separated from the middle, as is usual, by the musculo-cutaneous nerve. The middle and lower portions (medius and longus) are closely united in their whole extent and are inserted from the upper third of the humerus as far as the internal condyle.

Coraco-patagialis.—A muscle with a small short fusiform belly and a long delicate tendon rises from the coracoid process, and is inserted into the patagium midway between the spur from the elbow and the trunk. Its action seems to be to act as a stay to the membrane, and keep its edge down during flight, thus rendering the part of the patagium between the arm and the body more concave and parachute-like. As I have never seen anything homologous with this muscle in other mammals, I have suggested the name " coraco-patagialis " for it.

Brachialis anticus.—This muscle resembles that of most sciuromorphine rodents in having the inner and outer heads so closely connected as to be inseparable.

The *Extensor Cubiti* (Triceps), *Anconeus*, and *Epitrochleo-anconeus* call for no special remark.

Latissimo-olecranalis (Dorso-epitrochlearis).—This rises from the tendon of the latissimus dorsi as well as from that of the teres major. It is inserted into the inner side of the olecranon process.

Serratus ventralis (Serratus magnus and Levator anguli scapulæ).—This continuous sheet rises from the transverse processes of the posterior five cervical vertebræ and from the anterior ten ribs; it is inserted as usual into the vertebral border of the scapula. I only know two other rodents, *Georychus* and *Bathyergus*, in which the rib origin is so extensive.

The *Pronator Radii Teres* is inserted below the middle of the radius; it rises, as in *Sciurus* and *Pteromys*, from the lower part of the arch over the supracondylar foramen.

The *Flexor Carpi Radialis* and *Palmaris Longus* have the usual human attachments and relations.

The *Flexor Sublimis Digitorum* divides into three tendons for the index, medius, and annularis. There is no slip for the minimus; and I have called attention to this arrangement[*] as constantly occurring in the Myomorpha.

In the *Flexor Carpi Ulnaris* both olecranal and condylar heads are present, they join high up, and the usual insertion into the pisiform bone occurs.

The *Flexor Profundus Digitorum* has the five parts of the typical muscle—1, radial; 2, ulnar; 3, radio-condylar; 4, ulno-condylar; 5, centro-condylar. The latter joins the rest of the muscle about the wrist-joint.

The *Lumbricales* are peculiar; there were six in each hand in my specimen. One rose from each side of the two middle tendons, one from the ulnar side of the tendon to the index, and one from the radial side of the minimus tendon. They were too small for the nerve-supply to be made out with certainty.

The *Pronator Quadratus* is only attached to the lower quarter of the forearm. The Sciuromorpha are remarkable for the feeble development of this muscle.

The *Supinator Longus* is absent. Up to the present I have looked upon the absence of this muscle as a myomorphine characteristic.

The *Extensor Carpi Radialis*, *Extensor Carpi Ulnaris*, and *Extensor Ossis Metacarpi Pollicis*[†] have the usual mammalian attachments.

The *Extensor Longus Digitorum* divides into four tendons, as in all Sciuromorpha; often, in the Myomorpha, the slip to the minimus is absent.

The *Extensor Minimi Digiti* divides for the annularis and minimus.

The *Extensor Indicis* only goes to the index.

The thumb is too rudimentary to require any short thumb-muscles.

The first row of palm-muscles consists of an *Adductor Indicis* and *Adductor Minimi Digiti*, which have the usual rodent disposition. Deep to these is a layer of double-headed Flexores breves, one for each of the four digits, and no muscles dorsad to these were found.

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[*] P. Z. S. 1896, p. 188.

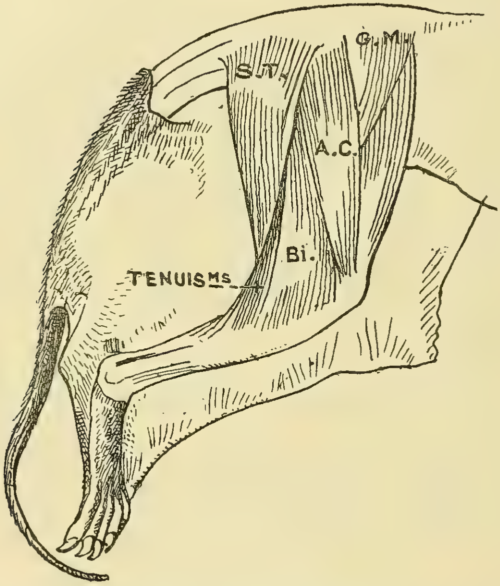
[†] The pollex is rudimentary.

Muscles of the Posterior Extremity.

Sartorius and *Tensor fasciæ femoris.*—These two muscles are feebly developed even for a rodent.

Ecto-gluteus and *Caudo-femoralis* (Agitator caudæ).—When I described the muscles of the Sciuromorphine and Hystricomorphine Rodents in 1894, I had not learned to draw any distinction between these two. The fact, however, was recorded that "in *Sciurus*, *Spermophilus*, and *Pteromys* the gluteus maximus (ecto-gluteus) is inserted by two slips, one into the third trochanter, the other into the lower part of the femur." I have now no doubt that the upper of these is the true ecto-gluteus, the lower the caudo-femoralis or agitator caudæ. *Anomalurus* resembles these animals in the low insertion of the latter muscle; indeed the ecto-gluteus and caudo-femoralis together are inserted into the whole length of the femur (see fig. 4.)

Fig. 3.



Muscles of Thigh (outer side).
S.T., Semitendinosus; G.M., Ectogluteus; A.C., Caudo-femoralis (Agitator caudæ); Bi., Flexor cruris lateralis (Biceps).

The *Meso-gluteus*, *Ento-gluteus* and *Gluteus ventralis* (*Scansorius*) were present; the latter I have not hiterto seen in sciuromorphine rodents, but it is seldom such a distinct muscle as to be unmistakable.

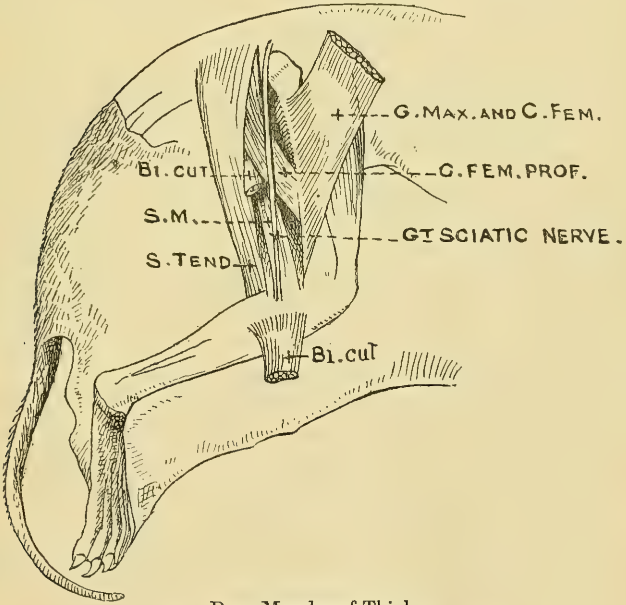
Nothing worthy of special remark was seen in the examination of the short rotator muscles of the hip.

The *Biceps femoris* (*Flexor cruris lateralis*) has only one head, and that from the tuberosity of the ischium (fig. 4). It is inserted into the fascia of the upper third of the leg. In most rodents a superficial head from the spines of the anterior caudal vertebræ is also present, but in *Sciurus* and *Pteromys* no head from this origin was found.

The *Tenuissimus* (Bicipiti accessorius) rises from the sacral vetebræ deep to the ecto-gluteus and runs down to be inserted with the posterior fibres of the biceps (fig. 3).

The *Semitendinosus*, as is usual in rodents, rises by two heads, one from the anterior caudal vertebræ, the other from the tuber ischii; these join in the upper third of the thigh, and are inserted into the junction of the upper and middle thirds of the internal surface of the tibia.

Fig. 4.



Deep Muscles of Thigh.
The references in this figure explain themselves.

When the semitendinosus, caudo-femoralis, and ecto-gluteus are cut and reflected, the great sciatic nerve is exposed. Deep to this is a muscle which rises from the same origin as, but deep to, the semitendinosus, and after passing obliquely downward and forward, is inserted into the middle of the femur. Probably the name of caudo-femoralis profundus would best describe this (see fig. 4).

The *Semimembranosus* rises only from the tuber ischii, as is usual with rodents, and is inserted into the tibia deep to the internal lateral ligament of the knee.

The *Presemimembranosus* is quite distinct from the last and is closely connected with the adductor mass. This I have already pointed out (P. Z. S. 1894, p. 286) is a sciuromorphine characteristic.

The *Quadratus Femoris* is entirely fleshy, as in other Sciuromorpha.

The *Pectineus* is inserted just below the lesser trochanter of the femur.

The *Adductor longus* continues the plane of the last downward and is inserted just below it into about a third of the femur.

The rest of the *Adductor mass* rises from the ramus and tuber ischii, and is inserted into the lower two-thirds of the shaft of the femur.

The *Gracilis* (Adductor cruris) is a single broad muscle rising from the symphysis and ramus of the pubes and being inserted into the upper third of the shaft of the tibia. This single gracilis has been shown to be characteristic of the Sciuromorpha as opposed to the Myomorpha.

The *Tibialis anticus* rises from the tibia only, and is inserted into the innermost of the five metatarsal bones.

The *Extensor Longus Digitorum* has the usual femoral origin and is inserted into the outer four toes.

The *Extensor Proprius Hallucis* rises from the middle third of the fibula, and is inserted into the terminal phalanx of the hallux. The full complement of *Peroneal muscles* is present; viz., *Peroneus longus*, *brevis*, *quarti digiti* and *quinti digiti*.

The *Gastrocnemius* and *Soleus* have the usual rodent appearance, they form a twisted Tendo Achillis *.

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* See Journal of Anat. & Phys. vol. xxviii. p. 414.

The *Plantaris* expands in the sole into a muscular *Flexor Brevis Digitorum.*

The *Flexor Tibialis* does not join the *Flexor Fibularis* in the sole. This is a sciuro- and myo-morphine characteristic.

The *Accessorius* is present, and is inserted into the plantar surface of the flexor fibularis. In the Myomorpha the accessorius is absent, but it is usually present in the Sciuromorpha.

The *Lumbricales* closely resemble those of the fore limb, but there are seven instead of six; one rises from each side of the tendons to the index, medius, and annularis toes, while the seventh comes from the fibular side of the tendon to the hallux.

The *Deep Muscles of the Sole* are arranged in two layers: the superficial consists of an oblique adductor hallucis and minimi digiti, while the deeper is formed by the double flexores breves to each toe. The abductor hallucis and minimi digiti are the enlarged and somewhat displaced marginal members of this series.

Having given a brief survey of the myology of *Anomalurus*, it remains to contrast these muscles with those of other rodents, and to see whether they throw any light on the position and relationship of this animal in the order. In the first place, it will be well to review the chief myological characteristics of the four suborders, and contrast them with those of *Anomalurus.*

From experience gained in former dissections, I believe that the following are the chief myological characteristics of the Sciuromorpha:—

1. The anterior deep part of the masseter lies in a groove in front of the zygomatic process of the maxilla.
2. The digastric muscles have a central tendon from which a fibrous arcade stretches across the middle line; to this the anterior bellies are attached and they are in contact in the mid-line of the chin.
3. The transverse mandibular muscle is usually present.
4. The omo-hyoid is present.
5. The omo-trachelian muscle (levator claviculæ) always rises from the atlas.
6. The subclavius is never continued over the supraspinatus as a sterno-scapularis muscle.
7. The coraco-brachialis brevis is always present, as are usually the medius and longus.

8. The supinator longus is generally present.
9. The pronator quadratus is never attached to more than the lower third of the forearm.
10. The presemimembranosus is closely connected with the adductor mass, instead of being separate or fused with the semimembranosus.
11. The gracilis is a single muscle.
12. The flexor tibialis does not join the flexor fibularis in the sole.
13. The accessorius pedis is present.
14. The rhomboideus capitis forms a continuous sheet with the other rhomboids.
15. The rectus ventralis (abdominis) does not decussate with its fellow at its origin from the symphysis pubis.

The foregoing are not all found in the Sciuromorpha alone, though all are points of distinction between the Sciuromorpha and one or more of the other three suborders. It is only by taking a large number of characters that one can hope to neutralize the effects of individual variation or to reduce its disturbing influence to a minimum.

It will be noticed that *Anomalurus* agrees with the Sciuromorpha in the following points:—Nos. 2, 3, 5, 6, 7, 9, 10, 11, 12, 13, 14, and 15, but differs from them in Nos. 1, 4, and 8.

In reviewing the myological characteristics of the Myomorpha it will be evident that in a great many points they resemble the Sciuromorpha.

The following are characteristics of the Myomorpha:—

1. A certain amount of the masseter always passes through the infraorbital foramen.
2. The digastric muscles have the sciuromorphine arrangement.
3. The transverse mandibular muscle is present.
4. The omo-hyoid is present.
5. The omo-trachelian always rises from the atlas.
6. The subclavius does not usually form a sterno-scapularis.
7. The coraco-brachialis brevis is seldom present, and the three parts of the muscle never occur together.
8. There are always two heads to the biceps cubiti.
9. The supinator longus is absent.

10. The presemimembranosus is quite distinct from the adductor mass.
11. The gracilis is usually double.
12. The flexor tibialis does not usually join the flexor fibularis in the sole.
13. The accessorius is absent.
14. The rhomboideus capitis is usually distinct from the rest of the rhomboid sheet.
15. The rectus ventralis often decussates with its fellow at its origin.

Anomalurus agrees with the Myomorpha in the following characters—Nos. 1, 2, 3, 5, 6, 8, 9, 12. But it must be borne in mind that Nos. 2, 3, 5, 6, 8, and 12 are points which are common to both Sciuromorpha and Myomorpha.

From a comparison of the foregoing, it will be seen that in the greater number of characteristic muscles *Anomalurus* agrees with both the Myomorpha and Sciuromorpha, but that, where these muscles vary in the two suborders, it agrees with the Sciuromorpha in six and with the Myomorpha in two.

The six points which mark its sciuromorphine affinities are:—

1. The presence of all three parts of the coraco-brachialis.
2. The close connection of the presemimembranosus with the adductor mass.
3. The single gracilis.
4. The presence of the accessorius pedis.
5. The rhomboids forming one sheet.
6. The non-decussation of the rectus ventralis.

Of these I regard Nos. 1, 2, 3, and 4 as of great importance.

The two points of myomorphine affinity are:—

1. The passage of a small part of the masseter through the infraorbital foramen.
2. The absence of the supinator longus.

The second of these is a negative point, and probably too much stress should not be laid upon it; but the first is a point of great importance and to my mind shows undoubted myomorphine tendencies.

With regard to the Hystricomorpha there is no need to go into so much detail because this suborder has some very sharply marked characteristics, and without the presence of some of these no animal could be said to have hystricomorphine tendencies.

The chief of these characteristics are :—

1. A large part of the masseter passes through the infra-orbital canal.
2. The depressor mandibulæ (digastric) has no well-marked central tendon, and the anterior bellies are not in contact in the mid-line.
3. The subclavius is continued past the clavicle to the supra-spinosus fossa to form a sterno-scapularis muscle.
4. The flexor tibialis joins the flexor fibularis in the sole.

Anomalurus differs from the last three entirely, and from the first in degree, but this is a point in which the Myomorpha approach the Hystricomorpha.

It will have been noticed that, in the absence of the omo-hyoid *Anomalurus* differed from both the Sciuromorpha and Myomorpha, while in the Hystricomorpha it must be stated that the omo-hyoid may be present or absent. This may be looked upon as a feeble hystricomorphine tendency, but it is just as strong or as feeble a lagomorphine one.

It seems unnecessary to take up space by a detailed comparison of the muscles of the Lagomorpha with those of *Anomalurus*; firstly, because no one has suggested any relationship between the two, and, secondly, because I have never had the opportunity of completing my knowledge of the myology of this suborder by the dissection of a Pica. A general idea of the relationship of *Anomalurus* to the four suborders of rodents as illustrated by their muscles, may be gained by referring to the accompanying table, and, in criticising it, it should be borne in mind that the muscles have not been selected with any reference to *Anomalurus*. They were chosen as the result of previous dissections of many rodents, because they were found to vary with the different suborders. It cannot be too strongly insisted on that, if muscles are used for classificatory purposes, they should not be chosen haphazard, nor should one or two be used as crucial tests; but, by careful comparison of a large number of animals, some fifteen or twenty muscles should be picked out which vary more or less constantly with the different groups. The whole of these muscles should then be examined in the animal whose affinities are to be tested, and the average

	Sciuromorpha.	*Anomalurus.*	*Myomorpha.*	*Hystricomorpha.*	*Lagomorpha.*
1. Anterior deep part of Masseter.	In groove.	Through infraorbital foramen (small).	Through infraorbital foramen (small).	Through infraorbital foramen (large).	Absent.
2. Anterior bellies of Digastric.	In contact.	In contact.	In contact.	Separate.	Separate.
3. Transversus mandibulæ.	Usually present.	Present.	Present.	Absent.	Absent.
4. Omo-hyoid	Present.	Absent.	Present.	Present or absent.	Absent.
5. Omo-trachelian (Levator claviculæ).	Always from atlas.	From atlas.	Always from atlas.	Sometimes from basi-occipital.	From basioccipital.
6. Rhomboids	Continuous sheet.	Continuous sheet.	R. capitis separate.	Continuous sheet.	Continuous sheet.
7. Splenius colli	Absent.	Present.	Absent.	Sometimes present.	Present.
8. Recti ventrales (abdominis) origin from pubes.	Separate.	Separate.	Frequently decussate.	Sometimes decussate.	Separate.
9. Sterno-scapularis	Only subclavius.	Only subclavius.	Usually only subclavius.	Sterno-scapularis present.	Sterno-scapularis present.
10. Coraco-brachialis brevis.	Always present.	Present.	Rarely present.	Rarely present.	Present.
11. Biceps cubiti	Two heads.	Two heads.	Two heads.	One or two.	One head.
12. Supinator longus	Generally present.	Absent.	Absent.	Generally absent.	Absent.
13. Pronator quadratus	Lower $\frac{1}{4}$ of forearm or less.	Lower $\frac{1}{4}$.	Variable.	Often to $\frac{1}{2}$ forearm or more.	Absent.
14. Presemimembranosus	Fused with the Adductor mass.	Fused with the Adductor mass.	Separate.	Separate.	Separate.
15. Gracilis	Single.	Single.	Double.	Often double.	Single.
16. Flexor tibialis and Flexor fibularis.	Do not join in the sole.	Do not join in the sole.	Do not usually join in the sole.	Join in the sole.	Do not join in the sole.
17. Accessorius pedis	Present.	Present.	Absent.	Present.	Absent.

result will, in my experience, show a decided indication towards the group with which that animal is most nearly connected.

As a result of the application of this process to *Anomalurus*, I should say that its affinities are decidedly sciuromorphine in the main, though it shows certain definite myomorphine characteristics. It is extremely difficult to give an idea of the relationships of animals in a linear manner, and I submit a diagram giving my present ideas of the position of *Anomalurus*.

Fig. 5.

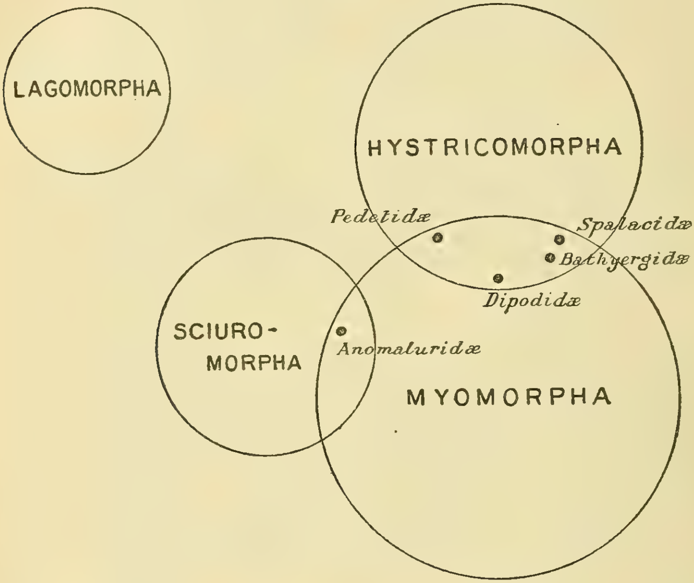

Diagram of the affinities of *Anomalurus*.

Winge * has urged that *Anomalurus* is closely connected with *Pedetes*. Fortunately I have lately had the opportunity of dissecting the latter animal, and have come to the conclusion † that it was rightly placed by Oldfield Thomas ‡ between the Hystricomorpha and Myomorpha. It may be advantageous to apply the same muscles used for determining the position of *Anomalurus* for a comparison of the two animals.

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* "Jordfundne og nulevende Gnavere fra Lagoa Santa," E Mus. Lundii, iii. 1887.

† P. Z. S. 1898, p. 858.

‡ P. Z. S. 1896, p. 1012.

Comparison of Muscles of *Anomalurus* and *Pedetes*.

	Anomalurus.	*Pedetes.*
1. Anterior deep part of Masseter.	Through infraorbital foramen (small).	Through infraorbital foramen (large).
2. Anterior bellies of Digastric.	In contact.	In contact.
3. Transversus mandibulæ.	Present.	Absent.
4. Omo-hyoid	Absent.	Absent.
5. Omo-trachelian	From atlas.	From atlas.
6. Rhomboids	Continuous sheet.	Continuous sheet.
7. Splenius colli	Present.	Present.
8. Recti ventrales (abdominis) origin from pubes.	No decussation.	No decussation.
9. Sterno-scapularis	Subclavius only.	Subclavius only.
10. Coraco-brachialis brevis.	Present.	Absent.
11. Biceps cubiti	2 heads.	2 heads.
12. Supinator longus	Absent.	Absent.
13. Pronator quadratus	Lower $\frac{1}{4}$.	Lower $\frac{1}{3}$.
14. Presemimembranosus	Fused with adductors.	Fused with semimembranosus.
15. Gracilis	Single.	Single.
16. Flexor tibialis and Flexor fibularis.	Do not join in the sole.	Do not join in the sole.
17. Accessorius pedis	Present.	Absent.

In these 17 points there are 12 in which the arrangement is the same in both animals, but it must be remembered that many of these simply denote myomorphine tendencies on the part of both; and in the five points in which they differ (Nos. 1, 3, 10, 14, and 17) the divergence is always towards the Hystricomorpha on the part of *Pedetes*, and the Sciuromorpha on the part of *Anomalurus*.

There are, however, three points (Nos. 4, 7, and perhaps 15) in which both animals wander away in the same direction from the arrangement which one might have predicted for them: it may be worth while considering these points in detail.

The first is the case of the omo-hyoid, which is absent in both animals, although it is constantly present in the Sciuromorpha and Myomorpha. In the Hystricomorpha it is present or absent, and its absence in *Pedetes* does not surprise us when the many hystricomorphine affinities of that animal are remembered. Its absence in *Anomalurus* is unexpected, and may be the result of an individual variation in the animal I dissected, or it may be that I have framed the generalization that the omohyoid is constantly present in sciuromorphine and myomorphine rodents on the observation of insufficient material. To the presence of the splenius colli, I am not disposed to attach too great importance. When the splenius capitis is largely developed there is not room for all the fibres to be attached to the skull, and some of the posterior ones become inserted into the transverse processes of the anterior cervical vertebræ to form the splenius colli; still in the Sciuromorpha and Myomorpha this muscle is of rare occurrence.

The single gracilis is capable of another explanation than that of pointing to a relationship between *Pedetes* and *Anomalurus*. The muscle is not constantly double even in the Myomorpha, while in the Hystricomorpha it is more often single than double, and in the Sciuromorpha always single. We should, I think, expect that animals on the sciuromorphine or hystricomorphine borderland of the Myomorpha would be more likely to have a single than a double gracilis.

Similarities between *Anomalurus* and *Pedetes* in any one of the three muscles discussed would have been hardly worthy of notice, and it has been shown that no one of them is by itself of first-rate importance, but the three occurring together do perhaps furnish a somewhat feeble plea for a connection between the two animals. Possibly Winge's and Oldfield Thomas's views might be brought more into harmony by the use of a diagram such as I have suggested (fig. 5, p. 332), in which *Anomalurus* and *Pedetes* are not so very far asunder.

On some Australasian Collembola. By the Right Hon. Sir John Lubbock, Bart., M.P., F.R.S., LL.D., F.L.S.

[Read 1st June, 1899.]

The following paper contains descriptions of some new species of Collembola from New Zealand and Tasmania, kindly sent me by Mr. A. Dendy of Christchurch, N.Z. The collection also comprised some specimens, representing one or two other species, which however were not in a condition enabling me to describe them satisfactorily. They have been for some three years in my possession, and I have tried, but in vain, to obtain more, in hopes of being able to give a more complete list of Australasian Collembola. Possibly the publication of this paper may induce entomologists to devote some attention to this interesting, though inconspicuous, group.

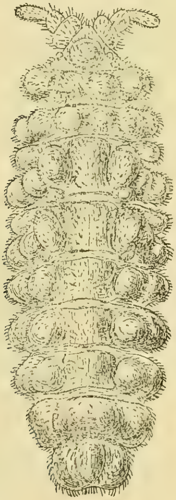
ANOURA TASMANIÆ, sp. n. (Fig. 1.)

Body long elliptical, dark purplish. Ocelli on a short pear-shaped bulb, about ten in number, on a reddish-black granular pigment, which covers most of the bulb, leaving only narrow interspaces. The antepenultimate segment of the antenna is quite short and almost covered by the overlapping edges of the 2nd segment. The body-segments present a series of arching mammillæ, and the skin is covered with scutellated, stiff, curved, whip-like hairs. Foot without tenent-hairs. Claw single, without teeth.

Length ·25 in. Breadth ·1 in.

Hab. Tasmania; found under a fallen log (*A. Dendy*).

Fig. 1.



Anoura tasmaniæ. × 10.

The colouring-matter is arranged in meshes, leaving more or less circular colourless spaces. The skin itself is covered with minute granules and rather long whip-like hairs.

This species is closely allied to our *Anoura muscorum*, but is much larger, and differs in the number and arrangement of the mammillæ, of the eyes, and of the stiff setæ.

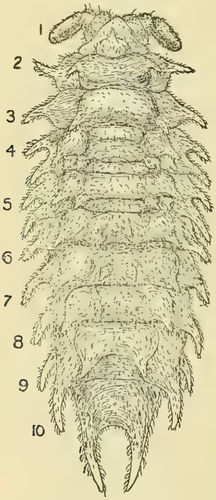
ANOURA DENDYI, sp. n. (Fig. 2.)

Body long elliptical, darkish purple; sides and back bearing a number of tapering projections (fig. 4), coloured at the base like the rest of the body, white towards the ends. Foot (fig. 5) without tenent-hairs; claw with a small tooth.

Length $\frac{7}{20}$ in. Breadth $\frac{2}{20}$ in.

Hab. Tasmania (*A. Dendy*).

Fig. 2.

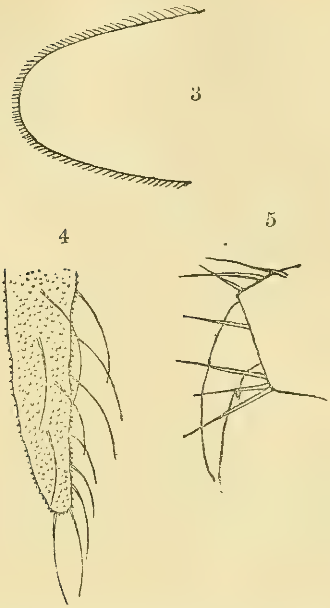


Anoura Dendyi. × 8.

The head has one spine in the centre of the upper part, the next segments have each a pair, one being at the margin, the other a little way from it. The second, third, and fourth abdominal segments have a pair of small processes, one on each side of the median line.

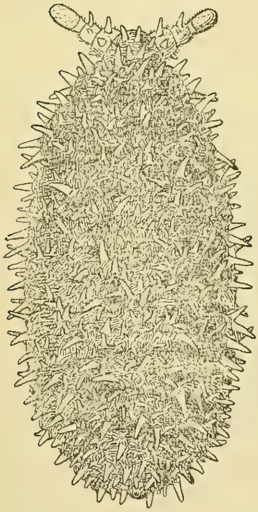
The terminal segment of the antenna bears (1) scattered, curved setæ; (2) numerous, close, very short hairs; (3) numerous close, broader, and somewhat conical bodies, probably sense-organs.

Figs. 3, 4, & 5.



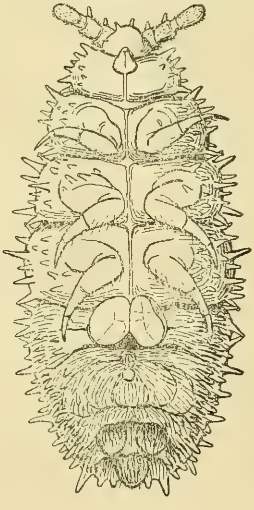
Anoura Dendyi.—3. Section through the tip of the antenna, × 250. 4. One of the processes, × 250. 5. Foot of 1st pair, × 250.

Fig. 6.



Anoura spinosa, dorsal aspect. ×12.

Fig. 7.



Anoura spinosa, ventral aspect. ×12

Anoura spinosa, sp. n. (Figs. 6 & 7.)

Body elliptical, bluish purple; body covered with spines, bluish purple at the base, and the rest yellowish brown. Skin granular. Antennæ four-jointed; basal segment large, but short; second segment longer; each with 1 large and 2 or 3 smaller spines; third segment small, without spines; fourth segment longer, also without spines. Feet without tenent-hairs; claw with a small basal tooth, but covered nearly to the tip with granules resembling those of the skin.

Length $\frac{2}{10}$ in. Breadth $\frac{1}{10}$ in.

Hab. Near Hobart, Tasmania; found under a decaying log of wood (*A. Dendy*).

On the Characters of the Crustacean Genus *Bathynella*, Vejdovsky. By W. T. Calman, B.Sc., University College, Dundee. (Communicated by Prof. D'Arcy W. Thompson, C.B., F.L.S.)

[Read 1st June, 1899.]

(Plate 20.)

In a memoir on the fauna of certain wells, published in 1882 *, Prof. Vejdovsky described under the name *Bathynella natans* a minute crustacean of very remarkable characters, of which two examples were obtained from a well in the city of Prague. Prof. Vejdovsky placed it at the end of his memoir as a species *incertæ sedis*, merely noting its superficial resemblance to a minute gammarid and giving no further discussion of its systematic position. No additional specimens of this interesting form have been obtained, and I am not aware that, with the exception of a passing remark by Moniez, any reference has been made to it by subsequent writers or any opinion expressed regarding its affinities †.

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* 'Thierische Organismen der Brunnenwässer von Prag,' 1882. I am indebted to my friend Dr. Chas. Chilton for calling my attention to this memoir.

† Since the above paper was read I have learned that Prof. Vejdovsky published in 1898 a short paper in the Bohemian language dealing with the systematic position of *Bathynella* (S.B. K. böhm. Ges. Wiss., math.-nat. Cl.

By the great kindness of Prof. Vejdovsky I have been enabled to make a re-examination of the unique existing specimen of *Bathynella*, which he has sent to me for the purpose. The specimen, which is mounted as a microscopic preparation in canada balsam, is, unfortunately, not in a good state of preservation, being much shrivelled and lacking the greater part of antennules and antennæ as well as part of the uropods. The following account is taken from Prof. Vejdovsky's description, supplemented in one or two points from my own observations.

Bathynella (Pl. 20. fig. 1) is described by Prof. Vejdovsky as resembling in general appearance the minute copepods of the genus *Canthocamptus*. The body is, in the present state of the specimen, about ·75 mm. long *, and consists, according to the original account, of (1) a cephalic region bearing two pairs of antennæ, mandibles, and at least two more pairs of mouth-appendages; (2) a thoracic region of seven free somites each bearing a pair of biramous appendages; and (3) an abdomen of six somites, of which the first and second bear small appendages while the last carries two pairs of caudal plates. It appeared to me, on examining the original specimen, that there were indications of an additional somite in the abdominal region, and on mentioning my belief to Prof. Vejdovsky, he informed me that he had actually seen this somite in the living animal and sent me one of his sketches in which it was plainly figured. The presence of this somite, as Prof. Vejdovsky himself remarked in sending me the sketch, is very important for the settlement of the systematic position of the animal, for it enables us to readjust the delimitation of the regions of the trunk in such a way as to bring their segmentation into precise accord with the normal arrangement for the Malacostraca.

Prof. Vejdovsky implicitly referred the segmentation of the body to the type characteristic of the Arthrostraca, in which the first thoracic somite, bearing the maxillipeds, is fused with the head. Were this the case we ought to find four pairs of buccal

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1898, xiv. 2 pp.). The author informs me that he has there expressed the opinion "das *Bathynella* eine besondere Stelle zwischen den Arthrostraken einnehmen dürfte, und vielleicht eine neue Ordnung '*Pleopodophora*' repräsentirt."

* Vejdovsky gives the total length as about 1 mm.

appendages, namely, mandibles, first and second maxillæ, and maxillipeds. As a matter of fact, however, the closest scrutiny of the undissected specimen shows only two pairs of appendages (maxillæ) behind the mandibles, and I believe accordingly that the maxillipeds are represented by the succeeding pair of conspicuous appendages, those, namely, which are borne upon the first free somite. Assuming that these represent the first thoracic appendages, the eighth and last pair will then be represented by what Vejdovsky has considered to be the first abdominal pair; that is to say, precisely those on which the male genital ducts appear to open, as in the great majority of the Malacostraca. And the additional abdominal somite, of the presence of which we are now assured, still leaves us with the normal number of six abdominal somites.

The two pairs of *antennæ* are short, composed of few joints not differentiated into peduncle and flagellum. The first pair, or antennules, are uniramous and consist of eight joints. The second pair are seven-jointed, and bear a small unjointed exopod, on the second joint. There is no trace of *eyes*.

The *mandibles* have a serrated cutting-edge and a strong two-jointed (or perhaps three-jointed) palp tipped with two stout curved spines. The two pairs of *maxillæ* are large, but nothing can be seen of their structure.

The first seven pairs of *thoracic limbs* (Pl. 20. fig. 3) are of nearly uniform structure. The main axis of the limb in each case is six-jointed. The small coxal joint bears on its outer face a small flattened vesicular appendage interpreted as a branchial plate or epipod. The epipod appears to be borne on a short peduncle, from which it is separated by a transverse articulation or suture. The second or basal joint is long, and carries near its distal end an exopod *, composed of two joints in the case, probably, of the first five pairs and of one joint on the sixth and seventh. The main axis of the limb is continued by a slender endopod of four joints, scantily supplied, like the exopod, with setæ. I cannot now find an epipod on the first pair of thoracic limbs (maxillipeds), but it is figured by Vejdovsky, and these appendages do not appear to differ in any other respect from the succeeding pairs. The eighth segment behind the head, described

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* Vejdovsky, by an oversight, refers to this as "ein innerer Ast." It is in fact, as his figures show, on the outer side of the limb.

by Vejdovsky as the first abdominal, but here regarded as the last thoracic somite, bears a pair of short appendages. These are described as consisting of two branches, an inner two-jointed stem, and an outer " penis-like process," the latter being apparently connected with the male genital duct. The appendages in question are now, unfortunately, so shrivelled that nothing can be made out as to their structure, but the position of the "penis-like process" on the *outer* side of the limb is so unusual that we are led to suspect some error in this part of the description.

The appendages of the first abdominal somite (second abdominal of Vejdovsky) are uniramous and two-jointed. The four succeeding somites appear to lack all trace of appendages. The last segment of the body bears terminally two pairs of "Schwanzplatten," a dorsal and a ventral. The ventral pair are described as consisting of two joints, each with a row of stout curved setæ along its distal edge, and of a small unjointed exopod inserted near the distal end of the first joint. These appendages, of which only the basal parts are now preserved, are clearly the uropods or appendages of the sixth abdominal somite; but it is not quite so easy to interpret the dorsal pair of "caudal plates." These might be regarded as the two halves of a deeply divided telson, such as occurs in many Amphipods, but their cylindrical form and the fact that each is very distinctly divided into two segments seem rather to suggest a comparison with the "caudal furca" characteristic of Phyllopods, Copepods, and other Entomostraca, and which also occurs in *Nebalia* and in some larval Malacostraca.

The presumed *gonads*, which have been already referred to, are described as a pair of tubular organs lying in the abdomen, each expanding in the last thoracic somite into a vesicular dilatation which in turn appeared to communicate with the "penis-like process." There can be little doubt that these organs constitute the male generative system. No other internal organ could be distinguished save a pair of oval "glandular" bodies of unknown significance, lying in the last somite of the abdomen.

Reviewing the characters here summarized, it seems plain, in the first place, that *Bathynella*, in spite of its minute size, must be referred to the Malacostraca. The number of the somites, the position of the genital apertures, the characters of the thoracic limbs, and the presence of appendages on the terminal somite of the abdomen, appear to afford conclusive evidence on this point. The possibility that it may be a larval form, as Moniez * has suggested, is excluded if the identification of the genital apparatus be correct; but it may be remarked that, as a larva, *Bathynella* would be no less unique than as an adult crustacean.

Assuming for the present that we have to deal with an adult form, it is clear that it cannot be received into any of the divisions of the Malacostraca as commonly defined. The apparent similarity to the Arthrostraca in the segmentation of the body, which led its discoverer to compare it to an amphipod, disappears when it is recognized that the first thoracic somite is free from the head and that the appendages carried by it are not specialized as maxillipeds but resemble the succeeding thoracic limbs.

The presence of natatory exopods and of external epipods on most of the thoracic limbs are further characters not shared by any of the Arthrostraca. The other divisions of the Malacostraca agree in possessing a carapace with which one or more of the thoracic somites are usually united dorsally. While some of them show isolated characters in common with *Bathynella*, as, for example, the free first thoracic somite of *Nebalia* and some Stomatopods, the natatory thoracic exopods of Schizopoda, Cumacea, and some Decapods, the undifferentiated maxillipeds of Euphausiidæ, and the plate-like epipods of Stomatopods, these resemblances are accompanied by differences so profound that there can hardly be any question of immediate affinity.

While our ignorance of many points in the structure of *Bathynella*, more especially as regards the mouth-parts, precludes for the present any definite conclusion as to its precise systematic position, the characters already ascertained sufficiently show that we have to do with a very peculiar and isolated type without close affinities to any of the recognized divisions of the Malacostraca. It appears to me, however, that some light may be thrown on its relationships by a comparison with the anomalous "schizopod" *Anaspides tasmaniæ* of Mr. G. M.

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* Rev. Biol. du Nord de la France, i. 1888-89, p. 253.

Thomson[*], the characters of which I have lately discussed[†] at some length, calling attention to its affinity with the Palæozoic *Gampsonychidæ* and their allies.

Anaspides (Pl. 20. fig. 2) agrees with *Bathynella* in having no carapace, in possessing natatory exopods and plate-like epipods on the thoracic limbs, and in the fact that the maxillipeds are not greatly different from the succeeding appendages. Like *Bathynella*, *Anaspides* was originally described as having eight free segments in the thorax; but I have pointed out that the so-called first thoracic somite is marked off from the cephalic region not by an articulation but by a groove on the integument, and that this groove probably represents the line of junction of the mandibular somite with that of the first maxillæ. *Anaspides* therefore differs from *Bathynella* and agrees with the Arthrostraca, in possessing only seven free somites in the thoracic region. In many other characters *Anaspides* shows important differences from *Bathynella*: the antennules are biramous, there are *two* epipodial lamellæ on each of the thoracic legs (Pl. 20. fig. 4) (except the last pair), the second or basal joint of the thoracic legs is unusually small, while it is large in *Bathynella*, the abdomen carries a complete series of appendages, the telson is simple and undivided.

Assuming, however, as I think we may fairly do, that such characters as the small size of *Bathynella*, the absence of eyes, the simple form of all the appendages and the reduced number of joints in most of them, are due to degeneration correlated with its subterranean habitat, there would seem to be adequate grounds for suggesting that *Bathynella* is at all events less distantly related to *Anaspides* than to any other existing Crustacean.

Many of the characters in which *Anaspides* agrees with the Palæozoic *Gampsonychidæ* are also shared by *Bathynella*; and in some points, such as the presence of a free first thoracic somite and of only a single series of epipods, the latter may even approach some of the fossil forms more closely than does *Anaspides*.

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[*] Trans. Linn. Soc. (2), Zool. vi. (3).

[†] Trans. Roy. Soc. Edin. xxxviii. pt. iv. no. 23.

EXPLANATION OF PLATE 20.

Fig. 1. *Bathynella natans*, Vejd. (Altered from Vejdovsky.) × 100.

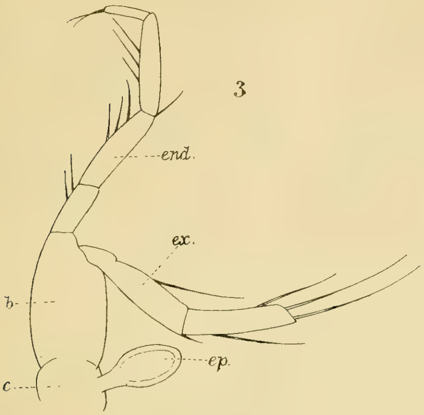
This figure was constructed from Prof. Vejdovsky's published figure and from observations on the preserved specimen. It conforms accurately (except that the abdominal segments appear a little shorter) with an original sketch (taken from the living animal) subsequently sent me by the author.

2. *Anaspides tasmaniæ*, G. M. Thomson. ×3. (Original.)
3. Third thoracic limb of *Bathynella*. (Original.)
4. Third thoracic limb of *Anaspides*. (Original.)

Reference Letters.

a', a''. First and second antennæ.
b. Basal joint of thoracic leg.
c. Coxal joint of thoracic leg.
c.gr. "Cervical groove" of *Anaspides*, marking off so-called "first thoracic somite."
e. Eye.
end. Endopod of thoracic leg.
ep. Epipod of thoracic leg.
ex. Exopod.
f. Caudal furca of *Bathynella*. (Dorsal caudal-plate of Vejdovsky.)
g. Supposed testis.
m.p. Mandibular palp.
mx', mx''. First and second maxillæ.
p. "Penis-like process" of last thoracic limb.
t. Telson.
ur. Uropod.
I. First thoracic somite, bearing maxillipeds.
II. Second thoracic somite.
VIII. Last thoracic somite.
1–6. Abdominal somites.

3



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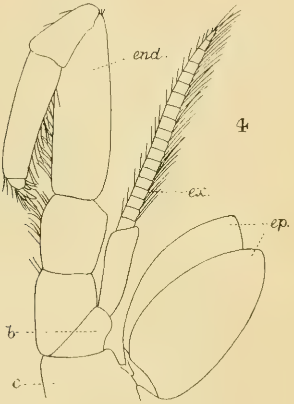

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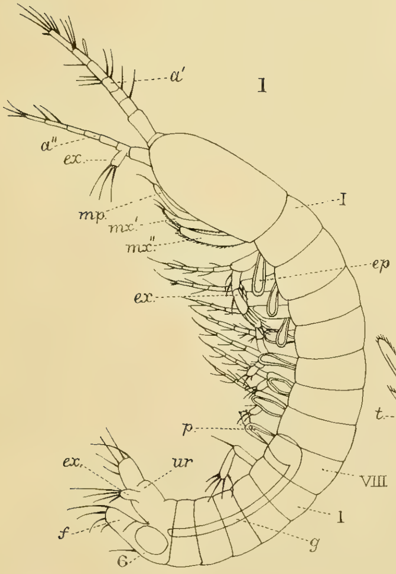

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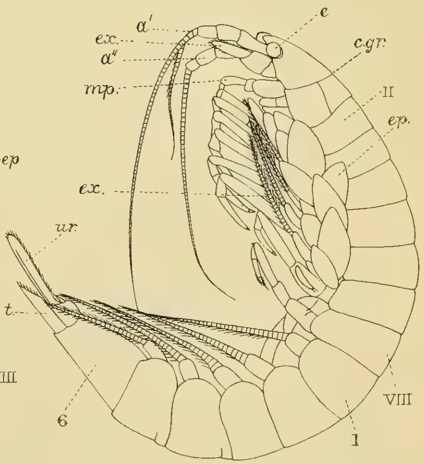

W.T.C. del. M.P. Parker lith.

1, 3, BATHYNELLA NATANS, *Vejdovsky.*
2, 4, ANASPIDES TASMANIÆ, *Thoms.*

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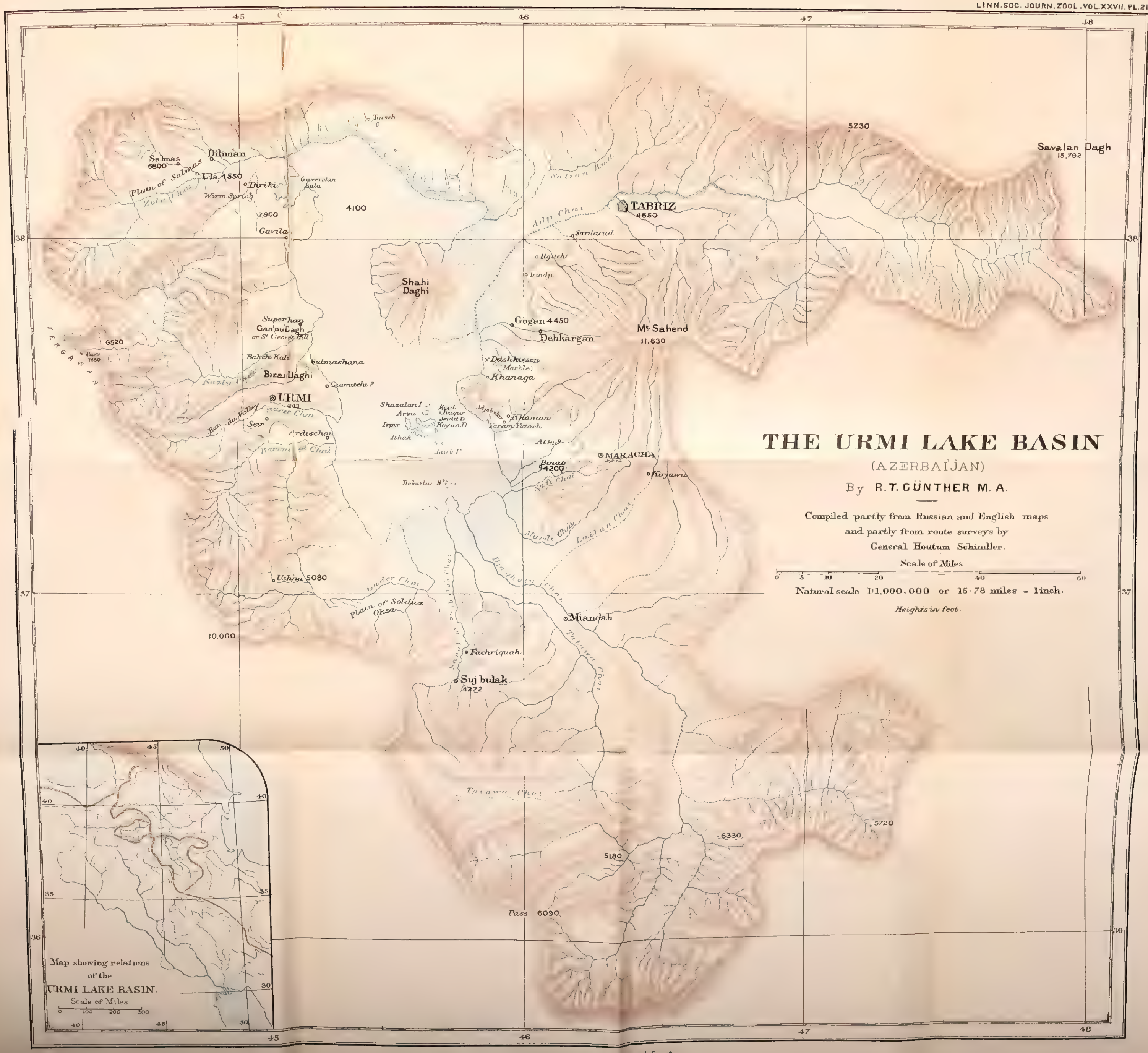

THE URMI LAKE BASIN

(AZERBAIJAN)

By R. T. GÜNTHER M. A.

Compiled partly from Russian and English maps
and partly from route surveys by
General Houtum Schindler.

Scale of Miles

Natural scale 1:1,000,000 or 15·78 miles = 1 inch.

Heights in feet.

Map showing relations of the URMI LAKE BASIN. Scale of Miles

Published by the Royal Geographical Society

1899

Contributions to the Natural History of Lake Urmi, N.W. Persia, and its Neighbourhood. By ROBERT T. GÜNTHER, M.A., F.R.G.S., Fellow of Magdalen College, Oxford. (Communicated by the President.)

[Read 15th June, 1899.]

(MAP PL. 21 & PLATES 22–30.)

CONTENTS.

Reports on the Specimens collected:—

GENERAL REMARKS.

IT is now more than three years since Mr. P. L. Sclater showed me a letter from my friend the Rev. F. F. Irving, dated Urmi, Oct. 6, 1895, in which the organism dwelling in the Salt Lake of Urmi, which Lord Curzon of Kedlestone had previously referred to as a jellyfish, is compared to "a tiny shrimp." Further searches in the literature showed that Abich had already recorded [illegible] presence of a Crustacean, but that the majority of travellers and writers described Lake Urmi as a "Dead Sea," totally devoid of life on account of its excessive salinity.

I received private information that edible fish were to be caught in the rivers; but I was unable to obtain any further information concerning the aquatic fauna of the Urmi basin, although its fossil fauna had been frequently described.

The fascination of an apparently entirely unknown zoological region near the waterparting of the hydrographic systems belonging to the Atlantic, Arctic, and Indian Oceans, induced me to devote a summer vacation to visiting the plateau of Northwestern Persia.

The chief problems which attracted my attention were naturally those which centred around the salt lake and its fauna, and its tributaries and their faunas; but incidentally I was able to collect a few terrestrial animals, which are described in the Reports. The results obtained during a few weeks of summer show, I think, how much still remains to be done by a naturalist-explorer who may be able to work the Urmi district during those months of the year which are most favourable for the purpose of collecting.

The present communication is chiefly concerned with observations and collections made between the middle of July and the middle of September, 1898. Wherever I have profited by the work of others I have endeavoured to make due acknowledgment but, in addition, I should like to record my especial obligations to a more extended circle of helpers. I am indebted to the Royal Society for a grant in aid of my expedition; to the Foreign Office for most useful letters of introduction; to Prince Imam Guli Mirza, at the intercession of the Amir Nizam, for the loan of the 'Nahangk,' a vessel of some 20-tons burden, upon the Lake of Urmi; to Mr. E. Chapman; and to the past and present members of the Archbishop of Canterbury's Mission to the Assyrian Christians at Urmi. Lastly, my sincere thanks are due to my friends and coadjutors, who have unselfishly helped on my own studies at the expense of their own, and who have contributed the most valuable part of the present paper. My readers are indebted to the Council of the Royal Geographical Society for permission to republish my map of the neighbourhood of Urmi, originally contributed to the Journal of that Society.

Before proceeding to the more purely biological characteristics of the region, it may be well to recall to mind its main physiographical features—its "external conditions of existence."

The geographical and, more particularly, the hydrographical relations of Azerbaijan, the N.W. province of Persia, are of interest because the highlands of this province are part of the system in which the most important waterpartings of the Old

World meet. The divides which separate three great systems of rivers—namely, the river-systems of the Indian Ocean from those of the Atlantic, the river-systems of the Atlantic from those of the Arctic, and the river-systems of the Arctic from those of the Indian Ocean—meet in the highlands of Armenia and Kurdistan, between the massif of Asia Minor and the Persian plateau. Notwithstanding the altitude of the region, the meteorological conditions tend towards those of a desert, and produce features characteristic of deserts. On the whole the annual evaporation is so much in excess of the annual precipitation that the lakes do not overflow, and their water is more or less salt. Similarly, in Turkish territory we have Lake Van, in Russian territory the Caspian Sea, and in Persia Lake Urmi.

Climate.—The climate of the Azerbaijan plateau may be fairly classed among the continental, or "excessive" climates as they have been termed by Buffon; but at the same time it is the healthiest in Persia, because the summer heat is more tempered than in the other provinces and there is generally a sufficiency of water for man and beast.

The seasons are extreme, but very variable both as regards duration and time of year. This variability is largely due to the fact that these uplands of N.W. Persia, of 4300 feet altitude and upwards, form part of a tongue of high land which runs from N.W. to S.E., and divides the warm depression of Mesopotamia, in which the palm-tree flourishes, from the deserts of Persia and from the hot South-Caspian provinces of Ghilan and Mazenderan. Thus we find, in close proximity, the snow-mountains of Kurdistan and tropical lands warm enough for the growth of the date-palm. It is a pity that methodical meteorological observations in so interesting a region should be practically non-existent. In default of the more accurate indications of the meteorological conditions, I am compelled to supplement my remarks by such observations on animal and vegetable life as seem to afford information on the climate.

The winter snows may commence towards the end of November (23rd in 1890), or they may not fall until February 1st (1893), There is often fine weather between the first snows and those of January and February. The last snows may fall as late as Lady-day. In cold January weather the minimum thermometer sometimes falls below 0° Fahr. (12° F. is a common temperature), and the snow does not melt in the middle of the day. As a general rule, snow may be expected to lie on the ground in the plain for three or four months, and on the hills (6000 feet) in streaks until well into July. In the winter of 1895 there is said to have been no sunshine for five weeks.

When spring comes the snow melts, often with surprising rapidity, and a few days' warm sunshine produces a marvellous change in the aspect of the country. Irises of a delicate purple colour, and white and pink crocuses are in flower before the end of March; the plum blossoms by the 1st of April, and sometimes even in March, with snow on the ground. The quince blossomed on April 18th in 1891. At the same time the storks and hoopoes return from their winter pilgrimages; the earliest record of the stork at Urmi seems to be March 14th, in 1898.

Summer commences about St. George's day, on May 6th, and usually lasts unbroken until late in October; popular tradition prolongs it until the second St. George's day in autumn, on the first Monday in November (O.S.). Rarely, as in 1895, a few rain-storms interrupt the continuity of the hot weather.

During the warmest months it is hot even at 6 o'clock in the morning. The glaring, eye-dazing sky is unrelieved by any clouds. The shade temperature rises to 90° F. in the open, and much higher among the sun-baked mud-walls of the villages. The nights are generally cool, and become uncomfortably cold during the latter months of summer, owing to unchecked radiation. The greater number of the fruit-trees are in blossom in the first week of June. The first fruits to ripen are the white and morella cherries and plums, which are followed by peaches and apricots, and in August by an abundance of excellent nectarines, melons, grapes, and also of cucumbers, vegetable-marrows, black and red tomatoes, &c.

No climate would seem better adapted for the growth of the vine. The grapes of the plain of Urmi are magnificent, both in flavour, size, lusciousness, and variety. On the other hand, the severe winters do not permit of the cultivation of the orange and the lemon.

Rainfall.—The rainfall seems to have been recorded during the year 1853–54 [*], but I have been unable to discover any subsequent series of observations. During that year 547 millimetres of rain seem to have fallen, and the monthly rainfall was

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[*] Supan, in Petermann's 'Mittheilungen,' Ergänzungsheft No. 124, 1898.

as follows:—January 43, February 72, March 103, April 133, May 62, June 11, July 0, August 12, September 16, October 38, November 24, December 33: total 547 millimetres.

Irrigation and Agriculture.—On the Urmi plateau, wherever there is water there is agriculture. Without artificial irrigation the greater part is a sterile waste of gravel, capable of supporting little but thistles, *Centaurea*, *Carduus*, *Achillea*, *Pyrethrum*, and other plants characteristic of the Persian steppes. In spring, the snow has hardly had time to melt away before this steppe-vegetation covers the plains and hillsides with a green mantle; but soon the water in the soil commences to give out, and then the brown-burnt stalks and leaves demonstrate the cessation of vegetable growth.

The chief objects of the agricultural engineer are first to convey water, with as little loss from evaporation as possible, from the valleys near their emergence from the hills to the most fertile soil of the plains, and, secondly, to distribute the water over as great an area as possible. The Persian poets praise King Menuchehr as the inventor of the system of subterranean canals which have become so universal in Persia, and which have converted many a wilderness into a fertile plain. Subterranean aqueducts or *kanats*, sometimes many miles in length, which are employed to convey water beneath arid tracts of land, have a double advantage: they not only reduce loss from evaporation to a minimum, but, inasmuch as they are nearer the underground water-level, little of their water is lost by drainage into the ground. It is always curious to note how similar inventions have been independently made in different parts of the world. The ancient Peruvians constructed subterranean watercourses on a noble scale in connection with their gigantic works of irrigation (one traversing the district of Condesuyu measured 400 to 500 miles), and, like the Persians, had laws prescribing the quantity of water which individual landowners might be permitted to draw (*Prescott*). The waters of the Persian kanats contain the ordinary chub, *Capoëta*, and *Leuciscus* of the rivers; and the dark-vaulted spaces are often the abode of great numbers of bats.

The chief crops cultivated are cereals, vines, castor-oil, tobacco, melons, rice, and cotton. The fields are so level, and so well trenched, that they can be watered by a simple diversion of an irrigation channel.

Vegetation.—Perhaps the most noticeable feature of the vegetation of the Urmi plateau is the almost total absence of indigenous, uncultivated trees. And yet in some parts the landscape can only be described as thickly wooded. The villages are often completely hidden by trees grown for fruit or fuel. There is no lack of all manner of fruit trees: apples, pears, quinces, apricots, peaches, nectarines flourish in the gardens round the villages; willows and poplars line all watercourses; planes, walnuts, and jujubes form avenues along roads; but all indigenous trees have long since been cut down. It is not the case that the conditions would be unsuited to the growth of arboreal vegetation, because they are much the same as those prevailing in the oak-forest districts in Turkish Kurdistan.

By roadsides and in villages the plane (*Platanus orientalis*, L.) is often planted, for the sake of the shade afforded by its spreading branches. Here and there a giant has been spared, and has become regarded as a holy tree. Chardin refers to one in a garden near Shiraz upon the branches of which amulets, rags, and other votive offerings were hung. The Rev. S. J. Daltry observed a similarly decorated tree near the sulphur-springs on the hills to the north of the plain of Gavilan. There is an enormous plane in the village of Dekhargan growing over a water-tank, which is reached by some steps descending between the buttresses of the tree. Close by are three ancient Mussulman tombstones rudely carved like the quadrupeds of our Noah's-arks. Beneath the same tree stands a stone bench used as a castor-oil press. It is a pity that more of these magnificent trees are not planted by the present generation, who, although ready enough to gain advantage by the good deeds of their forefathers, are too idle to follow their good example.

I did not see any specimens of the Oriental plane or of the walnut (*Juglans regia*) which could unhesitatingly be described as wild or indigenous in the Urmi district. I am therefore inclined to consider that Dr. Radde's * dictum that all planes and walnuts in the Caucasus have been planted by man, with the possible exception of the walnuts of Gilan, is equally true of the Urmi district. I saw a few walnut-trees on the islands of Koyun and Arzu, in the Lake, which might be regarded as indigenous. The largest was a stunted tree of about 15 feet

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* G. Radde, 'Reisen an der Persisch-Russischen Grenze,' 1886.

in height, with a stem 2–3 feet in diameter near its base. It is, however, equally possible that the trees were planted when the islands were inhabited and joined to the mainland. Formerly the larger islands seem to have been fairly thickly wooded, but the fuel-collector has not only cut down the trees with an unsparing axe, but now the sailors of the ships earn a living by eradicating all trace of their existence by laboriously digging-out their very roots. Walnut-wood is in great request for the best joinery and cabinet-making.

The banks of the watercourses are recognizable from afar on account of the poplars and willows planted along them. The willows are generally pollarded at regular intervals of time. The long straight poplar poles are used as rafters for the roofs of houses and balconies. Split laths are laid transversely from rafter to rafter, matting is laid on them, then hay, and finally a thick layer of mud and chopped straw.

Geology of Urmi Basin.—The Azerbaijan lake-basin occupies an area of some 20,000 square miles; its greatest depression is more than 4000 feet above sea-level. The mountains on its periphery separate its water-system from the circumjacent basins of the Tigris, the Aras, and the Kizil Uzun, the latter two of which flow into the Caspian Sea. Several peaks rise above 10,000 feet, and the volcanic cone of the Savalan reaches 15,000 feet. Outcrops of volcanic rock occur in many localities, and probably had their origin during the vast upheaval of land which occurred after the Miocene age.

The geological record of Lake Urmi is still but very partially read. The oldest rocks are Palæozoic and probably of Carboniferous Limestone age, because the genus *Endothyra* is to be detected among their Foraminifera (p. 452). The Jurassic age is represented by a solitary Ammonite in my collections (p. 418); but Rodler, von Borne, and others have noted several localities near the west coast of the Lake of Urmi where Jurassic rocks are to be found. For the palæontology of the later deposits, I would especially refer the reader to Mr. Bullen Newton's comprehensive retrospect on p. 430.

The Carboniferous rocks of the Lake itself are overlaid by a great thickness of Miocene chalk, an important section of which is referable to the Helvetian period, and which contains the remains of organisms identical with those of the Lower Miocene (pp. 430–452). The North Persian Tertiary rocks are divisible into three well-characterized equivalent zones, which have been defined by Pohlig as :—

Zone 1. The marginal zone of sandstones, conglomerates, and gravels, often containing organic remains from earlier strata. The Seir hill probably belongs to this zone.

Zone 2. Light-coloured marls, generally bright red, with beds of rock-salt and gypsum. Both zones 1 and 2 take a large part in the formation of the hills of the Persian plateau.

Zone 3. Limestones and calcareous marls; best seen in the islands in the Lake of Urmi, but also in the mountains to the south-west, and which are very rich in molluscs, reef-building corals, and silicious sponges.

At Guverchin Kala, near the northern end of the lake, the entire series of Miocene strata rest almost horizontally and directly on red granites traversed by felspar-dykes, which are a very conspicuous feature in the landscape.

Urmi must therefore have been covered by a sea of normal salinity in Miocene times, which was apparently an extension of the Miocene Mediterranean Sea. Then commenced those vast changes of level which resulted in the upheaval of a Miocene sea-bottom some 5000 feet to its present position as part of the Persian plateau; this vast earth-movement is still clearly recorded by the numerous volcanoes and outbursts of volcanic rock which, monument-like, mark the spots where the earth-crust gave way before overwhelming strains and irresistible pressures. The next chapter in the story of Urmi tells us how at a later date the dry land about Maragha supported a mammalian fauna, which must have been very similar to the almost contemporaneous fauna of Samos and of Pikermi in Greece. The bones of herds of elephants, antelopes, and horses, as well as those of many other mammals, are to be found preserved in the pumiceous tufa-deposits of Kirjawa near Maragha (p. 376); it is still uncertain whether or not the animals perished in consequence of a volcanic eruption or from some other cause.

During Pliocene and post-Pliocene times the land undoubtedly underwent considerable changes both of level and of contour. There is no evidence that the present lake is the remains of a Miocene sea, and therefore it is not to be regarded as a "Relikten-See," a view which is also shared by Rodler. The excellent American monograph on Lakes Bonneville and Lahontan is an example of how the physical geographer has been able to reconstruct former lake-basins by an examination of terraces and of sinter and travertine formations; but in the case of Lake Urmi neither were the investigations of Loftus or Rodler rewarded by the discovery of lake-terraces, nor do the travertine deposits of Dashkiesen appear to be of lacustrine origin. The travertine deposits round Lake Urmi seem to be the result of mineral springs. Pohlig mentions Pleistocene flood-zones of *Neritina* and *Dreissena* on the islands and on the Shahi peninsula; but although I saw a single specimen of a *Dreissena*-travertine mass in Urmi, I was not able to discover where it had been found, and consequently I was not able to confirm Pohlig's theory.

Lake of Urmi.—The lower parts of the depression of the Azerbaijan plateau are covered by the great salt-lake of Urmi. The length of this sheet of water, as measured from north to south, does not fall short of 80 miles, and its breadth is about 25 miles at the wider parts, but is far less where the Shahi peninsula, jutting out, lessens the distance to ten miles. In former days the mountain of Shahi seems to have been entirely surrounded by water, but now it is connected with the eastern shore by dry land except when the spring floods convert the isthmus into a marsh. The area covered by the lake is about 1750 square miles.

The shores of the lake, in some few places where the hills come down to the water's edge, are rocky, and falling away abruptly exhibit low cliffs of erosion; but for the most part the land slopes so gradually that the bather may have to wade for a mile or two before he reaches water which is out of his depth. The more notable elevations on the coast-line besides Mt. Shahi are at Guverchin Kala, a promontory of granite with pink felspars and of Miocene limestone with shells and echinoderms, near Gavilan; at St. George's Hill, Superghan; and at the Bezau Daghi, which are at any rate partly of volcanic origin, since their lower flanks are composed of pumiceous hornblende-biotite-andesite.

The islands will be described in greater detail below. There are a few small islets off Guverchin Kala, at the northern end of the lake, which I was unable to visit; but the more important group of islands is situated in the southern half of the lake, though its exact geographical position has yet to be defined.

The depth of the lake is inconsiderable. At no place does this huge expanse of water appear to be more than 40 feet in depth, and it is doubtful whether the average sounding would be as much as half this; indeed, it seems to me to be probable that 15 feet would more nearly represent the mean depth. As in other salt lakes the height reached by the water is liable to considerable seasonal variation; the difference of level seems to bear such a large proportion to the average depth of the lake that the composition and specific gravity of the water must undergo very considerable alteration during the change from the dry-season level to that of the wet-season. It might be quite possible to compute the total volume of the lake from the data supplied by gravimetric measurements considered in relation to the easily measurable increase of volume after the rainy season.

The specific gravity of a sample of water obtained on September 16, 1898, was 1·1138 at 15° C. Its salinity was equal to about $\frac{3}{5}$ of that of the Dead Sea (sp. gr. 1·2225 at 120 metres, *Lartet*).

A chemical analysis of the filtered water, undertaken for me by my friend Mr. J. J. Manley, gave the following proximate results, calculated in parts by weight in 100 grammes of the solid salts:—

Sodium chloride	86·203
Magnesium chloride	6·816
Magnesium sulphate	3·915
Calcium sulphate	1·151
Potassium sulphate	1·741
	99·826

·017 per cent. of free carbonic acid gas was also present, as well as an unweighable trace of barium. The weight of the total solids came to 14·893 parts in 100 of the water *.

The average temperature of the water during the month of August was about 80° F. at the surface and some two degrees lower at the bottom (depth 25 feet). The very shallow water very near the shores was of course heated up to a higher temperature (82° F.), and was far more concentrated by evaporation than the open lake-water: in many places along the margin the

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* For further details concerning the chemical and physical characters of the water, see a paper by R. Günther and J. J. Manley, "On the Waters of the Salt Lake of Urmi," in Proc. Royal Society, 1899, vol. lxv. pp. 312–318.

concentration of the saline solution had become extreme, and the salts were being deposited upon the surface of the loathsome black mud, reeking of sulphuretted hydrogen and probably yielding marsh-gas as well, which seems to be such an inseparable feature of salt lakes. For some distance from the water's edge the foreshore was covered with a dazzling crust of white salt.

The salt water has a very unpleasant physiological action upon all the mucous membranes, and produces nausea if swallowed, but is otherwise innocuous to the bather. The Syrians are in the habit of bathing in the lake upon St. Thomas's day (July 3rd O.S.), in order to commemorate the tradition that the Saint crossed the lake on his way to India. On emerging from the water the skin becomes rapidly covered with a thin crust of salt, unless the water be rapidly removed with a towel. But although harmless and even invigorating to man, the salinity is fatal to any freshwater fish of the rivers which may happen to swim out too far; wherefore at the present day the lake forms a very efficient barrier to the distribution of fish from one river to the next. Quantities of dead fish may sometimes be seen near the mouths of some of the rivers. I tried the experiment of putting freshly-caught chub into the salt water, and found that they died in three and a half minutes. When the salt water was gradually substituted for the fresh, the fish died when the mixture contained about a third of the salt water, which was at the end of forty minutes. On the 2nd of August a specimen of the green tree-frog was found vainly endeavouring to escape from the salt water into which he had accidentally jumped; but his rapidly weakening efforts showed that he too would soon have become a victim of the salt water, and have involuntarily verified Semper's observations ('Animal Life,' p. 150), had he not succumbed to the collector's alcohol.

Plankton.—It might very naturally have been supposed that so hostile an environment as a strong saline solution, surrounded by a zone of a still stronger one almost saturated with sulphuretted hydrogen, would have been incompatible with organic life. The Lake of Urmi, however, is in no sense of the word a Dead Sea: it is simply teeming with living organisms, both animal and vegetable. Whether near the shore or miles from it, the clear water may be seen to sparkle in the sunlight owing to the enormous numbers of organisms which constitute its plankton. Throughout all the vast volume of water the distribution of life seemed to be fairly uniform, for even water drawn from a depth of 28 feet contained its due proportion.

In the month of August the vegetable portion of the plankton consists of small green masses, either of a globular or of a membranous, flat and irregularly expanded form, of soft or gelatinous substance, and varying from $\frac{1}{10}$ to $\frac{3}{4}$ of an inch in diameter. I at first regarded them as simple colonies of algæ; but Mr. G. Murray, who has been kind enough to examine my all too scanty material, assures me that their structure is that of a bacterial zooglœa of micrococci invested by a number of small diatoms.

Their presence in such enormous quantities in the lake makes me suspect that there may possibly be some more intimate vital relations between the two organisms than would appear at first sight. Their abundance in parts of the lake where there is unlikely to be a proportionately large food-supply for plants of holozoic nutrition, seems to indicate symbiotic relations between the chlorophyll-containing diatoms and the bacterial colonies, of a nature very similar to those which enable the constituents of the lichen to maintain life in situations where life would be impossible without such a symbiosis. At the same time, it is possible that the colonies may feed upon matter brought down by the rivers, and that they may owe their universal distribution to the surface-drift of the waters caused by the wind.

The vegetable portion of the plankton affords nutriment for the fauna. As I have already stated in my letter to 'Nature' of Sept. 8, 1898, the so-called "jellyfish" alluded to by Lord Curzon of Kedlestone and Mr. P. L. Sclater is a species of brine-worm allied to *Artemia salina*, Leach. In the shallows near the muddy shores are to be found the aquatic larvæ of a Dipterous insect not unlike the larvæ of *Ephydra riparia*. As in the rat-tailed larvæ of *Eristalis* and of *Ptychoptera paludosa*, the respiratory tubes are prolonged posteriorly and admit of considerable extension, so that the larva is able to draw air into its tracheal system while crawling in search of food beneath the surface. The extremity of the respiratory tube is forked, and each branch is tipped with small hairs which naturally increase the clinging power of the apparatus to the surface-film of the water. The larvæ were about 10 mm. in length.

The little brine-worms (*Artemia urmiana*) were as a rule uniformly distributed throughout the lake, but clouds and streaks of *Artemia* are occasionally to be seen at certain places near the shore. In such streaks in which the Artemias were more than ordinarily numerous, there were always a large proportion of dead individuals or of individuals with impaired swimming powers; the greater density of their aggregation seemed to be the result of local currents. In the clear green waters brightly illumined by the sun, the delicate cuticles of the Artemias sparkle like star-spangles. In order to obtain data for comparing the density of population of Lake Urmi with that of other lakes, a tow-net of silk bolting-cloth (meshes ·25 mm. square) was slowly drawn horizontally through about 35 yards of water in the middle of the island archipelago, and again in a vertical direction through 25 feet (the utmost obtainable at the station); the organisms captured were put into alcohol, their numbers were counted and their apparent volume measured. The two horizontal fishings gave results not differing from the mean by more than 3 per cent. The cubic metre of water was found to contain 1577 individual Artemias—or roughly, an Artemia to every pint of water. The preserved material, after being allowed to settle for 24 hours, occupied an apparent volume of 42·5 cubic centimetres. The vertical fishings gave rather lower results. Six hauls of the plankton-net showed that the average vertical distribution was about 1203 Artemias to the cubic metre of water. The inference is that, although the population is less dense near the bottom than near the surface, yet on the whole the organisms may be said to be fairly uniformly distributed throughout the lake. My observations are therefore in accordance with those of Reighard made during a biological examination of Lake St. Clair *.

The fishings recorded above were made at 8 o'clock in the morning, but others made at midnight (with strong moonlight) and at midday showed that there does not seem to be any extensive diurnal migration of the kind which Forel has shown to be characteristic of the pelagic fauna of deep freshwater lakes, and which is also usual with many marine pelagic animals. Indeed, during the day, owing to the shallowness of Lake Urmi, the bottom is not much less brightly illuminated than the surface, and a fauna of negatively heliotropic nature would search in vain for twilight in its inconsiderable depths. I am of opinion, therefore, that 1200 Artemias per cubic metre

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* Bull. Michigan Fish Commission, 1894, No. 4.

is a fair estimate of the density of the population. If it be assumed that the average depth of the lake is 6 metres, the total population of the 1750 square miles of lake must be at least 39×10^{12} adult individuals.

The eggs of the Artemia may often be seen floating on the surface in long, interlacing streaks of a brown colour. The Artemias and their eggs are indubitably the food of the great concourse of water-fowl which have been remarked by all travellers as dwelling on the shores of the lake. In August I saw no flamingoes, although quantities of their pink feathers on the beaches testified to their presence earlier in the year. Gulls and ducks were very abundant.

Influence of a Saline Environment.—It appears that although the water of Lake Urmi is not incompatible with the well-being of all organic life, yet its salinity is too great to admit of the existence of more than a few species. They are on the whole similar to the species described from other salt lakes in desert regions, but the fauna is rather more limited. Lake Urmi, in respect of its fauna, is very similar to the Adschidarja, near the Caspian Sea; it does not contain so many species as the less saline pools of the neighbourhood of Odessa (*Schmankewitsch*), nor do any Coleopterous insects appear to have become acclimatized to its waters as has happened in certain American and European salt waters. It is possible that a worm may yet be found living in its waters, as *Pachydrilus* does in the strong brine-springs of Kissingen (*Semper*) and Kreuznach (*Claparède*). The affinity of the Urmi fauna is undoubtedly with that of the fresh-water rather than with that of the sea; the fauna is therefore not to be regarded as *halolimnic* in Mr. J. E. S. Moore's sense of the word: it is decidedly *halophilous*.

The influence of a strong saline solution upon the structure and habits of an organism has engaged the attention of several naturalists. The early researches of Plateau and Beudant proved that many freshwater animals will live in sea-water and *vice versa*, so long as the change from one to the other be not effected too suddenly; and also that different animals have different powers of resistance to such a change. In 1889 Boas * described the remarkable changes of structure which occur in *Palæmonetes varians* in accordance with its growth in fresh or salt water. The last few years have produced

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* Zool. Jahrb. iv.

an abundant crop of literature dealing with the effect of salinity upon the early stages in the development of organisms and especially of Echinoderms (Morgan, Loeb, Rawitz, Norman, Vernon, and other students of "Entwickelungsmechanik"). None, however, are of more importance than the classical treatises of Schmankewitsch upon *Branchipus*, *Artemia salina*, and *A. Mülhausenii.* By some accident a tank near Odessa became filled with salt water of a density of 1·0567 (8° Beaumé) in 1871. The water in the tank became concentrated by very gradual evaporation until in 1874 it reached a density of 1·2015 (25° B.). The *Artemia salina* which populated the tank in 1871 underwent a gradual change as the salt water became more and more concentrated. The setæ of the furcal lobes of the tail became fewer in number and dwindled in size, the gill-lamellæ enlarged and altered in shape, the abdomen tended to alter its segmentation, and finally the entire species became metamorphosed into *A. Mülhausenii*, a species only known from the most saline waters.

The *Artemia urmiana* lives in a far more saline water than the *A. salina* of Schmankewitsch did, but not in such a saline solution as *A. Mülhausenii.* Consequently we should expect *A. urmiana* to be intermediate in structure between these forms in those characters which are determined by the strength of the saline environment; and this is precisely what I have found to be the case with respect to the tail-lobes and their setæ. Many of the *Artemia urmiana* exhibit clearly the intermediate condition figured by Schmankewitsch on plate vi. fig. 5*, The specific gravity of the water which produced this condition in Schmankewitsch's experiment was about 1·1373, while the specific gravity of the water of Lake Urmi is 1·1138, or ·0235 lower. It must be remembered that the salinity in the ponds of Schmankewitsch was increasing at a very rapid rate as compared with the rate of change of the salinity of Lake Urmi. It is therefore likely that if the Artemias of Odessa had had more time, as measured by *Artemia*-generations, in which to adapt their structure to a salinity indicated by a specific gravity of 1·1138, the resemblance between the Russian and Persian Artemias would have been even yet more striking. Even as it is, the Artemia seems to act as a hydrometer with an error of less than ·03 in the determination of specific gravities.

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* Zeitschr. f. wiss. Zool. 1875.

Islands.—In the southern half of the lake is a small group of rocky islands which from a distance present a rounded appearance, like the knolls on our chalk downs, but from a nearer point of view their precipitous cliffs and rugged hill-sides testify to the erosive powers of the heavy salt waves in stormy weather. Their geological structure has been investigated by Abich, who pronounced them to be built of Miocene chalk resting upon Palæozoic calcareous strata which are to be seen near the north end of Koyun Daghi. The Miocene chalk is divisible into three main divisions. The uppermost is porous and contains *Ostrea Virleti*, Deshayes; the middle division is of a more compact nature and is rich in corals. In the lower deposit bivalve and coral fragments are found, together with *Turritella Archimedis*, Brongniart, *T. turris*, d'Orb., and *T. gradata*, Menke.

On many of the islands are beaches of shells, coral fragments, and echinoderms, organisms which could have lived only in a sea of marine salinity and in connection with the ocean. These marine reliquiæ, now for a second time rolled by salt waves, tell the tale of a Miocene sea of normal salinity which has been supposed by Pohlig to have been a northerly continuation of the Persian Gulf from the Indian Ocean, but which, as already stated, was more probably an extension of the Mediterranean. This Miocene sea, like the Red Sea of to-day, was a coral sea. Upon its floor were laid down the chalk and limestone formations of the Urmi Archipelago, as well as those of the calcareous mountains to the south of the lake.

The largest of the islands are Koyun and Arzu, of which the former measures between 3 and 4 miles in length and rises to a height of about 1000 feet above the level of the lake.

The islands appear to have been formerly inhabited, and there may still be seen foundations of houses near a spring at the south-eastern end of Koyun Daghi. At the present time they are uninhabited, but are often visited by sailors, who turn out goats and sheep to pasture on them during certain months in the year, and who not only cut down the trees, but even dig up for fuel the roots of trees felled by their predecessors. There is a tradition that some eighty years ago the islands were connected with the mainland by a causeway which can, it is said, still be detected by sounding. This tradition is certainly confirmed by the zoology of the islands. There are at least five species of land-shells and two species of lizards (*Eumeces Schneideri* and *Ophiops elegans*), which would be very unlikely to have crossed the broad expanse of water separating the islands from the mainland. There were also mollusks, woodlice, scorpions, *Galeodes*, and several wingless insects.

The most interesting feature of the fauna of these islands is that upon them once lived a wild sheep, a distinct variety, apparently allied to the Cyprian *Ovis ophion*. Unfortunately, I brought home only one skull, although there was an entire skeleton upon Koyun Daghi. It is possible that this sheep, too, may belong to a "Relikten-fauna," if I may be permitted to apply Credner's term to a terrestrial area.

Some eagles (probably *Aquila chrysaëtus*, L.) breed among the highest crags of Koyun Daghi, and the lower crannies are the homes of countless rock-pigeons. The shores are often lined with ducks and gulls, which feed on the crustaceans (*Artemia*) and bacterio-diatom colonies of the Salt Lake. On the pebble-beaches I picked up many pink feathers of the flamingo, but I did not see any of the birds during my stay; they are abundant in winter, and are snared on the mainland in spring. Some of the beaches are covered with reed-stems, which have probably been drifted across from the mouths of the great southern rivers by southerly winds. Partridges and quails were occasionally heard, and magpies were to be seen at the spring disputing with the pigeons for the right of drinking first.

Upon the small grass-grown Shazalan Island, to the north of Arzu, I saw two young specimens of *Eumeces Schneideri* as well as many *Ophiops elegans*. Myriads of rock-pigeons which nest in the crevices of the rocks are regarded by the sailors as an unfailing source of pigeon dinners. The rocks consist of a dark slate-coloured limestone, with many crevices and cavities containing secondary depositions of calcium carbonate. The limestone is very similar to that of the N.W. end of Koyun Daghi, and is of Carboniferous age.

The vegetation growing on the islands at the time of my visit was mostly burnt up by the sun except near the springs. On Koyun and Arzu there are a few stunted walnut-trees, the largest of which measured between two and three feet through at a yard from the ground. The calcareous soil favours the growth of the *karuan* plant (*Artemisia*): the effect of its aromatic odour as an insectifuge is as well known as it was in the days of our forefathers, when the housewife was taught that—

> "Where chamber is swept, and wormwood is strewn,
> No flea, for his life, dare bide or be known!"

Plains.—The shores of the lake are for the most part surrounded by gently sloping gravel or alluvial plains, which extend as far as the feet of the hills. They are traversed by the numerous rivers which flow into the lake, and which distribute their waters among innumerable villages and over vast tracks of cultivated land. When seen from a distance the irrigated fields look like extensive forests, owing to the poplars and willows which line the watercourses, and which doubtless have given rise to the misleading statement that Lake Urmi is "surrounded by wooded shores and hills" (Curzon, 'Persia,' p. 532).

The country which is too far from water to be irrigated is of the nature of a thistle-covered steppe, whereas the lower marshy portions exhibit rank growth of rushes and blue irises.

My first impressions of the Zoology of the Urmi plains were of disappointment, and for two reasons—firstly, because the general facies of the fauna is pre-eminently European, and, secondly, because I found the country much more densely populated than I had expected. There are villages wherever sufficient water is obtainable to make agriculture possible; and as these villages have existed for very long periods of time, within their spheres of influence, Nature has been tamed and the fauna profoundly changed.

Among domesticated animals the most striking are the camels, buffaloes, and fat-tailed sheep (*Ovis steatopygus*). Buffaloes only do really well where they can spend several hours a day in the water. When water deep enough for complete immersion cannot be found, a small boy is often told off for an hour or so to bale up water in a pot and to pour it over their backs. The winter on the Urmi plateau is so severe that the buffaloes have to be kept in stables until the return of warm weather.

The gazelle (*Gazella subgutturosa*) doubtless once lived on the plains of Urmi, but has now become exterminated by the spread of cultivation. The badger (*Meles canescens*) is rare. The rats and mice are unknown to science, although their holes are common in the fields and along watercourses. A species of gerbille occurs, but is not very common.

Quails and partridges are common, and afford a favourite sport to native falconers, who use sparrow-hawks. The bee-eaters (*Merops apiaster*) were extremely plentiful near the northern end of the lake in July, but were not to be seen further south in August and early September.

Storks are abundant; their twig nests are to be found in trees or on the roofs of the houses in most of the villages. The Syrians have learnt the Persian story that the stork visits Mecca during his winter migration, and doubtless that is why "Hajji Laqlaq" is regarded as bringing good luck and is attracted by nesting-baskets put up in trees. Storks return about March 14th.

The hoopoe is common. The Syrians consider them unclean birds (Lev. xi. 19, R. V.; Deut. xiv. 18), and call them "Pupu" and also "Birds of Solomon," from the old legend that they got their crests from him. "A flock of them once sheltered him from a burning sun. In gratitude the king asked them what he should do for them, and they asked for crowns of gold. But finding that they were being killed by greedy men for the sake of the crowns, they begged Solomon to change them for the crest which they retain to this day" (*Maclean*).

In addition to the reptiles mentioned below, *Clemmys caspia*, de Filippi, is common. Many may be seen walking along the banks of the watercourses, ready to dive into the stream on being disturbed. After lying still for three to five minutes in a hole or beneath some water-weed, they cautiously come up to see whether the danger is past. All the specimens examined had the yellow sternal shields with black patches characteristic of *C. caspia* as opposed to the European *C. leprosa.*

Testudo ibera is common at Seir, as indeed it is on the mountains to the east of the lake. On Koyun Daghi I found the fragment of a carapace which probably belonged to this species.

Fish.—Inasmuch as the rivers which flow into the lake are separated from each other by a medium, the salt water, in which no fish can live for a period long enough to enable it to swim from one river to the next, the characteristics of the fish fauna of the individual rivers are deserving of the most careful investigation, because they may supply us with a clue to the physical conditions which obtained during a particular epoch in the lake's history. If it can be shown that the faunas of all the rivers are identical, or that no local variations or species are distinguishable in the different rivers, then it must be inferred that the rivers have not been isolated from each other long enough for such faunistic differences to have appeared. But if, on the other hand, it can be proved that there are faunistic differences between the rivers, then it must be inferred either that the rivers have been populated from different stocks, or that they have been populated from the same stock at so remote a period that their isolated faunas have had time to become modified in different directions.

My collections and observations are by no means as complete as could be desired for the solution of the problem, but still they would seem to afford a strong indication of the existence of local faunistic differences in the rivers. I think they show that there are not only differences of species and varieties, but that the relative abundance of the common species varies greatly in the different rivers.

As I have already pointed out, the rivers which flow into Lake Urmi may be divided into three groups*. The Zola, Nazlu, Shaher, Barenduz, and Gader rise in the mountains to the west of the lake; the Tatawa and the Djaghatu enter the lake from the south; and the Murdi, Safi, and Adji receive the eastern drainage.

Probably all the rivers contain the chub, *Capoëta gracilis*, and an *Alburnus*. The Gader, Tatawa, and Djaghatu are noted for the *Silurus glanis* which is absent in all the western series of rivers except the Gader Chai, which opens near the Tatawa, and which probably often mingles its flood-waters with those of the latter stream on the flat land between their mouths. *Leuciscus ulanus* seems to be peculiar to the waters of the Plain of Salmas, and *Leuciscus gaderanus* to the southern rivers. I succeeded in catching *Barbus caucasicus* and *Nemachilus persa* only in the more northern streams, although the former is common all over Persia.

Most of the fish procured were taken by means of poison, a method of fishing which, so far as its efficiency and unsportsmanlike character are concerned, is second only to the method of fishing with dynamite. A mixture of flour and the pounded berries of *Cocculus indicus* is mixed with sufficient butter to make a stiffish paste. A backwater or reach where the stream does not flow too rapidly is then ground-baited with small pellets of the paste. If the fish are feeding, the poison will begin to work in about ten to fifteen minutes; and the poisoned fish will

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* 'Proc. Roy. Geographical Society,' vol. xiv. pp. 504–523.

begin to swim in small circles at the top of the water, and may be taken in a landing-net. Many which have eaten much of the poison will swim into the bank and lie helpless in the shallow water. If the river is at all full of fish, a great number may be caught with a surprisingly small quantity of poison. On September 9 I mixed about six ounces of the poisoned paste and ground-baited the Tatawa Chai near Sūjbulak. We took 38 Capoëta and chub of five ounces and upwards, and both sides of the river were silvered by lines of poisoned smaller fish for a distance of about a hundred yards.

The fish which have not eaten much of the poison gradually recover, and regain the power of coordinating their movements. The dead fish which are too small to be worth picking up by the villagers, who always turned out in crowds at the mere mention of fishing, are soon devoured by the crabs. If the poisoned fish be carefully cleaned, they have no bad effect when cooked and eaten.

The large rivers which flow into the lake from the southern end —the Djaghatu Chai, Tatawa Chai, and Gader Chai—are stated by the natives to contain "whales" whose ancestor swallowed Jonah. The "whales" turned out to be *Silurus glanis.* They are caught either by being driven into nets or by the gaff. A Jewish fisherman accompanied me to a place near Ocksa, where the Gader Chai has cut a deep channel under a bank overgrown by willow-trees. After divesting himself of all needless clothing, he dived into the deep water with his gaff, and hooked about among the willow-roots at a depth of about 4–5 feet. After eight minutes he succeeded in gaffing a large female Silurus 3 feet 9 inches in length, and before a quarter of an hour had elapsed he had three fine fish out on the bank. He told me that the largest "whale" he had ever seen was about five feet long. They spawn in deep pools below the willows, where the water runs slowly, about one and a half months after the melting of the snow. The Silurus is eaten by Armenians, but is unclean to Jews and Mahomedans on account of the absence of scales on its body.

I was informed that the Governor, when he wishes to do honour to a guest, organizes a "whale" hunt, and all the villagers assist at the "tamasha." The buffaloes of several villages are turned into the river and are made to walk upstream for a couple of miles, with the result of driving the fish before them. At a suitable place, a line of men with nets stand prepared to catch all fish driven in their direction; and in this way several hundred "whales" may be caught amid the din of the exhortations of the enthusiastic onlookers, who often cannot refrain from rushing into the water and from joining their struggles with those of the splashing fish.

Invertebrata.—The most conspicuous member of the freshwater invertebrate fauna is the freshwater crab, *Telphusa fluviatilis*, which may be found under stones in burrows, part in and part out of the water. Always on the look-out for carrion, these scavengers were frequently seen trying to drag poisoned fish from the margin of the stream to some more retired nook in the deeper water.

In clear spring-beds *Gammarus pulex* was often met with, but *Asellus* seemed to be entirely absent; and by its absence the pond-life afforded a very striking contrast to that of Europe within the range of *Asellus*. Leeches and planarians were common.

My small collections of terrestrial invertebrata have been examined by Messrs. Edgar Smith, Butler, Pocock, Burr, and Sir G. Hampson, and are described below.

The traveller in Persia is always interrogated about "insect" pests, and consequently a few words upon them may not be out of place. Mosquitoes are painfully abundant in the Araxes plains both in Russian and in Persian territory. I was not troubled by them at all in August and September, either at Urmi or in any of the villages at some distance from the lake, although I always slept on balconies or housetops without any protection to the face. On the other hand, in the country near the lake, as at Superghan and Ardishai, they are said to be intolerable during September.

The much-dreaded *Argas persicus* is not rare, but its venomous bite does not appear to be followed by the fatal or fabulous consequences often attributed to the bug of Mianeh, where, according to Maurice Kotzebue, a victim "éprouva bientôt dans tout son corps une chaleur violente, tomba dans une espèce de délire, et expira enfin au milieu d'épouvantables convulsions." The native cure is the application of the still smoking skin of a newly-flayed ox to the seat of the evil.

Scorpions are common, but are rather local. Many Persians are familiar with the old story of the scorpion which, when surrounded by a circle of live coals and unable to escape, stung itself in the head. Dr. Wills ('The Land of the Lion and the Sun,' 1891, p. 249) even asserts that he has witnessed the suicide of fire-girt scorpions on more than one occasion. Unfortunately Dr. Wills does not designate the particular kind of scorpion with which his experiments were performed. A solitary experiment of my own, made with *Buthus caucasicus* subsp. *persicus* at Maragha, proved as unsuccessful as those which were undertaken by Prof. Ray Lankester.

The sting of scorpions is greatly feared, and peculiar precautions are taken against them in many places. Many stories are told of deaths attributed to scorpions, but it is always difficult to ascertain whether the venom was the sole cause or merely an accompanying complication. However, it is certain that scorpion stings are better avoided. In some parts dried thistles, spread loosely under the beds, are employed in order to keep scorpions away: indeed, many of the mountain folk of Kochanes hold that a goat-hair blanket will suffice for this purpose; since scorpions have such a tender skin on their stomach that if they can be made to walk over the hair of a goat, they will receive a "mortal wound."

Mimicry.—On August 19 I noticed some interesting cases of what appeared to be protective coloration. Near the spot where the Shaher Chai leaves the hills and enters upon its course across the plain of Urmi, numerous poplar trees have been planted. The bark of the *Populus alba* is on the whole of a grey colour, the ground being dark and sprinkled with light-tinted, almost white stippling. Upon the bark of the trees were several species of insects which so exactly mimicked the bark upon which they were sitting that it was extremely difficult to distinguish them from their background (Pl. 27. fig. 1). The insects found upon the poplar bark were *Yponomeuta padellus*, L., *Pentatoma baccarum* (?), and *Bathyoscopus poceilus*, H.-Sch. There were also numerous spirally coiled shell-like larva-cases or cocoons of *Apterona crenulella*. No other insects except ants were seen. The *Pentatoma*, with its grey speckled thorax and wing, and with its antennæ barred alternately white and black, was more invisible against the grey bark than its emerald-green relative was upon the fresh green leaves of herbaceous plants near the stream.

Seir.—The chief locality in the hills at which collections were made was near the small village of Seir, 5–6 miles W.S.W. of Urmi. It is situated at a height of some 1460 feet (*Loftus*) above the level of the lake, on the eastern slopes of the Seir Dagh. Here a gravel, conglomerate and sandstone hill rises to a height of 7260 feet above sea-level; its strata dip to the east and overlie the limestone of the plain of Mergawar. From Seir there is a fine view over the wide cultivated plain of Urmi to the deep blue lake, interrupted only by the triple-crested Bezau Daghi and the conical hill of Superghan; and when the mountains on the further side of the lake are covered with snow, the prospect must be indeed superb. Here, as it were on the dividing-line between the rich cultivation of the plain of Urmi and the barren wildness of the Kurdish hills, the Christian Missionaries seek the healthful fresh mountain air when the noisome summer heats of the city become unendurable, and exchange an artificial environment for a natural one.

The hillsides have been dissected by the rain-water torrents, and many a section has been laid open for geologists. The uncompacted sands and gravels which intervene between the more coherent conglomerates and sandstones are rapidly removed by the spring torrents, and the compacter rocks fall away and litter the stream-beds with great boulders which may measure a score of feet square and half as many through.

The pebbles in the conglomerates, consisting of both igneous and calcareous rocks, have not as a rule been very thoroughly rounded, and therefore appear to be of a fluviatile rather than of a sea-worn origin. I was quite unable to discover any organic remains coeval with the conglomerates; but many of the pebbles are of older, fossiliferous formations. Especially abundant were limestone fragments containing three or four species of corals, while others with shells were occasionally met with. The igneous rocks consisted of granites and felsites.

Seir Vegetation.—In August the vegetation covering the hillsides above the village of Seir was burnt to a dull yellow hue by the summer drought. It was always a subject of wonderment to me how flocks and herds pasturing on such barren-looking slopes could manage to pick up a living. Earlier in the year the hillsides are green and gay with white and pink crocuses and irises; but in August the most conspicuous plants were large blue thistles, dwarf yellow hollyhocks, yellow-green euphorbias, not unlike our own species but larger, and yellow everlastings, and here and there a few Daphne bushes*.

I am indebted to Dr. O. Stapf, the authority on Persian Botany, for the identification of the following species. The list has no pretence to completeness; it is merely intended to give an idea of the general aspect of the flora in the latter half of summer:—

Farsetia suffruticosa, DC.
Scabiosa olivieri, Coult.
Cephalaria sp.
Xeranthemum squarrosum, Boiss.
Helichrysum armenium, DC.
—— *aucheri*, Boiss. (?).
Centaurea virgata, Lam., var. *squarrosa.*
Lactuca orientalis, Boiss.
Campanula sp.
Podanthum sp.
Acantholimon sp.
Odontites aucheri, Boiss.
Ziziphora clinopodioides, M. B., var.
—— *rigida*, Boiss.
Thymus kotschyanus, Boiss. & Hoh.
Teucrium polium, L.

In moister situations on the sides of a small stream from a spring were:—

Glycyrrhiza glabra, L.
Eryngium billardieri, Laroch, var. *meiocephalum*, Boiss.
Echinops sp.
Pulicaria dysenterica, Gaert., var. *microcephala*, Boiss.
Centaurea solstitialis, L.
—— *virgata*, Lam., var. *squarrosa.*
Mentha tomentosa, Urv.
Marrubium crassidens, Boiss.
Euphorbia cheiradenia, Boiss. & Hoh.
Daphne acuminata, Boiss. & Hoh.

Seir Zoology.—Foxes are said to be common in the valleys near Seir. The only individual which I saw was of a much paler colour than our English species.

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* Of the bulbs from Seir which have reached this country alive, *Puschkinia scilloides* is the only one up to the present time which has flowered.

Wolves occasionally visit the villages by night, when they are received like Kurds, with gunshots fired in no particular direction from the roofs of the houses.

Two bats (probably *Rhinolophus hipposideros*, Bechst.) were seen flying about the houses in the evening.

The birds most in evidence were magpies, hoopoes, small insectivorous hawks which nest in great numbers in the higher trees in the city, tits, and numberless sparrows. In the hills a few coveys of the red-legged partridge are to be seen, but they are difficult to approach. Quails frequent the cultivated fields and are taken by hawking, a very popular and fashionable amusement in Persia. Quails are also caught by taking advantage of their stupid curiosity. The fowler and his assistants walk out into the field where the quails are supposed to be and hold up a large white sheet, often decorated with painted snakes, birds of prey, or other unpleasant but conspicuous creatures. The inquisitive quails cautiously walk towards the lure, and finally approach near enough for the patient fowler to put a net over them.

Testudo ibera is common in the dry torrent-beds on the hill-sides. I examined about a couple of dozen and found only three which were free from parasitic Acari, which Mr. A. Michael has kindly identified for me as *Rhipicephalus simus*, or *sanguineus*. The parasites are always attached to parts where they are in no danger of being rubbed off. One tortoise had four of these bloodsuckers, one in the "armpit" of the right hind foot and three on its tail.

Neither lizards nor snakes were as common as I should have expected. *Phrynocephalus* seemed to be unknown to the natives, who, however, described a lizard which seemed to be *Stellio caucasicus*. *Eremia* was fairly abundant.

A list of the insects collected at Seir is given on p. 408. The general character of the Lepidoptera struck me as being remarkably European at first sight; but many of the species exhibit a rather more sandy or desert type of coloration. In the early morning the blues were extremely common on the *Mentha tomentosa* growing near the little stream, ½ mile to the S.W. of the village. Several fell a prey to the voracity of a large black-and-yellow spider (*Lycosa*). The only beetles which I obtained were *Julodis lævicostatus*, L. & G., and *Lixus bardanæ*, F., covered with yellow pollen. The higher slopes of the hills were poor in butterflies during the middle of the day, but rich in

Orthoptera (*Decticus* and *Œdipodidæ*), which, almost invisible when at rest, used to get up in blue clouds before the feet of our horses. Towards evening many wall butterflies come out of their hiding-places under stones and fly about during the short twilight.

Mole-crickets (*Gryllotalpa gryllotalpa*, L.) are common in the moister localities. Ants and ant-lions are to be found up to a height of 6000 feet.

List of Animals distinguished by special names by the Syrians living in the Urmi Basin.

In the compilation of the following list I owe much to my interpreter friends, Shamasha Josip of Superghan and Pepino Sadok or "Popina." The list is confined to those animals with which my informants professed to be personally acquainted, and will enable the reader to form some idea of the state of their zoological knowledge, even though the English equivalents of many of the names are very doubtful. My heartiest thanks are due to Professor Margoliouth and to his talented wife for their help in the revision of the list and in the identification of the languages to which the words belong, whether Old Syriac (O.S.), Neo-Syriac (N.S.), Armenian (Arm.), Arabic (Arab.), Persian (P.), or Turki (T.). (Stoddard) indicates that the word is to be found in his Modern Syriac Vocabulary, of which the manuscript is now in the possession of Professor Margoliouth.

MAMMALIA.

Bat	praka lélé, O.S.; *lit.*="flier by night."
Cat	catou, Arm.
Leopard	nemra, O.S.
Dog	kalba, O.S.
Otter	kalba dmia, O.S. "Water dog."
Wolf	deva, O.S.
Fox	tala, O.S.
,,	vachaque, P.
Bear	débba, O.S.
Badger	kouja, N.S. (Stoddard).
Hyæna	hotare. Rare in plain of Urmi, common at Mosul.
Hedgehog	kadouda, koutoulta, koubda. (?=the name of a bird.)
Squirrel	sennara.
Mouse	ukb'ra, O.S. (?=jerboa.)
Water-rat (?)	kora mechk.
Gerbillus or Dipus	kaecha.
,,	garoun.
Hare	kirviche, N.S. (Stoddard).
?	qara bache. "Black head," T. (Perhaps the caracal, or desert-lynx *.)

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* According to Prof. Blochmann our word *caracal* is derived from the Turki *qara-qolaq*, signifying "black-ear."

Bull	tora, O.S.
Buffalo	kalla, N.S. (Stoddard).
Sheep	vana, O.S. Generally *Ovis steatopygus.*
,, wild	vana dtoura, O.S.
Lamb	péra, O.S., N.S. (Stoddard).
Goat	aza, O.S.
,, mountain	aza dtoura, O.S.
Deer	khzura.
Camel	gamla, O.S.
Hog	surni, O.S.
Horse	sussya, O.S.
Donkey, ass	khmara, O.S.
Mule (Horse ♀ × Ass ♂.)	cavédna, O.S.

AVES.

Eagle	nishra, O.S. =Persian bargut.
Hawk, ? sp.	bashuka, Arab.
Falcon	tocha. =Persian bahri. (See below, bahra.)
,,	nessa, O.S.
Falco venaticus	djoudjna, P.
Lanner	baziqa, P.
Sparrow-hawk	baza, Arab. =Persian báshá.
Goshawk	tarlane, N.S. (Stoddard). Used for hawking; =Persian taigun, and tarlán male and female.
Owl	buma, Ar. or O.S.
Goldfinch	sagga, Arab.
Nightingale	andali, Arab.
Thrush	khazel.
Hoopoe	vadvade.
Lark (?)	djidjerta.
Blackbird	shoukrta. *Cf.* shakhroura, O.S.
Fire-crested Wren.	gorguma, P.; azel doukbé, P.
Raven	ourva, O.S.
?	djara.
?	djekha. *Cf.* djakha, below.
Swallow, Swift	snonita, O.S.
Cuckoo	koukou.
Pigeon	kavédare.
Turtle-dove	shoufnina, O.S.
Pheasant (?)	djourda, P.
Partridge	qiqvana, N.S. (Stoddard); qaqbana in O.S.
,,	zarkha.
Quail	goupshina, O.S.
?	kheta, déchta. "Hen of the plain."
Stork	laqlaq, Arab.
Flamingo	smouqta, baqlane, O.S.
Pelican	qotan qaqa, O.S.
Gull	qakhouka, NS. (Stoddard).
,, (?)	sevanoga, Arm. =blackbird.
Duck	tona.
,,	ourdak, T.
,,	jandja.
Goose	gaza, T.
Wild Goose	laqlaq quissé.
Swan?	qiqanousse.

The following Bird names are of uncertain signification:—juka; kourta; dédé, or korkore; sissiarek; djarguna; métlédérou; shagra; djita; marïa toré; poupou; bahra; djoulourda; djapdgepa, N.S. (Stoddard) ("flapping wings"); chavere chagane, O.S.; shavere balga, O.S.; souravéle; gatou margué ("cat of the marsh"); sharvélta, gaza lake; garkha diama; khazel, separmari; jeho; gogtatan; djaroura; alidji; djelkima; kadare; angourte; djakha, P. (sparrow or owl); hogare; vaga, P.; metloue.

REPTILIA.

Lizards belonging to various genera: Eumeces, Phrynocephalus, &c.	masousta, N.S. (mésazé in Stoddard).
	jdelourin.
	mgadia goudayé.
	kémkéma.
Snake	khouvé, O.S.
„	khouvé dkanouchta, O.S. "Serpent du ballet," grey, poisonous.
„	api. (?=hyæna.) Said to bleat like a goat.
„	jira mar. Long, thin, crawls very fast.
„	khélda. Very poisonous.
„	soïa. Pointed head, creeps in a straight line.
Tortoise	qaraïa, N.S. (Stoddard).

AMPHIBIA.

Frog	piqqa, paqé, N.S. (Stoddard).

PISCES.

Fish with barbels.	nuna oursa. "Male fish," with moustaches.
Fish without barbels	nuna niqua, O.S. "Female fish," without moustaches.
Silurus glanis	naqe, N.S. (Stoddard). "Whales," occur at Solduz.

INSECTA.

Insects	bajouji (or rakhsha), N.S. (Stoddard). From rkhish, to creep.
Caterpillar	terterra, N.S. (Stoddard).
Locust, Cricket, or Grasshopper	kamsa, O.S.
Mole-cricket	qerwâ khmarē (lit.="Ass's scorpion").
Earwig	karsu.
Flea	perta'né, O.S.
Myriopods	madala, O.S.
Fly	didwa, N.S. (Stoddard).

ARACHNIDA.

Spider	zakra gardē, O.S., shikrā dmaiâ.
Scorpion	agerwa, O.S.
Galeodes	harapasse. ="Reptiles" in O.S.

CRUSTACEA.

Crabs, Crayfish	kėdjala.
Woodlouse	'arsha.

VERMES.

Intestinal worms	kurkana, N.S. (Stoddard).
Leech	zalu.
Earthworm or Long worm.	sektéara, O.S., or sikta dar'â. *Lit.*, a pointed stake or ploughshare of the ground in Old Syriac.
Hairy worm	spadita dkhouvé, O.S. Spadita is derived from O.S. word for "pillow."

The Wild Sheep of the Urmi Islands.

By Dr. A. Günther, F.R.S., P.L.S.

(Plate 22.)

A cranium in tolerably good condition with the skin and hairs adhering to the face and forehead, with perfect horns, but without lower jaw, was picked up on Koyun Daghi, the largest island of the Urmi Archipelago. The head is that of an adult ram. There is no other wild sheep (at least not in the very rich collection of the Natural History Museum) to which this head comes nearer, as regards size of cranium and form of the horns, than the Cyprian Mouflon (*Ovis ophion*). Yet there is a striking difference in the sweep and direction of the horns; but without further information it would seem to me premature to introduce this sheep as a distinct species. It certainly must appear very singular that a sheep from a lacustrine island of Western Persia should be more nearly allied to the distant and local form from Cyprus, than to the typical *Ovis orientalis* which is reported from the Elburz and Armenian mountains* and other parts of Asia Minor.

Ovis ophion, var. urmiana.

I have no materials to demonstrate any craniological characters by which this form may differ from either *O. orientalis* or *O. ophion*, but the size of the skull (and by inference of the whole animal) may be conceived from the following measurements:—

	millim.
Distance between end of intermaxillary and upper rim of occipital foramen	230
Distance between end of intermaxillary and palatal notch	120
Length of molar series	65 and 69
Distance between the two series in front	15
" " " behind	50
Distance between lower rims of orbits	125
" " styloid processes	63
Greatest width of occipital condyles	57

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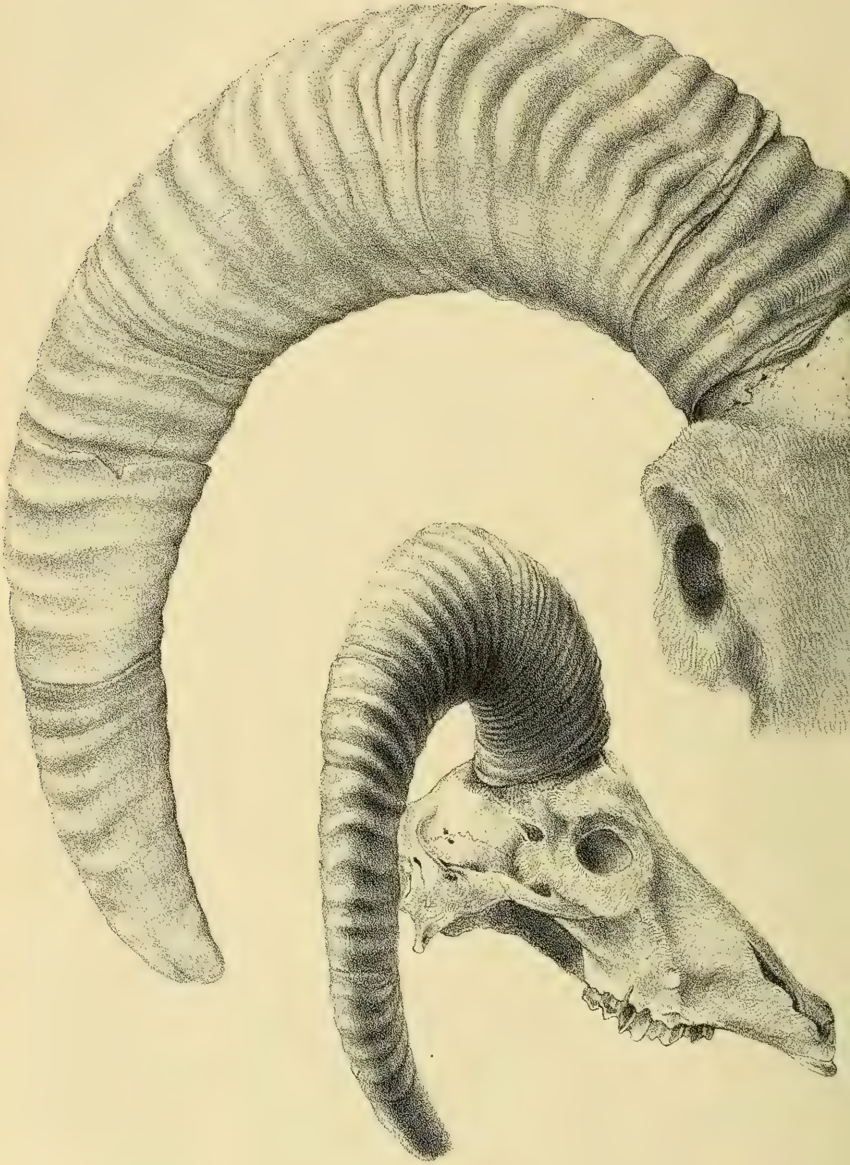
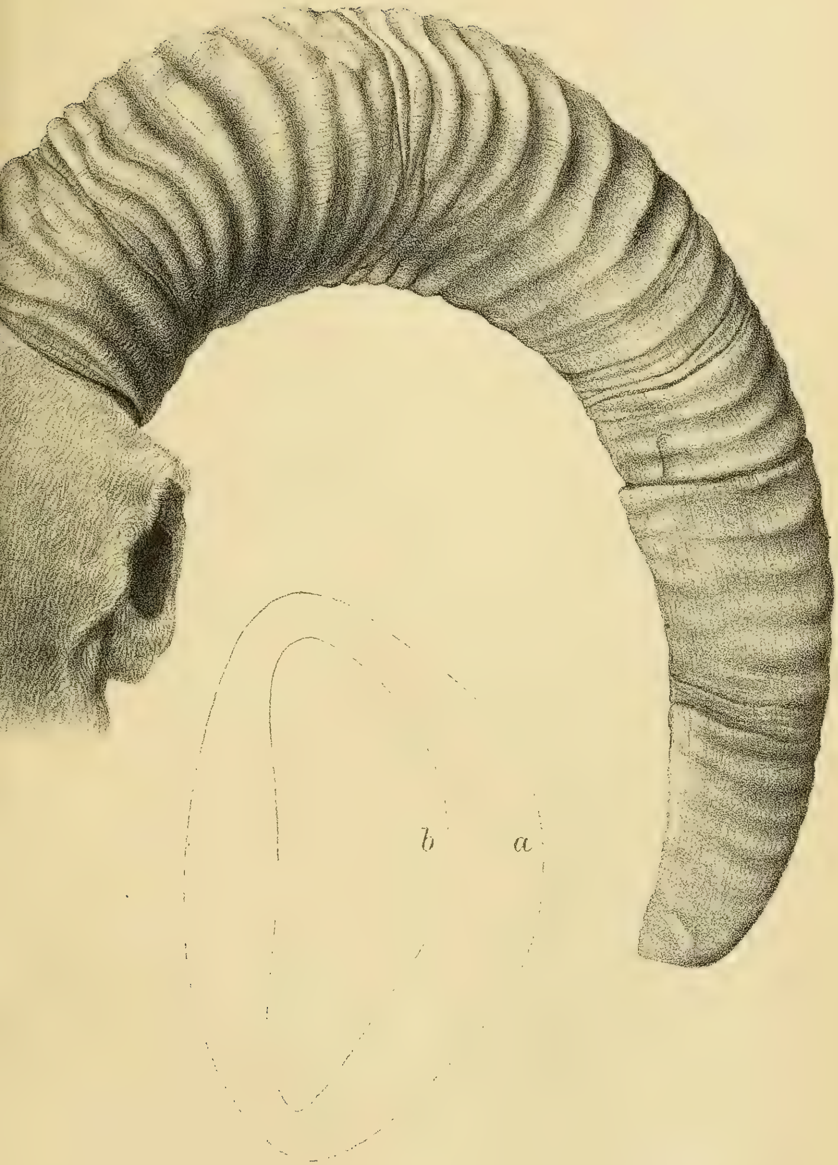
* W. T. Blanford, 'Eastern Persia,' ii. p. 88; Danford & Alston, Proc. Zool. Soc. 1880, p. 55.



J. Green del. et lith.

OVIS O



RMIANA.

Mintern Bros. imp.

J Green del et lith

[illegible]

Mintern Bros. imp.

The horns are bent outwards in a regular curve, describing a semicircle, without any trace of that spiral twist at the extremity which seems to be constant in the adult Cyprian Mouflon; in fact the whole of their posterior surface, which is broad and flat (or partly concave), lies in the same plane; and the horns are so little turned backwards, that this plane would make an angle of about 70° with a plane vertically bisecting the cranium. The horns measure round the outer curve 500, round the inner 305 millim., their circumference round the base being 190 millim. and the distance from tip to tip 360 millim. They are remarkably flattened and compressed in a vertical direction, with an obtuse upper and a sharp lower ridge; a fronto-orbital ridge, which I observe to be still very distinct in *O. gmelini* and *O. cycloceros*, has nearly disappeared on the left horn, and is very obtuse near the base of the right horn. A transverse section through the left horn about two inches from the base would represent one half of an irregular oval (fig. *a* on Plate 22), and one about the middle of the horn would be still more compressed (fig. *b*). The end of the horn is almost knife-shaped. The transverse wrinkles are blunt, coarse, and rather distant. Besides these transverse wrinkles, there are at irregular intervals five deep grooves penetrating through the substance of the horn, and dividing each horn into six sections of unequal length. These grooves are, as regards position, perfectly symmetrical on both sides, and evidently indicate periods of growth (probably annual); and if this be the case, the skull would be that of an animal six or seven years of age. The terminal (oldest) section measures (along the middle) 70 mm., the next 70 mm., the third 40 mm., the fourth 115 mm., the fifth 75 mm., the sixth (during which the animal was killed) 33 mm. Abundance or scarcity of food, or other physiological causes, may account for the want of regularity in the growth of the horn.

No trace of the fronto-orbital ridges is visible on the bony core, a transverse section of which represents one half of a regular oval.

The colour of the hair attached to the head is now a uniform light isabelline, but no importance can be attached to this, as the colour may have been bleached by exposure; the horns are also similarly bleached, traces of the normal dark colour being still visible in some parts.

If the specific limits of the Asiatic Mouflon (*Ovis orientalis* s. *gmelini*) be so far extended as to include the Cyprian Mouflon*, our sheep should be named *Ovis orientalis,* var. *urmiana*; but in the present very fragmentary state of our knowledge of the wild sheep of Western Asia, I think it best to associate it with the Cyprian Mouflon, to which it seems to be more closely allied than to any of the other forms from Asia Minor.

THE PLIOCENE MAMMALIA OF THE BONE-BEDS OF MARAGHA.

By ROBERT T. GÜNTHER, M.A.

On arriving at Maragha my first enquiries were about the fossil bones found in the neighbourhood. I stayed at the house of Quasha Mushi, a Christian preacher, who informed me that he had already excavated and despatched 14 loads of Mammalian bones and two boxes of other stones (? Jurassic fossils) to Dr. Pohlig at Vienna. He also told me that his palæontological researches had been stopped by a suspicious government who believed that all digging was for hidden treasure, and therefore was an illicit interference with the rights of the mineral monopolists.

On Sept. 5th I started soon after sunrise on a three-hours' ride to Kirjawa, the village nearest the bone-beds. The road from Maragha crossed a succession of gravelly hills largely composed of pebbles of andesites of varying basicity, from hornblende-andesite to basalt, which shortly before Kirjawa are succeeded by hills of pumiceous tufa. Mr. Prior, who has been kind enough to examine my specimens, assures me that this volcanic deposit is remarkably similar to the tufa of the bone-beds at Samos of similar age.

During the day the villagers and myself were able to pick up the bones in the following list. In their identification I have been greatly helped by the experience of Dr. C. I. Forsyth Major, who has recently studied the contemporaneous fauna of Samos. I am glad to take this opportunity of thanking him for the kind way in which he interrupted his other researches to help on mine. The species in *italics* have been described from Maragha by other palæontologists †.

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* A view taken by Lydekker in 'Wild Oxen, Sheep, and Goats.'

† *Cf.* Forsyth Major, 'Le Gisement ossifère de Mitylini.' Lausanne, 1894.

MAMMALIA.

CARNIVORA.

Hyæna eximia, Roth. et Wagn.
Ictitherium hipparionum, Gaudr.
Meles maraghanus, Kittl.

ARTIODACTYLA.

Fam. ANTILOPIDÆ.

Gazella deperdita, Gaudr.
Gazella brevicornis. Horn-core.
Prostrepsiceros (?) sp.
Tragoceros amalthæus, Gaudr. Upper left m^1, m^2.
Palæoreas lindermayeri, Gaudr.
Antilope sp. Right upper molar. Metacarpal about 1 ft. 2 in. in length.
Palæoryx pallasii, Gaudr.
Protoryx longiceps, Maj.
Protoryx gaudryi, Maj.
Helicophora rotundicornis, Weith.

Fam. OVIDÆ.

Criotherium argalioides, Maj. Left upper m^3.

Fam. GIRAFFIDÆ.

Samotherium boissieri, Maj. 2 calcanea.

Fam. SUIDÆ.

Sus erymanthius, Roth. et Wagn. Right upper molar.

PERISSODACTYLA.

Fam. EQUIDÆ.

Hipparion mediterraneum, Hensel. 14 upper molars and premolars; 5 lower molars and premolars; 1 incisor; right and left astragali; fragment of splint bone.

RHINOCEROTIDA.

Rhinoceros sp., probably blanfordi, Lyd. Fragments of teeth and of lower jaw; patella.

PROBOSCIDEA.

Fam. ELEPHANTIDÆ.

Mastodon pentelici, Gaudr. et Lart. Molar.
Mastodon sp. Tusk.

EDENTATA.

Orycteropus gaudryi, Maj.

It will thus be seen that the presence of *Tragoceros amalthæus*, Gaudr., at Maragha is confirmed, and that the known fauna has been enriched by the discovery of a sheep which Dr. Major considers identical with his *Criotherium argalioides* from Samos, and of which there is an exceedingly fine skull in the British Museum. The presence of *Gazella brevicornis* is also indicated.

The bones are well preserved in a deposit of light brown pumiceous tufa, stratified in horizontal beds of unequal hardness, but they are difficult to get out entire without fracture. The village people regard the Mastodon bones as the remains of the big men who lived before the flood; but the chief man of the village classified the bones under the heads elephant, deer, swine, unicorn, and "dēvy," or men with horns like genii.

REPTILIA AND AMPHIBIA.

By G. A. Boulenger, F.R.S., F.Z.S.

LACERTILIA.

1. **Phrynocephalus helioscopus**, *Pall.*

Khoi: 1 specimen. North of Lake Urmi: 2 specimens.

These specimens agree with the Persian variety described by De Filippi and by Blanford under the name of *P. persicus*, having a pair of pink spots, edged with blue, on the nape. One of the specimens from L. Urmi differs, however, from Blanford's description of *P. persicus* in having the larger scales along the spine bluntly but very distinctly keeled. The large series preserved in the British Museum removes all doubts as to the specific identity of *P. persicus* with *P. helioscopus*. The bright nuchal markings are often present in Central-Asian examples.

An excellent description of the coloration from living specimens has been given by L. v. Méhely, Zool. Anz. 1894, p. 82; but I can see no sufficient ground for the establishment of his var. *Horvathi*.

2. **Lacerta viridis**, *Laur.*

Bash Nurashin, Sept. 23.

A young specimen of the var. *strigata*, Eichw.: uniform dark olive-brown above, with five yellowish-white longitudinal lines. Ventrals in 6 longitudinal series; 38 scales across the body; 17 pores under each thigh.

3. **Ophiops elegans**, *Ménétr.*

Numerous specimens of the typical form, all with two superposed postnasals. Considering the wide range of variation of the numbers of scales and femoral pores, it may be of interest to record the figures occurring on the specimens collected by Mr. Günther. Under A is given the number of scales round the middle of the body, ventrals included; under B the number of femoral pores on both sides.

	A.	B.
Arzu Island, ♂	33	9–9
„ „ ♀	31	8–9
„ „ yg.	32	9–8
„ „ „	32	8–9
Shazalan Island, ♂	33	8–8
Sujbulak, ♂	34	11–12
St. George's Hill, Superghan ♂	31	10–10
„ „ ♀	31	11–10
„ „ ♀	35	10–10
Between Superghan and Urmi, ♂	33	8–8

	A.	B.
Seir, ♂	33	10–11
„ ♂	32	10–10
„ ♂	32	12–12
„ ♀	30	9–9
„ ♀	31	10–11
„ yg.	32	10–11
„ yg.	34	10–10
Kirjawa, ♀	30	9–9
„ yg.	34	10–10
„ yg.	32	10–10

4. MABUIA SEPTEMTÆNIATA, *Reuss.*

A single half-grown specimen from Koyun Daghi.

34 scales round the body, dorsals indistinctly tricarinate. As in one of the Persian specimens in the British Museum (Teheran), the four black dorsal stripes of the typical form are present on the nape, whilst on the back they are broken up into spots.

5. EUMECES SCHNEIDERI, *Daud.*

Two specimens from Koyun Daghi agree entirely with the typical, widely distributed form, as figured by Anderson in his 'Reptiles of Egypt,' pl. xxv. Greyish olive above, with small orange spots and an orange lateral streak. 28 scales round the middle of the body. The distance between the end of the snout and the fore limb is contained once and four-fifths in the distance between axilla and groin.

A remarkably large specimen from Vizastra (17 centimetres from snout to vent) is brownish above, without orange spots, but with a darker dorsal stripe occupying the two median rows of scales, and a still darker stripe, two scales wide, on each side above a yellow lateral streak which extends from the mouth, through the ear, to the hind limb. The body is more elongate, the distance between end of snout and fore limb being contained twice in the distance between axilla and groin; and there are but 24 scales round the body. This lizard approaches the form figured by Geoffroy in the 'Description de l'Égypte,' Rept. pl. iii. fig. 3, of which we have a specimen from Jerusalem in the British Museum, and agrees with specimens from Cyprus (*Scincus cyprius*, Cuv.), Transcaspia, and Persia.

A young specimen from Shazalan Island (73 millim. from snout to vent) agrees in the proportions and the number of scales (28 round the body) with the Koyun Daghi examples, but the back is marked with four blackish stripes, in addition to which every other scale in every longitudinal series bears a central yellowish spot. This system of coloration is closely approached by that of a young specimen from Jerusalem in the British Museum, which differs only in having a blackish line bordering the belly below the yellow lateral stripe.

A study of the juvenile livery of this species would be a great help towards the establishment of geographical varieties; but it is a most curious, and to me unaccountable fact, that young specimens of the common Palæarctic *Eumeces* are extremely rare in collections. I have only seen three of *E. Schneideri* and not one of *E. algeriensis*.

OPHIDIA.

6. Eryx jaculus, *L.*

A single specimen from Seir, near Urmi. It agrees in every respect with the typical or Western form, the habitat of which is known to extend from Greece and the Ionian Islands to Lower Egypt and Persia; the Eastern form, var. *miliaris*, with smaller head-shields, inhabiting Transcaspia, Turkestan, and Afghanistan. The Urmi specimen has 5 scales between the eyes, 3 between posterior nasal and eye, 9 round the eye, and 9 upper labials on each side. 48 scales across the thickest part of the body. Ventrals 186; subcaudals 18.

7. Tropidonotus tessellatus, *Laur.*

Eastern shore of L. Urmi, Seir, Maragha. Four specimens.

This is a common and widely-distributed snake; but one of the specimens is of interest in having the upper labials almost excluded from the eye by the suboculars, merely the point of the fourth labial penetrating between the latter. Specimens of this species may probably turn up some day with the labials entirely excluded from the eye, as in *Tropidonotus ferox*, *anoscopus*, and *cyclopium*.

BATRACHIA.

8. Rana esculenta, *L.*

Several specimens, half-grown, young, and larvæ, belonging to the var. *ridibunda*, Pall. Ocksa, Superghan, Maragha, Kirjawa.

9. Rana Camerani, *Blgr.*

Banda, Urmi River. Two young specimens.

10. Bufo viridis, *Laur.*

A young specimen from Sujbulak and several tadpoles from the town-ditch at Urmi.

11. Hyla arborea, *L.*

Several specimens, half-grown, young, and larvæ, belonging to the var. *Savignyi*, Aud. Bash Nurashin, Urmi town, Banda, Superghan; also a young specimen from Lake Urmi, "in salt water."

The tadpoles have the black lines on the muscular part of the tail to which attention has been drawn by Camerano.

12. Pelobates fuscus, *Laur.*

Three large tadpoles from Superghan, one with well-developed limbs. This species was known to occur at Lenkoran on the Caspian, but had not yet been recorded from Persia.

FISHES.

By Dr. A. Günther, F.R.S., P.L.S.

(Plates 23 & 24.)

The general character of the Freshwater-fish Fauna of Western Asia, as a part of the Europæo-Asiatic region, is well known through the researches of Russell, Heckel, de Filippi, Keyserling, Kessler, Radde, Lortet, Sauvage, and myself[*]; and in this respect the small collection from the Urmi basin does not contribute any additional facts of great novelty. On the other hand, our acquaintance with the local faunas of the various districts of Western Asia is more or less fragmentary, and a comparative study of the several species of which they are composed is a great desideratum. Of the Fish-fauna of the Urmi district we had no positive knowledge whatever; and the materials available at present for a useful direct comparison of the species inhabiting the rivers which take their rise in the Kurdistan and Armenian mountains, viz., the Tigris, Euphrates, Kur, Araxes, and the Lake Van and Urmi rivers, are extremely scanty and insufficient for the purpose.

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[*] Consult more especially H. E. Sauvage, "Notice sur la Faune ichthyologique de l'Ouest de l'Asie," Nouv. Arch. Mus. vii. 1884.

In the consideration of the Urmi fauna we have to bear in mind that the rivers of this basin do not communicate with the sea, and, consequently, that migratory fishes are absent: like the Jordan, they are not inhabited by shad, eel, sturgeon, or lamprey. Neither is there direct communication between the rivers themselves in spite of the close proximity of their mouths, the water of the lake being of such concentrated salinity as to prevent the passage of fish from one river into another. Such an isolation of the inhabitants of the several rivers must have been a favourable factor for the development of differential specific characters. The great severity of the climate in winter will account for the absence of warmth-loving types such as *Cyprinodon*.

If we are permitted to draw conclusions from so small a collection, we may say that the fauna bears distinctly the character of that of Central Europe, so far as the genera are concerned (with the addition of *Capoëta*); and although the majority of the species seem to be sufficiently differentiated local representatives, two of them, namely, the Silurus and Chub, are identical with the European forms. Probably further investigations may reveal the presence of certain other fishes, such as stickleback, trout, *Rhodeus*, which Mr. Günther has not been able to find; but the fish-fauna as a whole is certain to prove to be poor in species, much poorer than that of the Kur and Araxes, to which, however, it is most closely allied, as is evidenced by the identity (real or supposed) of five out of the ten species enumerated below.

The specimens were collected,—

1. In the Tatawa Chai near Sujbulak, entering the south end of the Lake.
2. In the Gader Chai near Ocksa, likewise at the southern end of the Lake.
3. In the Urmi River (Shaher Chai).
4. In the Nazlu Chai, entering the north-western part of the Lake, at Superghan near the mouth, and at Tergawar in its upper courses.
5. In the Zola Chai, near Ula.

SILURUS GLANIS, *L.*

It might have been supposed that the *Silurus* of Western Persia would prove to be identical with the form which Sauvage *

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* Bull. Soc. Philom. 1882, p. 163; Nouv. Arch. Mus. 1884, vii. p. 19, pl. fig. 1.

has described from the River Kur under the name of *Silurus chantrei*. But this supposition is not borne out by a specimen obtained in the Gader Chai at Ocksa. It is the skin of an adult individual much cut about and without pectoral fins. However, the number of anal rays can be ascertained to be 84, thus nearly approaching in this respect our European *S. glanis*, whilst 65 is the number given for *S. chantrei*. Also in other respects, especially with regard to the composition of the dorsal fin and the length of the barbels, it proves to be a typical *S. glanis*. I have some doubts as to whether *S. triostegus* of Heckel, from the Tigris, can be maintained as a distinct species. The dorsal fin of *Silurus* is a rudimentary organ, and therefore may be expected to vary in the number and development of its rays. Even in European specimens the fourth dorsal ray is not constantly branched, but may be simple and reduced in size, and I have found it so also in a specimen from the Tigris. However, the barbels of Mesopotamian specimens seem to be shorter than in European.

CAPOËTA GRACILIS.

Scaphiodon gracilis, Keyserling, Zeitschr. ges. Naturw. xvii. 1861, p. 9, tab. 4.

Scaphiodon sieboldii, Steindachner, Verh. zool.-bot. Ges. Wien, 1864, p. 224.

? *Capoëta sevangi*, De Filippi, Viaggio in Persia, p. 312 (1865).

Capoëta gracilis, Günther, Fish. vii. p. 80 (1868).

D. 3/8. A. 3/5. L. lat. 53–55. L. transv. $8\frac{1}{2}/6$–7.

The height of the body is one fourth or two ninths, the length of the head two ninths of the total length (without caudal); the diameter of the eye is one fifth of the length of the head and contained $1\frac{2}{3}$ in the length of the snout, and $2\frac{1}{4}$ in the width of the interorbital space. Barbels rather shorter than the eye. Origin of the dorsal fin midway between the end of the snout and the root of the caudal; distance between the first dorsal ray and occiput rather less than that between the last dorsal ray and root of the caudal. Least depth of the caudal peduncle about one half of the length of the head. Third dorsal ray feeble, soft in its terminal portion, and distinctly serrated, the serrature being hidden below the skin. Pectoral rather shorter than the head, not extending to the ventral. Caudal deeply emarginate. Scales in the anal region not distinctly enlarged. Coloration uniform.

This fish was originally described from the neighbourhood of Ispahan, and, if my identifications are correct, at later periods from Amasia (Asia Minor) by Steindachner, and from Lake Gokcha by De Filippi. Thus it seems to have a considerable range in Western Asia, and the present collection contains specimens from Sujbulak, from the Urmi River, and the Nazlu Chai. The largest specimen is 213 millim. long. The species is subject to a considerable amount of variation, not merely dependent on local influences, but apparently quite individual, as it obtains in specimens captured at the same spot and at the same time. In specimens from Sujbulak the cleft of the mouth is quite straight, extending the whole width from side to side, the dorsal spine is very feeble, and the crown of the head flattened. In a specimen from the Urmi River the crown of the head is more convex, the dorsal spine sensibly stronger, the mouth gently crescent-shaped, and there are only six longitudinal series of scales between lateral line and ventral fin. The form of the mouth varies in three specimens from Superghan (Nazlu Chai), from straight to a gentle crescent, and to a distinct crescent; the strength of the dorsal spine is intermediate between the Sujbulak and Urmi specimens, and the longitudinal rows of scales between lateral line and ventral fin varies from six to seven; they have altogether the appearance of being less well-fed than the specimens from Sujbulak. Two specimens from Ula represent a dwarf form with very feeble and indistinctly serrated dorsal spine; the larger, a male, is only 125 millim. long, yet fully mature, with developed testicles and with a seasonal growth of minute tubercles along the whole side of the body.

These fishes, for which I have adopted Keyserling's name, belong to a group of the genus which is distinguished by the feeble development of the dorsal spine and by scales of moderate size. The fishes of this group show a considerable amount of modification of the characters of various organs, such as I have pointed out in the specimens from the Urmi district. Consequently they have been described under numerous specific names; but without long series of specimens with exact localities, it is impossible to form an opinion as to which of these names deserve recognition.

Thus, *Capoëta steindachneri*, Kessler (Izvest. obshchest. Lynbit. estestv. x., Mosc. 1872, p. 47, pl. 6. figs. 3–5, or Fedschenko, Fauna of Turkestan, Pisces, St. Petersb. 1874, p. 7, pl. 1. figs. 3 & 4), seems to be distinguished (if we judge from the figure) from our *C. gracilis* by a greater number of scale-rows between lateral line and ventral fin. It is said to have *one or two* pairs of barbels. The specimens were from the River Sarefschan.

Filippi's description of his *Capoëta sevangi* from Lake Gokcha contains nothing by which we could distinguish this fish from *C. gracilis*. But the fish described and figured under the name of *C. sevangi* by Kessler * is certainly distinct from our *C. gracilis*. As, according to Kessler's investigations †, Lake Gokcha is inhabited by several species of *Capoëta*, we are left in uncertainty as to whether the fishes named *sevangi* by Filippi and Kessler are specifically the same.

Scaphiodon sieboldii, Steindachner, is described from a specimen 133 millim. long. The eye is noted as of somewhat larger size than in our specimens, but the comparative size of this organ is subject to the usual changes with the growth of the individual.

BARBUS CAUCASICUS.

? *Barbus caucasicus*, Kessler, Aralo-Caspio-Pontine Ichthyol., in Grimm, Aralo-Casp. Exped. p. 102.

D. 10. A. 8. L. lat. 90 ‡. L. transv. 13–14/18–20.

The height of the body is contained $5\frac{1}{2}$ or $5\frac{2}{3}$ times in the total length (without caudal), the length of the head $4\frac{1}{4}$ or $4\frac{3}{4}$ times. The diameter of the eye is one half of the length of the snout and two elevenths of that of the head; interorbital space not quite twice as wide as the eye. Anterior barbels a little shorter than posterior, which are not twice as long as the eye. Caudal peduncle longer than deep. Dorsal spine rather feeble, but finely serrated behind, somewhat nearer to the root of the caudal than to the end of the snout, opposite to the root of the ventral. Anal fin not reaching to the caudal. Caudal slightly emarginate, but in young examples (of 110 millim.) the excision is deeper. Pectoral shorter than the head, rounded. Eleven longitudinal

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* "Fish of the Aralo-Caspio-Pontine region," in Suppl. Trans. St. Petersb. Nat. Hist. Soc. 1877, p. 81, fig. 18.

† *L. c.*; Sauvage, Nouv. Arch. Mus. vi. 1884, pp. 5, 22. In the figure of *C. gotschaica* (pl. 3. fig. 3) the scales are represented much larger than in the description.

‡ 90, counting the transverse series above the lateral line; the perforated scales of the lateral line are somewhat larger and irregular, and about 80 in number.

series of scales between the lateral line and ventral fin; pharyngeal teeth 5 | 3 | 1. Sides of the body, dorsal and caudal fins speckled with greyish.

Three small specimens were obtained in the Zola Chai at Ula, and a larger one in Tergawar, in the upper waters of the Nazlu Chai. The latter is 153 millim. long, and presumably young. It shows some larger scales on each side of the vent, and therefore the question arises whether our fishes are the young stage of a species of *Schizothorax*. I have no materials which would assist me in ascertaining whether the peculiar anal sheath of *Schizothorax* is developed with age. The two genera, *Barbus* and *Schizothorax*, are so closely allied that in all probability species exist in which the initial stages of the development of an anal sheath may be traced either as a distinctive specific character or as an individual, more or less abnormal condition.

The determination of these Persian specimens as *Barbus caucasicus* is not by any means satisfactory. I should not have recognized them from Kessler's description, who gives as scale-formula 60, $\frac{11\text{–}12}{8\text{–}9}$, 65, indicating a fish with scales considerably larger; but the Natural History Museum has received from Russian sources, two larger specimens named *B. caucasicus*. These specimens approach the Persian closely enough to be referred to the same species. That collection possesses also specimens of *Barbus ciscaucasicus* and *Barbus goktschaicus*, two other species described by Kessler in the work quoted. These also are most closely allied to *B. caucasicus*, but *B. goktschaicus* has the dorsal spine extremely feeble. I have finally to add that neither of the two specimens of *B. caucasicus* in the Natural History Museum has enlarged anal scales, and that in one of them the anal fin reaches to the caudal, when laid backwards.

Our fishes differ from *Barbus miliaris* (de Filippi, Viaggio, p. 358), from Teheran, in having only 13 or 14 series of scales between the dorsal fin and lateral line, the Teheran species having 18.

GOBIO PERSA, sp. n. (Pl. 23. fig. B.)

D. 10. A. 8. L. lat. 43. L. transv. 6/9.

The height of the body is contained $5\frac{1}{2}$ times in the total length (without caudal), the length of the head 4 times; caudal peduncle slender, but slightly compressed, its greatest depth being two fifths of its length. Snout not greatly elongate, the diameter of the eye being two thirds of its length and one fourth of the length of the head; *interorbital space broad* and flat, its width being a little more than the diameter of the eye. Upper jaw overlapping, but not much projecting beyond the lower; maxillary barbel reaching to the hind margin of the eye. Dorsal fin with seven, anal with six branched rays; pectoral reaching the ventral, ventral the anal. Caudal moderately excised, with pointed lobes. Five series of scales between lateral line and ventral fin. Back and sides irregularly speckled with black; a series of from seven to nine larger ovate spots along the lateral line. Dorsal and caudal rays speckled with black.

Seven specimens, 70 millim. long, from Ocksa in the Gader Chai.

This form of Gudgeon comes nearest to *G. uranoscopus*, having a slender peduncle of the tail, but slightly compressed; and compared with specimens of the same size, it shows a distinctly shorter snout and a greater width of the interorbital space. I have not the means of comparing it with *Gobio kessleri* from the Dniester, which, however, is described as possessing eight branched dorsal rays.

LEUCISCUS CEPHALUS, *L.*

The Chub is one of the most common fishes in the rivers falling into Lake Urmi. Specimens of small and moderate size were obtained at Sujbulak, in the Gader Chai and Urmi Rivers, and in the Nazlu Chai. I consider them specifically identical with the European Chub; their head is equally broad, but rather more elongate or depressed than is usually observed in British specimens. But Continental specimens frequently show the same degree of elongation and the same form as the Persian fishes.

The short description given by de Filippi of his *Squalius turcicus* (Viagg. Pers. p. 359), from Erzeroum, applies very well to these Persian specimens.

LEUCISCUS ULANUS, sp. n. (Pl. 24. fig. A.)

D. 10–11. A. 13. L. lat. 44. L. transv. 8/5.

The height of the body is contained from $3\frac{1}{2}$ to $4\frac{1}{4}$ times in the total length (without caudal), the length of the head 4 or $4\frac{1}{4}$ times. The diameter of the eye is one fourth of the length of the head and a little less than the width of the interorbital space, which is transversely convex. Snout obtuse, as long as the eye; upper jaw slightly overlapping the lower; cleft of the mouth oblique, the maxillary not quite reaching the vertical from the front margin of the orbit. Nape of the neck but little raised above the level of the head. Extremities of the fins obtusely rounded off. The origin of the dorsal fin is nearer to the root of the caudal than to the end of the snout, and behind the vertical from the root of the ventral; it is higher than long. *Anal fin rather lower than long.* Caudal excision moderate. Pectoral shorter than the head, not reaching the ventral. Caudal peduncle nearly or not quite twice as long as deep. There are three series of scales between the lateral line and ventral fin. Back bluish, sides silvery, both colours separated by a narrow straight black band running from the upper half of the eye to the end of the lateral line. Pharyngeal teeth 5.2–2.5.

Two specimens, 105 and 83 millim. long, from Ula on the Zola Chai.

LEUCISCUS GADERANUS, sp. n. (Pl. 24. fig. B.)

D. 11. A. 12. L. lat. 40. L. transv. $6\frac{1}{2}/4$.

The height of the body equals the length of the head and is one fourth of the total (without caudal). Diameter of the eye one fourth of the length of the head and a little less than the width of the interorbital space, which is transversely convex. Snout obtuse, as long as the eye; upper jaw slightly overlapping the lower; cleft of the mouth oblique, the maxillary not reaching the vertical from the front margin of the orbit. Nape of the neck but little raised above the level of the head. The origin of the dorsal fin is nearer to the root of the caudal than to the end of the snout, and behind the vertical from the root of the ventral; it is higher than long. *Anal fin a little higher than long.* Caudal excision moderate, lobes pointed. Pectoral shorter than the head, not reaching the ventral. Caudal peduncle twice as long as deep. There are two and a half series of scales between the lateral line and ventral fin. Back bluish, sides silvery, dotted with numerous minute pigment-spots; a narrow straight blackish band runs from the upper end of the gill-opening to the end of the lateral line. Pharyngeal teeth 5.2–2.5.

Three specimens, the largest 90 millim. long, from the Gader Chai; three young specimens from near the mouth of the Nazlu Chai at Superghan.

The propriety of distinguishing this form from *L. ulanus* under a separate name may be questioned. However, the larger size of the scales is so striking a feature, that, without having intermediate forms, I think it better to keep the two forms distinct. *Telestes leucoides*, Filippi, Viagg. Pers. p. 359, from the Batoum River, seems to be also a closely allied species, but is described as agreeing in form with *L. aula*, which is a fish with a much higher body.

ABRAMIS URMIANUS, sp. n. (Pl. 23. fig. A.)

D. 11. A. 14–16 *. L. lat. 58–62. L. transv. 12/8.

The height of the body is two sevenths, the length of the head one fourth of the total (without caudal). Snout neither pointed nor obtuse, equal to the diameter of the eye, which is one fourth of the length of the head; interorbital space transversely convex, scarcely wider than the orbit. Cleft of the mouth slightly oblique, with the jaws equal in front, the maxillary not extending to the vertical from the front margin of the eye. Abdomen rounded in front, and compressed behind, the ventrals. Caudal peduncle longer than deep. Pectorals not reaching the ventral, shorter than the head. Origin of the dorsal midway between the end of the snout and the root of the caudal. Caudal excision moderate. Five series of scales between the lateral line and ventral fin. Pharyngeal teeth 5/2, hooked. Silvery, greenish-olive on the back; sides with numerous minute brownish pigment-spots; they are more crowded above the lateral line, producing an inconspicuous darker band along the whole length of the side.

Five specimens from the Gader Chai and two small ones from the Urmi River; the largest is only 144 millim. long, but specimens of this size are mature, showing not only fully developed sexual organs, but also some of those deep-black spots which appear in so many Cyprinoids during the breeding-season. The gill-rakers are very short, triangular in shape, and widely set, as is characteristic of the genus *Abramis*, in opposition to *Alburnus*.

This species resembles *Alburnus punctulatus*, Kessler (Aralo-Caucas.-Pont. Ichthyol. p. 159), but has a shorter and smaller anal fin, whilst in the former species this fin is composed of 17

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* 14 in two, 15 in five, 16 in one specimen; the first three rays being simple in all.

to 20 rays. The gill-rakers of *A. punctulatus* are very short; and therefore this species should be referred to *Abramis*. A specimen from Tiflis is in the Natural History Museum.

ALBURNUS FILIPPII.

Alburnus filippii, Kessler, in Grimm's Aralo-Caspian Exped., Pisces, 1877, p. 153.

D. 11. A. 13–14*. L. lat. (54) 56–60. L. transv. (9) 10/6.

The height of the body is contained 4⅔ times in the total length (without caudal), the length of the head 4⅓ times. Snout rather pointed, equal to the diameter of the eye, which is scarcely one fourth of the length of the head. Interorbital space transversely slightly convex, scarcely wider than the orbit. Cleft of the mouth oblique, with the lower jaw slightly the longer, the maxillary not extending to the vertical from the front margin of the eye. Abdomen rounded in front, slightly compressed behind, the ventrals. Caudal peduncle at least twice as long as deep. Pectorals not reaching the ventral, shorter than the head. Origin of the dorsal nearer to the root of the caudal than to the end of the snout. Caudal excision moderate. Four series of scales between the lateral line and ventral fin. Pharyngeal teeth † 4/2, hooked. Silvery, olive on the back; a narrow, straight, well-defined blackish band from the upper end of the gill-opening to the middle of the caudal fin.

Three specimens from Sujbulak, the largest 113 millim. long; one specimen from Superghan near the mouth of the Nazlu Chai.

The gill-rakers are lanceolate, closely set, but the longest scarcely half as long as the eye.

The specimen from the Nazlu Chai differs slightly from the others, inasmuch as the scales are apparently a little larger; I count only 54 in the lateral line, and 9 in the transverse series between dorsal fin and lateral line.

Kessler states that his specimens were obtained from the Kur at Tiflis and at Borjom; in the fin-formula the number of dorsal rays is stated to be 1/6–7, which would be so abnormal in this genus that I suspect it to be due to some inadvertence.

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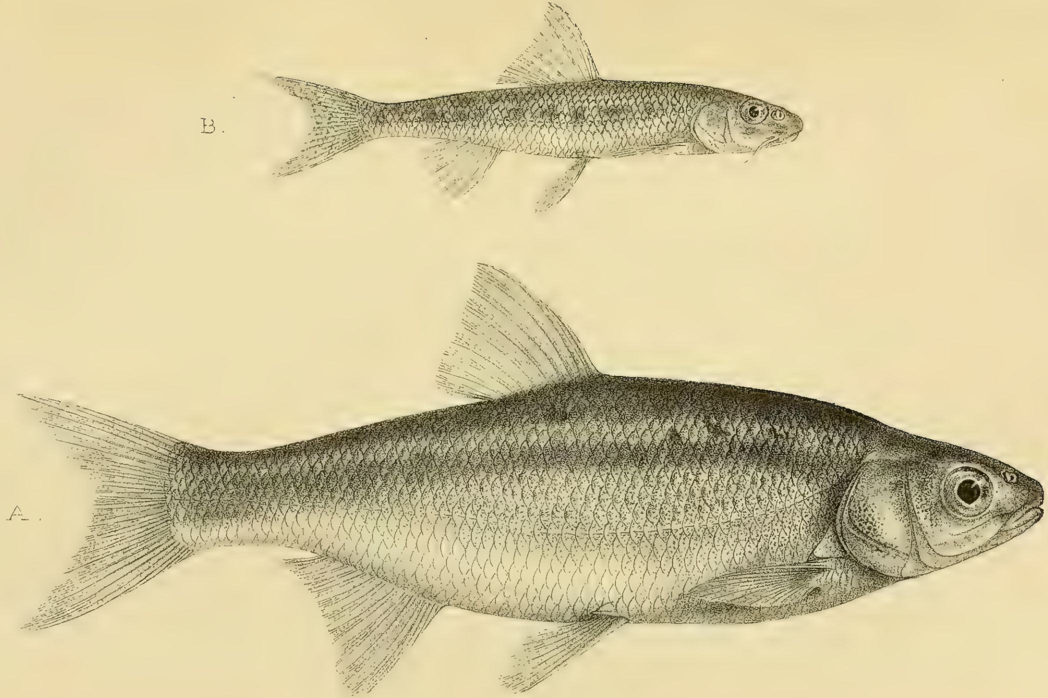
* 13 in one, 14 in three specimens, the three anterior rays being simple.

† Examined in one specimen only.

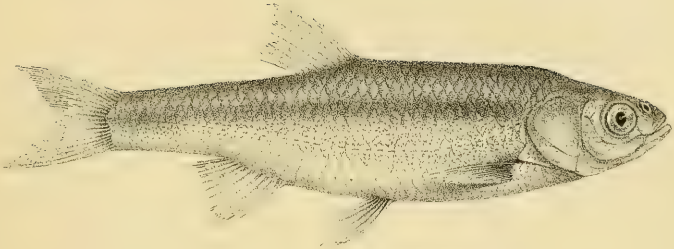


J. Green del. et lith.

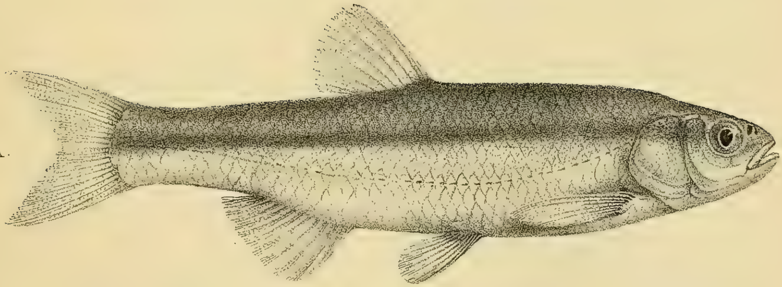
A. ABRAMIS URMIANUS. B. GOBIO PERSA.

Mintern Bros. imp.

B.



A.



J. Green del. et lith. Mintern Bros. imp.

A. LEUCISCUS ULANUS. B. LEUCISCUS GADERANUS.

NEMACHILUS PERSA.

Cobitis persa, Heckel, in Russegger's Reis. ii. 3. p. 266; de Filippi, Viaggio, p. 360.

Nemachilus persa, Günth. Fish. vii. p. 347.

D. 11. A. 7. P. 10. V. 7.

Scales minute, but conspicuous. Caudal fin distinctly emarginate. Origin of the dorsal fin nearer to the root of the caudal than to the end of the snout. The height of the body is less than the length of the head, which is contained $4\frac{1}{4}$ times in the total (without caudal). Head rather narrow; snout somewhat pointed, nearly as long as the postorbital portion of the head; eye small. Pectoral as long as the head, its length being two thirds of the distance between its base and that of the ventral. Caudal peduncle nearly twice as long as deep. Whitish, densely reticulated and speckled with greyish. Dorsal and caudal fins speckled with greyish.

Four specimens, 65 millim. long, from the Zola Chai; others from the Elinja Chai, a tributary of the Araxes.

The specimens on which this species was founded were obtained at Persepolis; de Filippi found it generally distributed in abundance in all Persian rivulets.

EXPLANATION OF PLATES 23 & 24.

Pl. 23.	Fig. A.	*Abramis urmianus,* sp. n.
	Fig. B.	*Gobio persa,* sp. n.
Pl. 24.	Fig. A.	*Leuciscus ulanus,* sp. n.
	Fig. B.	*Leuciscus gaderanus,* sp. n.

LAND AND FRESHWATER MOLLUSCA.

By EDGAR SMITH, F.Z.S.

1. HELIX (HELICOGENA) FIGULINA (*Parreyss*).
Hab. Seir.

2. HELICELLA ACUTISTRIA (*Böttger*).
Hab. Koyun Daghi.

3. HELICELLA PARABLETA (*Böttger*).
Hab. Urmi district (?).

4. HELICELLA, n. sp.

Hab. Seir.

A single specimen only, with the peristome immature. Prof. Dr. O. Böttger very kindly examined this and several other species enumerated in this list, and considers it a new species "aus der Gruppe *apicina*, Lmk." He also observes, "Aehnliche Arten sind meines Wissens aus Asien noch nicht beschrieben." It has very much the form of the preceding species, but with the spire less elevated. It is white, prettily marked with about eight interrupted spotted brown spiral lines, whereof three are above the obtusely-keeled periphery, the rest and a few intervening series of minute dots being on the lower surface. Some of the brown spots are punctate, especially the row just above the peripheral keel. The two nuclear whorls are light corneous and smooth, the remaining three volutions being marked with strong, very oblique, incised lines of growth.

5. HELICELLA PISIFORMIS (*Pfeiffer*).

Hab. Seir.

6. BULIMINUS (ZEBRINUS) HOHENACKERI (*Krynicki*).

Hab. Ula, Plain of Salmas.

7. BULIMINUS (CHONDRULUS) TRIDENS (*Müller*).

Hab. Ula?, Plain of Salmas.

These specimens belong to the var. *major*, Kryn. (=*bayerni*, Parr.), and var. *diffusus*, Mouss. Of the latter variety Prof. Böttger possesses specimens without any trace of oral teeth from several localities.

8. BULIMINUS (CHONDRULUS) TETRODON, *Mortillet.*

Hab. Seir.

A rare species, occurring also in Armenia and Transcaucasia near Tiflis.

9. BULIMINUS (CHONDRULUS) DIDYMODUS, *Böttger.*

Hab. Koyun Daghi.

The series of specimens exhibit considerable variation in size, the convexity or flatness of the whorls, and the general form, but the armature of the aperture is very constant.

10. BULIMINUS (AMPHISCOPUS) CONTINENS, *Rosen.*[*]

Hab. Koyun Daghi.

Three rather short examples, 6 millim. long.

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[*] Nachrichtsblatt deutsch. Malak. Gesell. 1892, p. 125.

11. PUPA GRANUM, *Draparnaud.*
Hab. Koyun Daghi.

12. PUPA SIGNATA, *Mousson.*
Hab. Koyun Daghi.

13. LIMNÆA STAGNALIS, *Linn.*
Hab. Urmi district (?).

14. LIMNÆA PALUSTRIS, *Müller.*
Hab. Maragha.

15. LIMNÆA TRUNCATULA, *Müller.*
Hab. Seir.

16. PLANORBIS MARGINATUS, *Draparnaud.*
Hab. Maragha.

17. SPHÆRIUM LACUSTRE, *Müller.*
Hab. Town ditch, Urmi.

18. UNIO SIEVERSI, *Drouet*, var. KOBELTI.
Hab. River Gâder near Ocksa.

Prof. Böttger considers this form distinct from *U. batavus*, with which I had united it.

The collection, presented by Mr. Günther, although containing few specimens of each species, and mostly in poor condition, forms a useful addition to the Museum collection, which contains but very few specimens from the north-western part of Persia. Their value is also considerably enhanced by their having been partly named, or their names confirmed, by Prof. Böttger. Most of the species quoted are extremely common forms, having a wide geographical range in the South and South-east of Europe and Turkey in Asia. Their distribution is well known and fully recorded in various works. Westerlund's 'Fauna der paläarctischen Region,' and Rossmässler's 'Iconographie der Land- und Süsswasser-Mollusken, etc.' should be consulted for such information, references, and figures.

CRUSTACEA.

By Robert T. Günther, M.A., F.R.G.S.

(Plate 25.)

MALACOSTRACA.

Decapoda.

Macrura.

I was unable to discover that the Crayfish is known from any of the streams that flow into the lake. It is abundant in the Kur. The Syrian zoologist does not differentiate between crabs and crayfish: to him both are 'Kédjala' and unclean.

Brachyura.

Telphusa fluviatilis, *L.*

This freshwater crab is extremely common in all the rivers. They are to be found beneath stones and in little burrows in wet banks. A favourite attitude is sitting half in and half out of the water, so that they are able to pass either air or water at pleasure through the branchial chamber. They seemed to be able to employ the openings into the branchial chamber either as exhalant or as inhalant apertures. Indeed, instead of continually propelling water through the branchial chamber in the same direction, they were continually changing the direction, and using the apertures at the anterior margin of the carapace and at the axils of the ambulatory appendages alternately as inhalant and exhalant apertures.

When sitting *regardant*, their eyestalks and feelers are set at an angle of 45° with the antero-posterior axis of the body. In colour they are of a greenish-sepia hue, often tending more to green in older specimens, owing to the growth of a green alga on the carapace. The chelæ and ambulatory limbs are generally tipped with orange-red, and their sides are often streaked with a purplish tinge.

The Persian specimens do not appear to differ essentially from those of Italy, Greece, and Palestine which are preserved in the National Collection in the British Museum.

Isopoda.

Hemilepistus.

Common under stones in damp places at Seir.

ASELLUS, which is so common in all European waters, seemed to be entirely absent in the Urmi basin. It is said to occur in the western tributaries of the Caspian, but not in Russian Turkestan or N.E. Persia.

AMPHIPODA.

GAMMARUS PULEX, *De Geer*.

In the springs near Seir, and also on the other side of the lake in the clear water of a stream near Kirjawa. My observations confirm those of Dr. Walter in regard to the fact that *G. pulex* seems to prefer the cool, upper, narrow courses of the streams to the warmer, more sluggish, lower reaches in the plains.

ENTOMOSTRACA.

COPEPODA.

A Cyclopid was very common in a pond near Kirjawa, Maragha, but I was not able to determine the species.

PHYLLOPODA.

DAPHNIA sp.

Common in the stagnant water of the ditch surrounding the walls of the town of Urmi; also at Kirjawa.

ARTEMIA URMIANA, sp. n. (Pl. 25.)

The general shape of the body is similar to that of *A. salina*, but stouter than in the American species. The males are somewhat shorter than the females, in the proportion of 10 mm. to 13 mm. The head and "thorax," bearing the eleven swimming-appendages, are very slender, and measured together are nearly equal to the abdomen in length. The segmentation of the abdomen is so difficult to recognize that I am inclined to regard the segmentation as having been partially lost. The first two or three abdominal segments are the only ones clearly distinguishable. The labrum is well developed and is bent over the mouth so as to hide the mandibles. Its distal end is square-ended, with two papilliform processes at the corners; the processes bear small tufts of hairs at their apices, and are probably sensory in function.

The ventral appendage of the genital segment differs greatly in the two sexes. In the female it has the function of an ovisac and usually contains ripe eggs. Its shape has been described as resembling that of broad flask. When quite ripe the eggs escape through a transverse slit just below the apex of the ovisac. The ovaries extend into the posterior thoracic and anterior abdominal segments. The eggs vary from about ·25 to ·3 mm. in diameter.

In the male the vasa deferentia open at the slightly expanded extremities of a V-shaped organ, which probably contains paired sperm-sacs and ductus ejaculatoria. The distance between the external sexual apertures exactly corresponds to that between the two processes on the claspers, which will be described below, and which I am inclined to consider as being employed for the purpose of transferring the spermatozoa to the female. Near the base of each of the two processes, and on its inner aspect, is a small spinular process with a sharp tooth.

The abdomen terminates in a slight dilatation, within which numerous rectal muscles arranged radially and obliquely traverse the space between the body-wall and the rectum. The anus is terminal and is flanked by two small lateral furcal lobes, upon which are implanted two simple non-plumose setæ in the males, but none in the females. In respect of the scant development of these setæ, *A. urmiana* approximates to the condition of *A. mülhausenii*, as Schmankewitsch described it, from brine of sp. gr. 1·2015, rather than the form from brine of 1·1373 sp. gr., which was provided with one or two, though seldom three, setæ. At the same time it must be remembered that *A. urmiana* has lived for a longer time in its water of sp. gr. 1·1138 than Schmankewitsch's type from water of sp. gr. 1·1373, and has therefore had a longer time to develop those anatomical characters which seem to be the direct result of life in brine.

Appendages.—The antennæ are sometimes twice the length of the eyes and eyestalks. The joints seem to vary in number and relative proportion; as many as five may be distinguished in some individuals. The terminal joint bears three sensory hairs.

The claspers are enormously developed in the adult males, and may measure as much as 4 mm. across. The proximal joints are much thickened, and carry upon their inner faces two rounded processes which are used for clutching the females, and which are probably of service in transferring the spermatozoa (spermatophores?) to the females from the two lateral expansions of the male genital organs. The second joint is large, flattened and triangular in shape; it terminates in a pointed process which is often incurved.

The female homologues of the claspers are insignificant in comparison, their width not exceeding 1·5 mm. across.

Mandibles are powerful, with a finely serrated margin and a palp which does not appear to be always present.

Maxillæ are in two pairs. The first is provided with a tuft of anteriorly directed setæ.

The eleven natatory appendages are all constructed on the same plan. Their axes all bear two respiratory bracts upon one margin and five endites upon the other. The 6th endite is terminal. The 1st or proximal endite bears extremely numerous close-set setæ upon its two lobes in all the swimming-appendages except the last, in which the setæ of the distal lobe are longer and not so closely set as upon the longer proximal lobe.

Endites 2, 3, and 4 are small and only bear 3, 2, and 1 setæ apiece, respectively. The 5th endite has a rounded margin provided with numerous setæ armed with reflected barbs. Such barbed setæ do not appear to be present on any specimens of *A. salina* which I have had the opportunity of examining, and they are certainly absent in some specimens from Guernsey which were given to me by the Rev. Canon Norman. The setæ upon the distal portions of the margin are much longer than those on the proximal portion, and more nearly resemble the long swimming-setæ borne by the terminal endite.

The extraordinary numbers in which the Artemia is found in Lake Urmi have already been referred to (p. 357). The females, as in Lake Utah, were present in greater numbers than the males, in the proportion of 5 : 3. Many of the males were holding on behind the ovisacs of the females by means of their claspers, and with such strength that immersion in alcohol did not cause them to separate, even after death. Consequently, although parthenogenesis may have been a mode of reproduction, it was by no means the only one in August.

The Artemias swim by synchronous movements of the eleven natatory appendages, which are moved at the rate of 160 strokes per minute.

In colour the males incline to a pale greenish, and the females to a more reddish hue. The alimentary canal is usually dark brownish green, owing to the food contained in it.

It is a debatable point whether new specific names should be applied to newly discovered members of a group of animals of which the other species have been mainly diagnosed by characters of doubtful taxonomic value. *Artemia salina*, *A. mülhausenii*, *A. fertilis*, *A. gracilis*, *A. monica*, and *A. utahensis* have all been distinguished by characters which vary to a greater or less extent with the salinity of the water in which they live. I am inclined to agree with Packard that only two well-defined species of *Artemia* have been described, viz., the Old-World form *A. salina*, with which *A. mülhausenii* (or *Artemia* sp. gr. 1·2015) has been proved by Schmankewitsch to be identical, and the New-World *A. gracilis*, including Verrill's other American species as synonyms. At the same time it is possible that, when a complete revision of the group is made and more minute details are taken into account, other and better specific differences may be found to exist. In the meantime, in order to attract notice to its peculiar features, I venture to propose *Artemia urmiana* as a new Old-World species, with the following diagnosis:—

A. URMIANA, sp. n.

Resembling *A. salina*, but with an incompletely-segmented abdomen; furcal lobes bearing a single seta apiece in the male and none in the female; claspers of male of larger size than in the male *A. salina*; labrum with two sensory setose papillæ. The margin of the fifth endites of the thoracic feet bordered with short setæ bearing barbs of peculiar nature.

Hab. Lake Urmi, in water of specific gravity 1·1138.

EXPLANATION OF PLATE 25.

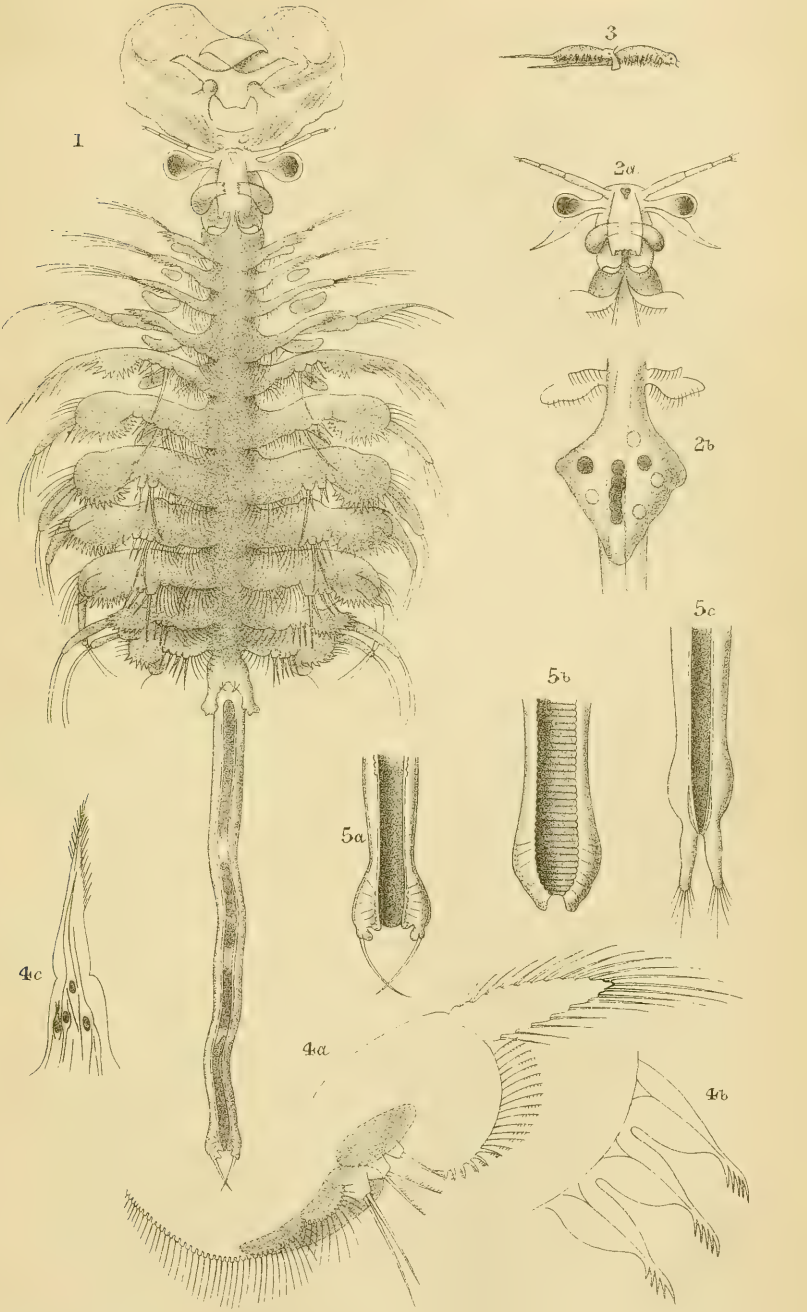
Fig. 1. *Artemia urmiana*, sp. n. Ventral view of male. × 15.

2. *a.* Ventral view of head of female. × 15. *b.* Ventral view of ovisac of female.

3. Lateral view, showing the position of the male when in the act of clasping the female. Twice natural size.

4. *a.* Postabdomen of ♂ *Artemia urmiana*. *b.* Postabdomen of ♀ *Artemia urmiana*. *c.* Postabdomen of ♀ *Artemia salina* (Coll. Norman).

5. *a.* The ventral margin of the seventh thoracic natatory appendage. × 40. The flabellum and bract are indicated by dotted lines. *b.* Barbed setæ from margin of the fifth endite. × 400. *c.* Sensory seta.



M.P. Parker del. et lith.
Geo. West & Sons imp.

ARTEMIA URMIANA.

CHILOPODA AND ARACHNIDA.

By R. I. Pocock, of the British Museum (Natural History).

(Plate 26.)

Class CHILOPODA.

Genus Scutigera, *Latr.*

Scutigera coleoptrata (*Linn.*).

Syst. Nat. ed. x. i. p. 637.

[For synonymy, *see* Latzel, Die Myriop. Oester.-Ungar. Mon. i. p. 25 (1880).]

Loc. Seir.

Ranges from Madeira and Spain throughout South Europe.

Genus Lithobius, *Leach.*

Lithobius persicus, sp. n.

Colour a uniform reddish brown as in *L. forficatus*. *Head* smooth, furnished on each side with about 15 ocelli arranged in four rows. *Antennæ* long, composed of about 42 segments, the exact number being doubtful on account of the indistinctness of the divisional line between some of the segments. *Tergal plates* smooth, the posterior sparsely punctured and hairy; the posterior lateral angles of the 11th not produced beyond the level of the posterior border; those of the 13th produced and spiniform, as for example in *L. forficatus*; the posterior angle of the remaining terga not produced. *Coxal teeth* of external maxillipedes 2–2. Coxal pores of posterior four pairs of legs 3, 5, 4, 5.

Anal leg with single claw; armed below with 0, 1, 3, 3, 1 spines, the coxa with a single external lateral spine. Tibia of anal leg and of preanal leg longitudinally sulcate above in the male; these appendages otherwise not modified.

Total length 19 mm.

Loc. Seir. A single male example.

Very closely allied to the common European species *L. mutabilis*, L. Koch, but apparently distinct on account of the presence of the lateral spine on the anal coxa and of the dentiform prolongation of the 13th tergite.

Genus Scolopendra, *Linn.*

Scolopendra canidens, *Newp.*

Scolopendra canidens, Newp. Ann. Mag. Nat. Hist. xiii. p. 98 (1844); id. Tr. Linn. Soc. xix. p. 399 (1845); id. Cat. Myr. Brit. Mus. pt. i. p. 48 (1856).

Scolopendra affinis, Newp. Ann. Mag. Nat. Hist. xiii. p. 98 (1844); id. Tr. Linn. Soc. xix. p. 386 (1845); id. Cat. Myr. Brit. Mus. pt. i. p. 33 (1856).

Scolopendra oraniensis, Lucas, Rev. Zool. 1846, p. 287; id. Expl. Sci. de l'Algérie, Anim. Art. p. 344.

Scolopendra dalmatica, C. Koch (1847); and recent authors.

Loc. Seir. A single specimen.

Although abundant in North Africa and South Europe, I am not aware that this species has ere this been recorded farther to the east than Egypt.

Class ARACHNIDA.

Order Araneæ.

Genus Argiope, *Sav.*

Argiope Bruennichi (*Scop.*).

Aranea Bruennichi, Scopoli, Obs. Zool. in Ann. V. Hist. Nat. p. 125 (1772).

[For synonymy, *see* Thorell, Remarks on Synonyms, &c. p. 518.]

Loc. Seir.

Widely distributed throughout Central and South Europe, and extending as far north as Paris, Hungary, &c.

Genus Tetragnatha, *Latr.*

Tetragnatha extensa (*Linn.*).

Aranea extensa, Linn. Syst. Nat. ed. x. i. p. 621 (1758).

[For synonymy, *see* Thorell, *loc. cit.* p. 459.]

Loc. Seir.

A single male example, identical with British examples of the species of *Tetragnatha* referred to *T. extensa* (Linn.).

Genus Lathrodectus, *Walck.*

Lathrodectus tredecim-guttatus (*Rossi*).

Aranea 13-*guttata,* Rossi, Fauna Etr. ii. p. 136 (1790).

[For synonymy, *see* Thorell, *loc. cit.* p. 508.]

Loc. Seir.

A single specimen of the black variety of the species (var. *erebus,* Sav.) was found.

Genus Lycosa, *Latr.*

Lycosa Guentheri, sp. n. (Pl. 26. figs. 1, 1 *a*, 1 *b*.)

♀. *Colour.* Carapace with two broad brown bands extending from the eyes to the posterior margin on each side of the pedicel, separated by a flavous median band about equal to them in width; a flavous band of about the same width running along the lateral border; abdomen yellowish white, with two fuscous bands extending along each side of the upper surface from the anterior to the posterior extremity, and a median dark band between them, distinct on the anterior half of the upper surface but breaking up and becoming obsolete posteriorly; sides and lower surface of abdomen yellowish white, with narrow indistinct abbreviated lines behind the epigastric fold; legs yellowish, infuscate distally, sometimes mottled with fuscous spots above; underside of femora yellow, of tibiæ yellow at base, becoming fuscous distally; tibia of 4th leg with two black bands, one apical and one basal, the basal sometimes obsolete; tibia of 3rd leg sometimes with apical band; coxæ and sternum flavous; mandible black in the apical half, yellow above; palpi flavous, with tarsus black.

Carapace about as long as patella and tibia of 1st leg and as protarsus of 4th, barely as long as patella and tibia of the 4th; width of carapace about equal to tibia of 4th and exceeding that of 1st; posterior median eyes not much more than half a diameter apart; eyes of anterior line narrower than those of the median line by about half the radius of one of the latter on each side, only slightly procurved, the upper edge of the laterals above the centres of the medians, the medians only slightly the larger; the laterals almost their own diameter below the posterior medians.

Mandibles clothed above and externally with yellow hairs, black internally and at the apex; posterior border of sulcus armed with 3 subequal teeth.

Legs 4, 1, 2, 3 in length, longish and slender; tibiæ of 3rd and 4th with two spines above; patellæ of 1st unarmed, of 2nd armed with a minute anterior spine, of 3rd and 4th spined in front and behind; tarsal scopula of 3rd and 4th divided by a narrow but sharply defined band of setæ.

Vulva as in fig. 1 *b*, Pl. 26.

♂. Carapace barely as long as patella and tibia of 2nd leg, distinctly shorter than those of 1st and of 4th and than protarsus of latter; patellæ of all the legs armed with an anterior and a posterior spine. Palpus as in fig. 1 *a*, Pl. 26.

Measurements in millimetres:—♀. Total length 18; length of carapace 7·8, width 5·5; length of 1st leg 21, of 2nd 19, of 3rd 18, of 4th 26 (all measured from base of femur); patella and tibia of 1st 7·5, of 4th 8·2; protarsus of 4th 8.

♂. Total length 15; length of carapace 7·6, of 1st leg 24, of 2nd leg 22, of 3rd leg 21, of 4th leg 29; patella and tibia of 1st leg 8·5, of 4th 8·8; protarsus of 4th 9·2.

Loc. Seir.

In size and colouring this species approaches *L. ferox* of Lucas, but may be at once recognized by its higher head, slightly procurved anterior line of eyes, of which the medians and laterals are subequal. A considerable number of Transcaspian species of this genus have been established, and the species that has been here described as new may perhaps belong to one of them; but until reliable figures of the generative organs of both males and females have been published, or until the specific characters have been set forth in tabular form, the satisfactory identification of the species will remain an almost hopeless task.

Order SOLIFUGÆ.

Genus GALEODES, *Oliv.*

GALEODES TRUCULENTUS, sp. n. (Pl. 26. figs. 2, 2 *a*.)

♀. *Colour.* Upper surface of head strongly infuscate, with median lanceolate pale stripe extending back from the black ocular tubercle; mandibles yellow, with a pair of faint fuscous stripes above; femur of palp yellow, lightly infuscate above at the tip; upperside of tibia infuscate, except for the two extremities which are pale; protarsus infuscate almost to its extremity; tarsus lightly infuscate above; distal half of femur and proximal two-thirds of protarsus of 4th leg, and in a lesser degree of the 2nd and 3rd legs, infuscate.

Width of *cephalic plate* almost equal to length of tibia of palp and exceeding the protarsus and half the tarsus of that appendage, equal to the protarsus of the 4th leg and exceeding the protarsus and half the tarsus of that appendage.

Mandibles with inferior fang armed with 5 teeth; 3 small teeth between the two terminal large teeth.

Legs and palpi short; palpus about three and a half times as long as the width of the head; 4th leg about four and a half times the length; spine-armature of legs as in normal *G. arabs* (see Ann. Mag. Nat. Hist. (6) xvi. p. 77).

♂. Coloured as in ♀; inferior mandibular fang armed with

5 teeth, as in that sex. *Flagellum* resembling that of *G. citrinus* and differing from that of the Egyptian form *G. arabs* (or *Lucasii*) in having the basal portion stouter and the distal sensory portion more expanded. Ocular tubercle of normal size, and about one-fifth the width of the head-plate.

Measurements in millimetres:—♀. Total length (not including mandible) 36; width of head 12·5; length of mandible 17, of palpus 43, its tibia 14, protarsus 11, 1st leg 33, 2nd leg 30, 3rd leg 37, 4th leg 56, its tibia 13, protarsus 9.

♂. Total length 32; width of head 8, of ocular tubercle 1·5; length of palp 49, of 4th leg 60.

Loc. ♀ (type), Island of Koyun Daghi on Lake Urmi; ♂, Superghan.

The females of the three species of *Galeodes* from South Persia may be recognized as follows:—

a. Width of cephalic plate almost equal to length of tibia of 4th leg, exceeding protarsus of 4th by more than half the tarsus and only a little shorter than protarsus and tarsus of palp; palpus about three and a half, 4th leg about four and a half times the width of the cephalic plate; cephalic plate and legs more strongly infuscate .... *truculentus*, sp. n.

b. Width of cephalic plate much less than tibia of 4th and not exceeding protarsus of palp and 4th leg; legs and palpi much longer; cephalic plate and legs scarcely infuscate.

  a′. Legs and palpi shorter; palpus a little more than four and a half, 4th leg about six times as long as width of cephalic plate .... *darius*, Poc.*

  b′. Legs and palpi longer; palpus a little more than five times, 4th leg a little less than seven times, as long as the width of cephalic plate.. *citrinus*, Poc.†

The males of the three South Persian species may be recognized as follows:—

a. Ocular tubercle very large, its width about one-third that of the head-plate; palpus longer,

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* Ann. Mag. Nat. Hist. (6) xvi. p. 81 (1895). A single female of this species from Fao on the Persian Gulf was sent to the British Museum by Mr. W. D. Cuming.

† *Loc. cit.* The British Museum has received many examples of this species, collected at Jask, on the Gulf of Oman, from Messrs. Butcher, B. T. Ffinch, and F. W. Townsend.

seven times as long as width of head; tibia, protarsus, and tarsus completely black; distal tarsal segment of 2nd and 3rd legs with two anterior spines .... *cyrus*, Poc.[*]

b. Ocular tubercle much smaller, its width about one-fifth that of the head-plate; palpus shorter, only about six times as long as the width of the head; the tibia pale at the apices; tarsus scarcely infuscate; distal tarsal segment of 2nd and 3rd legs with one anterior spine.

a′. Cephalic plate, legs, and femur of palpus scarcely noticeably infuscate; lower fang of mandible with only 1 small supernumerary tooth between the two larger teeth .... *citrinus*, Poc.

b′. Cephalic plate, posterior legs, and femur of palpus distinctly infuscate; lower fang of mandible with 3 supernumerary teeth...... *truculentus*, sp. n.

Order Scorpiones.

Genus Buthus, *Leach*.

Buthus caucasicus (*Fischer*).

Scorpio caucasicus, Fischer, Zoogn. p. 401, pl. iv. fig. 1 (1813) (= *eupeus* and *thersites*, C. Koch).

Subsp. persicus, nov.

Colour. Tergites yellow with five black stripes, three marking the keels and one on each side between the lateral keels and the border; carapace correspondingly marked in its posterior half; in its anterior half the tubercle, the frontal keels, and the anterior border are black, and there is a black patch on each side between the ocular tubercle and the lateral margin; median and lateral inferior caudal keels black; palpi yellow, with traces of black lines on the humerus, brachium, and hand; femur and patella (tibia) of legs also partially infuscate.

Structurally this Scorpion much resembles *B. afghanus*, Poc. (Tr. Linn. Soc. (2) iii. p. 116, 1889), from Meshed in Afghanistan; but the tail is considerably more powerful in *B. persicus*, the segments being relatively both higher and broader. For example, the height of the 3rd segment in the ♂ is about equal to the length of the inferior keel, and that of the ♀ a little less, whereas in *afghanus* (♂ ♀) the height is noticeably less. Again,

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[*] Ann. Mag. Nat. Hist. (6) xvi. p. 79 (1895). Based upon a single male example from Fao (*W. D. Cuming*).

although the tail is more powerful, the crests are very perceptibly less strongly granular. This is particularly noticeable on the inferior median crest of the 2nd and 3rd segments, which in *B. afghanus* are strongly elevated posteriorly, but are scarcely noticeably so in *B. persicus*. Similarly, the inferior lateral keels of the 5th segment are much less strongly denticulate, and the posterior lateral prominence is trilobate, not bilobate.

Pectinal teeth 25–26, ♂; 20–21, ♀.

In the palpi the hands are large, smooth and rounded, not crested in either sex, larger in ♂ than ♀. Fingers more strongly lobate in ♂; in both sexes the movable digit is much longer than the hand-back, and slightly exceeds the length of the brachium; 12 rows of teeth, as in *afghanus*.

Measurements in millimetres:—♂ (type). Total length 49; length of carapace 5·5, of tail 31; height of 3rd segment 3·9; length of inferior keel 3·8, width 4; width of hand 3·4; length of hand-back 4, of movable digit 6.

♀. Total length 61, carapace 6·2, tail 34.

Loc. Seir; landing on east side of lake.

According to Dr. A. Birula, who has examined many Transcaspian Scorpions allied to *afghanus* and *persicus*, *B. afghanus*, Poc., is synonymous with *B. thersites*, C. Koch *, the latter being but a subspecies of *B. eupeus* of C. Koch †. But since the locality of the original *thersites* is unknown, and the description of the specimen or specimens to which Dr. Birula gave that name does not apply to the typical examples of *B. afghanus*, at all events in the form of the 3rd segment of the tail, I prefer to cite the species or subspecies by the name under which I originally described it.

NOTE.—Subjoined is the description of a new species of the genus *Buthus* from Persia:—

BUTHUS VESICULATUS, sp. n. (Pl. 26. fig. 4.)

Colour of trunk, chelæ, and tail entirely pale yellow. In structural characters, *i. e.*, form of palpi, of cephalothoracic and abdominal keels, closely allied to *B. parthorum*, Poc., from near Meshed (Tr. Linn. Soc. (2) iii. p. 113, 1889), but at once recognizable by the form of the vesicle and the shortness of the aculeus of the tail. In *B. parthorum* the vesicle is small and piriform (Pl. 26. fig. 3), its width exceeding its

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* Die Arachn. vi. p. 51, fig. 466 (1839).

† Die Arachn. v. p. 127, fig. 419 (1838).

height, its height being much less than the width of the upper surface of the 5th caudal segment and only a little more than half the length of a straight line drawn from the outer side of the base of the aculeus to its point; the aculeus is very long and lightly curved, its length represented by a straight line, drawn as described above, considerably exceeding the width of the 5th caudal segment, exceeding also the length of the vesicle, equal to half the length of the movable digit and to the distance between the anterior edge of the median eye and the posterior border of the carapace. In *B. vesiculatus*, on the contrary, the vesicle (Pl. 26. fig. 4) is large and globular, the height exceeding the width; the aculeus is short and more strongly curved, its length represented by a straight line drawn as above being much less than, not much more than half, the length of the vesicle, less than the width of the 5th caudal segment, about one-third the length of the movable digit, and much less than half the length of the carapace.

Pectinal teeth 20 in ♀, 25 in ♂.

♀. Total length 55 mm.; length of carapace 65, of tail 33; height of vesicle 3, width 2·8; length of aculeus 2·5. [In type (♀) of *B. parthorum* the measurements, in mm., are:—Total length 74, carapace 8, tail 44; height of vesicle 2·5, width 3; length of aculeus 4·6.]

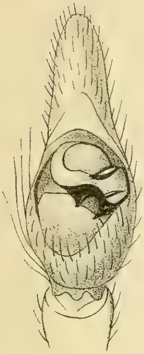
Loc. Astracan, in Persia.

There are three examples of this species in the British Museum: two, ♀ ad. and ♂ immat., from the above locality, and 1 ♀ ad. in bottle without locality but containing other typically Eastern Mediterranean specimens of Arachnida and Chilopoda.

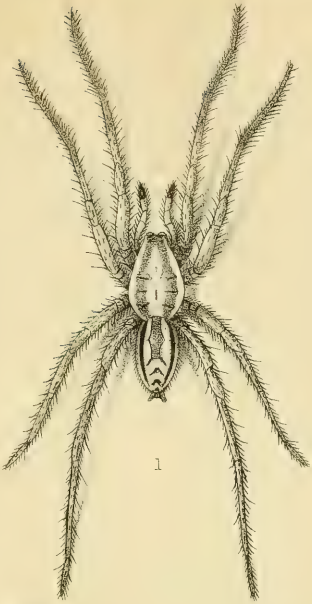
Prof. K. Kraepelin (Das Tierr., Scorpiones, p. 24, 1899) cites *B. parthorum* as doubtfully synonymous with *B. caucasicus*, Nordman (Demidoff, Voy. Russie, iii. p. 731, Arachn. pl. i. fig. 1, 1840). Judging by Kraepelin's description of the latter species, the two are certainly allied; but since nothing is said about the form of the caudal vesicle and aculeus, there is at present no certainty on this point. In any case the name *caucasicus* cannot stand for the species, since it was previously used by Fischer, as Birula has shown, for another species of *Buthus*. Hence, if *caucasicus*, Nord. = *parthorum*, Pocock, the latter will be the name for the species.

EXPLANATION OF PLATE 26.

Fig. 1. *Lycosa Guentheri*, sp. n. Dorsal view, ♂.
1 *a*. ,, ,, Palp of ♂.
1 *b*. ,, ,, Vulva of ♀.
2. *Galeodes truculentus*, sp. n. ♀, nat. size.
2 *a*. ,, ,, Flagellum of ♂.
3. *Buthus parthorum*, Poc. Vesicle and aculeus of tail.
4. ,, *vesiculatus*, sp. n. ,, ,,



1a.

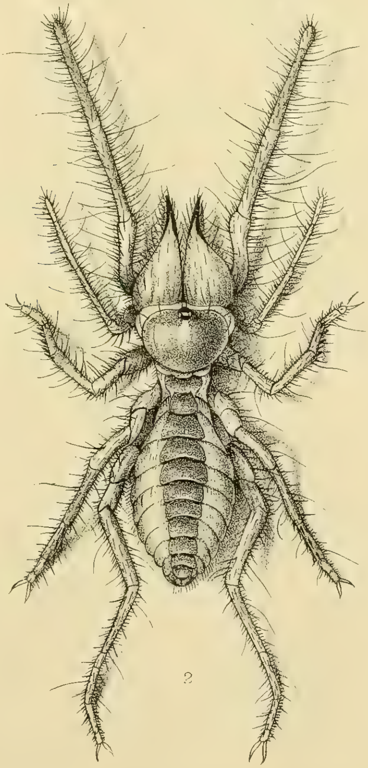


1

1b.

3

2 a.



2

4

F. O. Pickard-Cambridge del. et lith. West, Newman imp.

ARACHNIDA FROM LAKE URMI.

ACARI.

By Albert D. Michael, F.L.S., F.R.M.S.

(Plate 27.)

Among the specimens collected by Mr. R. T. Günther the following three species of Acari have been identified:—

Astoma gryllaria, *le Baron.*

This species, common in the Urmi district, was found attached near the bases of the wings of *Caloptenus italicus*, L., in July. The genus *Astoma* cannot be considered a good one, being founded entirely upon a larval type. The adult form would certainly be one of the Trombidiidæ. *Trombidium sericeum locustarum* was described as the adult form by Riley, but as the *Astoma gryllaria* larva is totally different from the larva of *T. sericeum*, this identification seems doubtful. Riley considered the larva very destructive to locusts and consequently beneficial to man, and brought it into notice in a series of articles ("The Locust in 1876," New York Tribune, Aug. 16, 1876; "Rocky-Mountain Locust," Appleton's Amer. Cyclop. 1875, pp. 371–374; and "Mite Transformations," Trans. Acad. Sci. St. Louis, vol. iii. Proc. p. 267).

Rhipicephalus simus, *C. L. Koch*; or sanguineus, *Latr.*

These are practically world-wide species; dogs and other animals carry them everywhere, and they will attach themselves to almost any creature which has blood to suck.

The Persian specimens were all found upon the hind legs and tails of the *Testudo ibera*, in situations in which they are free from the risk of being rubbed off. All the older tortoises at Seir carried three or four of these bloodsuckers.

Argas persicus, *Fischer.*

Hab. Seir Hill.

This species I regard as synonymous with *Argas reflexus* of Fabricius. I have obtained specimens which are indistinguishable from *A. reflexus* from all quarters of the globe; they are probably transported by pigeons and other birds. In a hot country the bite of this tick is believed occasionally to produce fever, madness, and even death (*cf.* p. 366). Mr. Günther found one specimen upon a tortoise.

A bright orange-coloured species of Acarid was in two instances found attached to the nape of the neck of a species of *Machilis* (Pl. 27. fig. 4).

INSECTA (LEPIDOPTERA RHOPALOCERA).

By A. G. BUTLER, Ph.D., F.L.S.

[For the specimens marked "*Daltry collection*" I am much indebted to the energy of the Rev. S. J. Daltry.—R. T. G.]

NYMPHALIDÆ.

SATYRINÆ.

1. HIPPARCHIA BRISEIS, var. TURANICA.

Satyrus turanica, Stgr.; (cf. Rühl, Palæarkt. Gross-schm. i. p. 532 (1892).

Seir, 8 miles west of Urmi, Aug. 13–19 (1898).

2. HIPPARCHIA PELOPEA.

Satyrus pelopea, Klug, Symb. Phys. 3, pl. xxix. figs. 5–8 (1832).

Seir, 8 miles west of Urmi, Aug. 13–16 (1898).

3. HIPPARCHIA CIRCE.

Papilio circe, Fabricius, Syst. Ent. p. 495 (1775).

♂, Urmi (*Daltry coll.*).

4. EPINEPHELE LYCAON, var. LUPINUS.

Satyrus lupinus, Costa, Faun. Nap. (1835?); Staudinger, Horæ Soc. Ent. Ross. 1870, p. 79.

♀, Seir, 8 miles west of Urmi, Aug. 13–16 (1898).

5. EPINEPHELE HISPULLA.

Papilio hispulla, Esper, Eur. Schmett. i. 2, pl. cxix. figs. 1, 2 (1809?).

♀ ♀, Urmi (*Daltry coll.*).

6. EREBIA AFER.

Papilio afer, Esper, Eur. Schmett. pl. lxxxiii. figs. 4, 5 (1783).

Urmi (*Daltry coll.*).

7. CŒNONYMPHA PAMPHILUS.

Papilio pamphilus, Linn. Syst. Nat. x. p. 472 (1758).

Seir, Aug. 19, and Urmi (*Daltry coll.*).

8. PYRAMEIS CARDUI.

Papilio cardui, Linn. Faun. Suec. p. 276 (1761).

♂, Urmi (*Daltry coll.*).

9. ARGYNNIS MAIA.

Papilio maia, Cramer, Pap. Exot. i. pl. xxv. B, C (1775).

♂, Urmi (*Daltry coll.*).

10. MELITÆA AURINIA.

Papilio aurinia, Rott. Naturf. vi. p. 5 (1775).

♀, Urmi (*Daltry coll.*).

LYCÆNIDÆ.

11. CUPIDO DAMON.

Papilio damon, Schiffermüller, Wien. Verz. p. 182 (1776).

♂, Seir, Aug. 16, 1898.

12. CUPIDO ADMETUS, var. RIPARTII.

♀ *Papilio ripartii*, Freyer, Beitr. Schmett. iii. pl. 133. fig. 3 (1830).

♂ ♂, ♀ ♀, Seir, Aug. 16, 1898.

The males have the veins of the primaries broadly bordered with woolly androconia from the base to beyond the middle. In the specimens from Seir these have been to some extent abraded, but are still easily discernible.

13. CUPIDO ICARUS.

Papilio icarus, Rott. Naturf. vi. p. 21 (1775).

♂ ♂, ♀ ♀, Seir, Aug. 16, 1898.

14. CUPIDO AGESTIS.

Papilio agestis, Schiffermüller, Wien. Verz. p. 184 (1776).

♂ ♂, ♀ ♀, Seir, Aug. 16, 1898.

15. CUPIDO BELLARGUS, var. OCEANUS.

♀ *Papilio oceanus*, Bergstrasser, Nomencl. iii. pl. 53. figs. 3, 4 (1779).

♂, Urmi (*Daltry coll.*).

The female has the submarginal red spots well defined above in this variety, but the male only differs from our *C. adonis* below.

16. CUPIDO ENDYMION.

Papilio endymion, Schiffermüller, Wien. Verz. p. 182 (1776).

Papilio daphnis, id. ibid.

♂ ♂, ♀ ♀, Seir, Aug. 16 & 19, 1898.

17. CUPIDO DAMA, var. ?

Lycæna dama, Staudinger; cf. Rühl, Palæarkt. Gross-schm. p. 287 (1892).

♂ ♂, ♀ ♀, Seir, Aug. 16 & 19, 1898.

This species is new to the Museum series. Mr. Elwes kindly informed me that it was "probably *C. dama*"; the description in Rühl's book does not, however, represent a form like that before me; indeed, the specimens from Seir seem rather to resemble the description of *C. aedon* of Christoph, but both fore and hind wings have the veins entirely blackish, not merely with blackish tips.

18. CHRYSOPHANUS THETIS.

Lycæna thetis, Klug, Symb. Phys. pl. 40. figs. 17, 18 (1834).

♂ ♀, Seir, Aug. 16.

19. CHRYSOPHANUS THERSAMON, var. OMPHALE.

Lycæna omphale, Klug, Symb. Phys. pl. 40. figs. 12–14 (1834).

♀, Seir, Aug. 16.

It seems hardly likely that this tailed form can be a mere variety of *C. thersamon*, but Dr. Staudinger regards it in that light.

PAPILIONIDÆ.

PIERINÆ.

20. COLIAS EDUSA.

Papilio edusa, Fabricius, Mant. Ins. ii. p. 23 (1787).

♂ ♂, Urmi (*Daltry coll.*); ♂ ♀, Seir, Aug. 13–19, 1898.

Although the names *hyale*, *electra*, and *croceus* all take priority over *edusa*, the later name is so widely recognized that the use of any of them without the general consent of Lepidopterists is likely to lead to misapprehension*. If the name *hyale* be rejected on account of its long application to a different species in the genus, I do not see how *electra* applied to a common African sport of the species can be ignored with any fairness or regard to the law of priority. That *C. electra* is not a species distinct from the European insect is certain, inasmuch as typical forms of both insects with numerous intergrades reach us from the same localities.

21. SYNCHLOË DAPLIDICE.

Papilio daplidice, Linnæus, Syst. Nat. 1, ii. p. 760 (1767).

♂, Seir, Aug. 13–16, 1898.

22. GANORIS RAPÆ, var. ERGANE.

Papilio ergane, Hübner, Eur. Schmett. i. figs. 904–7 (1827).

Seir, Aug. 13–16, 1898.

PAPILIONINÆ.

23. THAIS CERISYI.

Thais cerisyi, Godart, Mém. Soc. Linn. Paris, ii. pl. 2 (1822).

Urmi (*Daltry coll.*).

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* Another objection to the use of the name *edusa* for a *Colias* is that, in his 'Genera Insectorum,' Fabricius used it for *Synchloe daplidice*.

HESPERIIDÆ.

24. CHARCHARODUS ALTHEÆ.

Papilio altheæ, Hübner, Eur. Schmett. i. figs. 452, 453 (1798–1803).

Seir, Aug. 13–16, 1898.

25. ADOPŒA LINEOLA.

Papilio lineola, Ochsenheimer, Schmett. Eur. i. p. 230 (1808).

♂, Urmi (*Daltry coll.*).

26. AUGIADES SYLVANUS?

Papilio sylvanus, Esper, Eur. Schmett. i. 1, pl. 36. fig. 1 (1778?).

♀, Urmi (*Daltry coll.*).

The single example is larger than any specimen of this species which I have seen.

INSECTA (LEPIDOPTERA PHALÆNÆ).

By Sir G. F. HAMPSON, Bart.

THE following species have been identified in the collections made by Mr. R. T. Günther.

SYNTOMIDÆ.

SYNTOMIS PERSICA, *Koll. Denkschr. Akad. Wiss. Wien, Math.-nat. Classe,* i. p. 53 (1850); *Hmpsn. Cat. Lep. Phal. B. M.* i. p. 101, pl. iv. f. 5.

Urmi (*Daltry*), 2 ♂. Only known previously by the type ♂ in bad condition in the Vienna Museum; the patagia are yellowish white.

ARCTIADÆ.

DEIOPEIA PULCHELLA, *Linn. Syst. Nat.* 1, ii. p. 884.

Urmi (*Daltry*), 1 ♀.

NOCTUIDÆ.

AGROTIS YPSILON, *Rott. Naturf.* xi. p. 141.

Urmi (*Daltry*), 1 ♀.

AGROTIS CHRISTOPHI, *Stgr. Berl. e. Zeit.* 1870, p. 110.

Seir near Urmi (*Günther*), 1 ♀; Urmi (*Daltry*), 1 ♂.

HADENA BIMACULOSA, *Linn. Syst. Nat.* xii. p. 856.

Urmi (*Daltry*), 3 ♀.

ACRONYCTA CENTRALIS, *Stgr.*

Urmi (*Daltry*), 2 ♂, 1 ♀.

ULOCHLÆNA HIRTA, *Hübn. Eur. Schmett., Noct.* f. 591.
Urmi (*Daltry*), 1 ♂.

EPISEMA GLAUCINA, *Esp. Eur. Schmett.* 81. 4, 5.
Urmi (*Daltry*), 1 ♂.

XANTHIA OCELLARIS, *Bork. Nat. Eur. Schmett.* iv. 647.
Urmi (*Daltry*), 1 ♂.

BRYOPHILA PERLA, *Schiff. Wien. Verz.* p. 70.
Urmi (*Günther*), 1 ♂.

TARACHE LUCTUOSA, *Schiff. Wien. Verz.* p. 90.
Urmi (*Daltry*), 1 ♂.

TARACHE SULPHURALIS, *Linn. Syst. Nat.* i. 2. p. 881.
Urmi (*Daltry*), 2 ♂.

XANTHOPTERA TRIANGULARIS, *Warr. P. Z. S.* 1888, p. 309.
Urmi (*Günther*), 1 ♂.

CATOCALA NEONYMPHA, *Esp. Eur. Schmett.* 198. 1, 2.
Urmi (*Daltry*), 1 ♂.

CATOCALA ELOCATA, *Esp. Eur. Schmett.* 99. 1, 2.
Urmi (*Daltry*), 2 ♂; Seir (*Günther*), 2 ♂.

EUCLIDIA MI, *Clerck, Icones*, pl. 9. f. 5.
Urmi (*Daltry*), 1 ♂.

LYMANTRIADÆ.

LYMANTRIA DISPAR, *Linn. Syst. Nat.* x. 501.
Urmi (*Daltry*), 1 ♂.

SATURNIADÆ.

SATURNIA PYRI, *Schiff. Wien. Verz.* p. 49.
Urmi (*Daltry*), 1 ♂.

SPHINGIDÆ.

SMERINTHUS POPULI, *Linn. Syst. Nat.* x. p. 489.
Urmi (*Daltry*), 1 ♂.

MACROGLOSSA STELLATARUM, *Linn. Syst. Nat.* x. p. 493.
Urmi (*Daltry*), 1 ♂.

NOTODONTIDÆ.

DICRANURA VINULA, *Linn. Syst. Nat.* x. p. 499.
Urmi (*Daltry*), 1 ♂.

GEOMETRIDÆ.

MACARIA MURINARIA, *Schiff. Wien. Verz.* p. 105.
Urmi (*Günther*), 1 ♀.

ANAITIS PLAGIATA, *Linn. Syst. Nat.* x. p. 526.
Urmi (*Daltry*), 1 ♂.

ANAITIS USGENTARIA, *Stgr.*
Urmi (*Daltry*), 1 ♀.

CATACLYSME BILINEATA, *Linn. Syst. Nat.* x. p. 525.
Urmi (*Daltry*), 1 ♂, 1 ♀.

EUPITHECIA SUBUMBRATA, *Schiff. Wien. Verz.* p. 110.
Urmi (*Günther*), 2 ♂, 1 ♀.

RHODOSTROPHIA CALABRARIA, *Zell. Stett. e. Zeit.* 1852, p. 180.
Urmi (*Daltry*), 2 ♂.

RHODOSTROPHIA INCONSPICUA, *Butl. P. Z. S.* 1886, p. 391.
Urmi (*Daltry*), 1 ♂.

CRASPEDIA MARGINEPUNCTATA, *Goeze, Beytr.* iii. 3, p. 385.
Urmi (*Daltry*), 1 ♂.

LASIOCAMPIDÆ.

METANASTRIA TRIFOLII, *Schiff. Wien. Verz.* p. 53.
Ab. *terreni*, H.-S. Eur. Schmett. ff. 120, 121.
Transcaucasia, Kivorak (*Günther*), 1 ♂.

CLISIOCAMPA CASTRENSIS, *Linn. Syst. Nat.* x. p. 500.
Urmi (*Daltry*), 2 ♀ of a very pale form.

PSYCHIDÆ.

APTERONA CRENULELLA, *Bruand. Mon. Psych.* p. 76, f. 49.
Urmi (*Günther*), 3 larva-cases on a piece of bark.

ZYGÆNIDÆ.

ZYGÆNA CUVIERI, *Boisd. Mon. Zyg.* iii. 6, p. 53.
Urmi (*Daltry*), 1 ♂.

PYRALIDÆ.

HETEROGRAPHIS PYRETHRELLA, *Herr.-Schäff. Neue Schmett.* 80, p. 12.
Seir, near Urmi (*Günther*), 1 ♂.

AGLOSSA PINGUINALIS, *Linn. Syst. Nat.* x. p. 533.
Urmi (*Günther*), 1 ♂.

PYRALIS FARINALIS, *Linn. Syst. Nat.* x. p. 226.
Urmi (*Daltry*), 1 ♂.

HYPSOPYGIA COSTALIS, *Fabr. Syst. Ent.* p. 132.
Seir, near Urmi (*Günther*), 2 ♂.

SCOPARIA CEMBRÆ, *Haworth, Lep. Br.* p. 498.
Seir, near Urmi (*Günther*), 2 ♂.

NOMOPHILA NOCTUELLA, *Schiff. Wien. Verz.* p. 136.
Seir, near Urmi (*Günther*), 1 ♂.

PYRAUSTA CESPITALIS, *Schiff. Wien. Verz.* p. 123.
Seir, near Urmi (*Günther*), 2 ♂.

PYRAUSTA AURATA, *Scop. Ent. Carn.* no. 565.
Seir, near Urmi (*Günther*), 1 ♂.

ORNEODIDÆ.

ORNEODES sp.
Seir, near Urmi (*Günther*), 2 ♂.

TINEIDÆ.

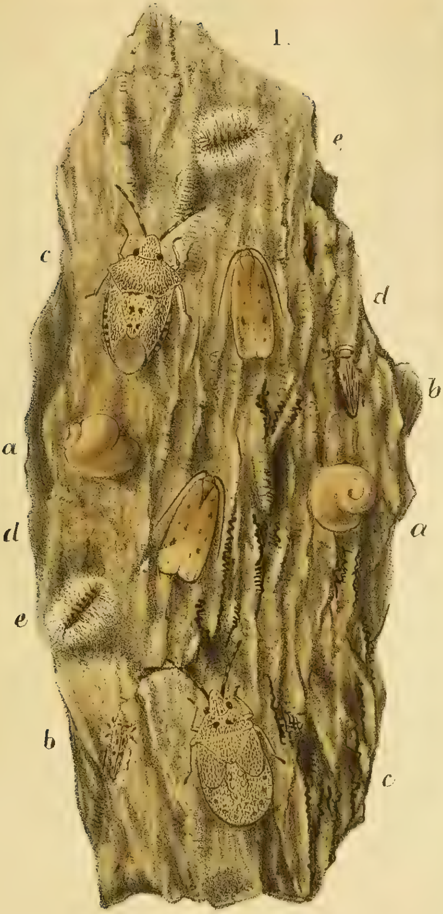
Three species undetermined.

NEUROPTERA (Hemerobiidæ) AND DIPTERA.

By ROBERT T. GÜNTHER, M.A., F.R.G.S.

(PLATE 27.)

ON Plate 27. fig. 2 is figured the larva of one of the Hemerobiidæ or Lacewing flies, which both in structure and habit is related to the larva of *Chrysopa perla*, and is not unlike the larva of an *Hemerobius*? figured by Sowerby in his 'British Miscellany,' pl. 66. The entire animal was hardly larger than a hemp-seed; the body is long and distinctly segmented; the head carries a pair of powerful mandibles, which are about one-third of the length of the body. The labial palps are at least 3-jointed, and the antennæ are longer than the mandibles and are unjointed. Immediately behind the conspicuous eyes are two knobs, each bearing a tuft of some two dozen white hairs; to these succeed four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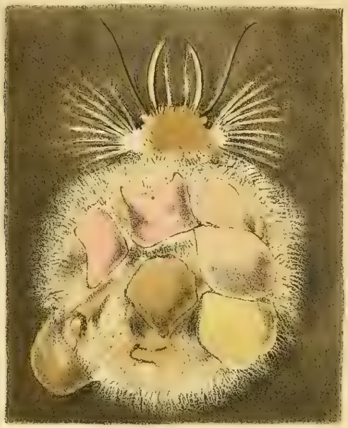
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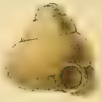
1a.


3.


3a.


4.

J. Green del. et lith

Mintern Bros. Chromo

INSECTA AND ACARID FROM LAKE URMI.

other pairs of similarly tufted basal knobs borne by the succeeding tergal portions of the segments. The posterior tufts carry a large globular mass of white cottony threads, like American blight, in which are entangled the inedible portions of the carcases of its prey. Upon a specimen captured on rocks near Seir the dry cuticle of a small spider was distinguishable.

DIPTERA.

Ephydra urmiana, sp. n. (Plate 27. fig. 3.)

The larvæ which are found in considerable numbers near the margin of the lake are so similar to the larvæ of *Ephydra salinaria* which were observed by Klug in "Salzsiederei" in Silesia, and described by Loew, and to the halophilous larvæ of *Ephydra* described by Packard, that I have no hesitation in referring them to the same genus. At the same time, the larva of the *Ephydra* of Lake Urmi does not agree with either *E. salinaria* or with *E. halophila*, and it is to accentuate this fact that I have ventured to base a new species upon a larval form.

The larvæ of *E. urmiana* caught on July 21st near Superghan were whitish in colour, and about 10 millim. long. The body is composed of eleven segments, nearly cylindrical, and pointed anteriorly but terminating bluntly behind, unlike the larva of *E. salinaria* (Westwood, Introduction, fig. 132, no. 11). The last segment is prolonged dorsally into a long bifurcated respiratory process, three-sevenths the length of the body, and containing two tracheal vessels which open by two spiracles situated at the tips of the two branches. Mouth-parts present. All but the first three smaller segments are provided with two groups of chitinous bristles, mounted on inconspicuous tubercles. Abdominal appendages, like those of the larva of *E. halophila*, absent.

The rarity of halophilous insects must enhance the interest attaching to the particulars of their life-histories, and consequently it is much to be desired that some naturalist should endeavour to rear the adult imago of this remarkable fly. The only other species of Diptera which have been recorded, so far as I am aware, from very salt water are:—

Ephydra salinaria (*Halmopota salinaria*) in Silesia, Dürrenberg, &c. (Westwood, loc. cit.; Bouché, Naturg.; Loew, Zeit. Naturwiss, Halle, 1867).

Ephydra halophila in Illinois. (Packard, Proc. Essex Inst. vi. 1869; Verrill, Proc. Boston Soc. 1866.)

Chironomus oceanicus in Salem Harbour. (Packard, loc. cit.)

Chironomus sp. in Utah. (Stansbury, Report on Valley of Great Salt Lake of Utah.)

Halophilus in Illinois and Salem Harbour. (Packard, loc. cit.).

EXPLANATION OF PLATE 27.

Fig. 1. Group of insects upon the bark of *Populus alba* (p. 367).
  a. Larva-cases of *Apterona crenulella.* *b. Bathyscopus pocillus.* *c. Pentatoma baccarum* (?) *. *d. Yponomeuta padellus*, L. *e.* Moulted skin of larval insect.
2. Larva of *Hemerobius* sp.
3. Larva of *Ephydra urmiana.*
4. Acarid upon *Machilis persa* (?).

* Or some allied species. The identification is that of Mr. C. O. Waterhouse.

ORTHOPTERA.

By MALCOLM BURR, F.Z.S., F.E.S.

THE small collection of Orthoptera made by Mr. R. T. Günther in North-west Persia contains twelve species, of which one is a new variety of a well-known species. The most interesting capture, perhaps, is the *Decticus assimilis* Fieb.

It is unfortunate that they have been preserved in spirit, which has bleached the colours of all, especially of the Œdipodidæ.

FORFICULARIA.

FORFICULA AURICULARIA, *L.*

Seir, N.W. Persia. 2 ♂, 1 ♀.

The two males represent the variety figured by Fischer (Orth. Eur. tab. vi. fig. 11 *l*). The Marquis Doria captured the same form in Northern Persia some years ago, and quite recently a similar specimen, undoubtedly British, was exhibited at the South London Natural History Society. It differs from the type in the narrowness of the dilated part of the male forceps above the tooth.

In the typical form the part of the forceps from base to this tooth is contiguous, the sides of the branches being parallel. In this variety the inner margins of the basal part diverge, making roughly a triangular area between the pygidium and the teeth of the forceps.

Mantodea.

Bolivaria brachyptera, *Pall.*

Seir, 2 ♂, 6 ♀; Koyun Daghi, 1 ♂, 1 ♀.

This species is common in Southern Russia, the Caucasus and Asia Minor.

Acridiodea.

Truxalidæ.

Truxalis unguiculata, *Ramb.*

Seir. 1 ♀. A widely distributed species.

Œdipodidæ.

Œdipoda Schochii, *Br.*

Seir, Aug. 16, 1898. 1 ♀.

This specimen, of which the wings have been bleached by the spirit, is 35 millim. in length; de Saussure gives 32 millim. as the dimensions of the female. Recorded from Aleppo and the Caucasus.

Sphingonotus satrapes, *Sauss.*?

Seir, Aug. 16, 1898. 1 ♂.

This specimen does not agree perfectly with de Saussure's description, the posterior femora showing no black; but this character may have well been destroyed by the spirit, which has considerably bleached it. The colour of the wings has entirely gone, leaving a whitish base, with the black fascia. I hesitate to regard it as distinct.

Œdalius nigrofasciatus, *De Geer.*

Seir, Aug. 16, 1898. 1 ♀.

Pyrgodera cristata, *F. de W.*

Seir, Aug. 16, 1898. 1 ♂.

A native of temperate Asia and Eastern Europe.

Acridiidæ.

Caloptenus italicus, L.

Found at Superghan, July 22nd, infested with *Astoma gryllaria* (see p. 407).

Pyrgomorphidæ.

Pyrgomorpha grylloides, *Latr.*, var. nov. Guentheri.

Seir. 4 ♀.

A *P. grylloide* typico differt, elytris alisque, in feminis saltem abbreviatis, segmentum abdominale quintum attingentibus.

The shortness of the elytra and wings gives this form an appearance different from the type, but the comparative development of organs of flight in Orthoptera is too slender a character on which to base a species.

LOCUSTODEA.

DECTICIDÆ.

PACHYTRACHELUS sp.

Seir, Aug. 16, 1898. 1 ♀.

This is very probably a new species, but it is impossible to describe it without the male. It is close to *P. striolatus*, Fieb.

DECTICUS ASSIMILIS, Fieb.

Seir. 2 ♀.

Both these specimens are considerably larger than an example in my collection from Tiflis, approaching more nearly to *D. albifrons*, Fabr., in size and appearance. It has hitherto been recorded by Brunner and Fieber from "Tiflis and Syria."

GRYLLODEA.

GRYLLOTALPIDÆ.

GRYLLOTALPA GRYLLOTALPA, *L.*

Seir, Urmi. Several specimens, in all stages of development. Mole-crickets were always abundant, but at the same time I never met the swarms which have been described from the neighbourhood of Ispahan and Shiraz, where one intelligent observer estimated their numbers at one to every square fathom over an area of many square miles.—R. T. G.)

NOTE ON A JURASSIC AMMONITE.

By G. C. CRICK, F.G.S., of the British Museum (Natural History).

THE only Jurassic fossil in Mr. R. T. Günther's collection is an Ammonite preserved on the surface of a small block of limestone of reddish-brown colour. It consists of a portion of the outer whorl that has been much flattened during fossilization, and of the impression of the greater part of the rest of the shell.

Jurassic Ammonites have been recorded from N.W. Persia by

Weithofer* and by Borne†; and the present specimen is doubtless referable to *Perisphinctes curvicosta*, Oppel, sp.‡, a species which Borne has recorded and figured (*op. cit.* p. 14, pl. i. fig. 1; pl. iv. fig. 14) from rocks of Callovian age in the neighbourhood of Maragha, whence the present specimen is believed to have come.

FOSSIL ECHINOIDEA.

By J. W. Gregory, D.Sc., F.G.S.

(Plate 28.)

Mr. Günther's collection of Echinoidea consists of five specimens all of which belong to the genus *Clypeaster*. According to Mr. Günther, they are "said to have come from Guverchin Kala, at the extreme northern end of Lake Urmi." This locality is no doubt the same as the Guverchine Kalak where the Hon. W. K. Loftus made a collection of fossils now in the British Museum.

Miocene Echinoidea from Lake Urmi have been described by Abich §, who has recorded thence eight species of *Clypeaster*.

1. Clypeaster aff. imperialis, *Michelin* ||, 1861. (Plate 28. fig. 1.)

The most massive Clypeaster in the collection is unfortunately so much broken on the margin and base that its positive determination is impossible. But it clearly belongs to the group of Clypeasters of which *C. olisiponensis*, Mich.¶, may be taken as the type. From that species the Urmi echinid differs by having

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* K. Weithofer, "Ueber Jura und Kreide im nordwestlichen Persien": Sitzungsb. d. k.-k. Akad. Wissensch. Wien, Bd. xcviii. Abth. 1, Dec. 1889.

† G. v. dem Borne, 'Der Jura am Ostufer des Urmiasees.' Inaugural Dissertation. Halle, 1891.

‡ A. Oppel, 'Die Juraformation,' p. 555 (1857). See also J. v. Siemiradzki, "Monographische Beschreibung der Ammonitengattung *Perisphinctes*": Palæontographica, Bd. xlv. p. 96, 1898.

§ H. Abich, "Ueber das Steinsalz und seine geologische Stellung im Russischen Armenien," Mém. Ac. Imp. Sci. St. Pétersb. ser. 6, vol. ix. pt. 1, Mém. Sci. Math.-Phys. vol. vii. 1859, pp. 111–114; and 'Geologische Forschungen in den Kaukasischen Ländern, Abth. ii. Geologie der Armenischen Hochlandes,' i. 1882, pp. 223–225, 270–283.

|| H. Michelin, "Monographie des Clypéastres fossiles," Mém. Soc. Géol. France, ser. 2, vol. vii. p. 118, pl. xviii. figs. 2, *a–d*.

¶ Michelin, *op. cit.* p. 118, pl. xx. figs. 1, *a–f*.

the height one half the length and not one-third; moreover, the granules on the ridges between the poriferous furrows are less numerous. In these respects the fossil agrees more closely with *C. imperialis*, a Miocene species from Crete. Michelin's figures do not show the side-view of the test, but in his description he gives dimensions which show the proportions.

The following table illustrates the relations of the Cretan and Armenian specimens of *C. imperialis* and *C. olisiponensis*:—

	C. imperialis.		*C. olisiponensis.*
	Michelin's type.	Specimen from Urmi.	Type.
Height	75 mm.	47 mm.	40 mm.
Length	175 „	92 „	127 „
Width	145 „	87 „	105 „
Ratio of height to length	1 : 2·3	1 : 1·95	1 : 3·0
„ „ width	1 : 1·9	1 : 1·85	1 : 2·6
Number of granules on ridge between interporiferous furrows	5	3–4	10

These dimensions show that the specimen is far closer to *C. imperialis* than to *C. olisiponensis*. As the elevation of the test is not illustrated in Michelin's figures, that aspect is shown on Plate 28. fig. 1. The petals in this specimen are unusually flat, and the test is very thick.

2. CLYPEASTER GUENTHERI, n. sp. (Plate 28. fig. 2.)

Diagnosis.—Test pentagonal, with well-rounded angles. The base is flat, with sharp, slightly sinuous ambitus. Upper surface flattened. Anterior slope at an angle of 45°–50°, fairly regular; posterior slope steep to a posterior foot-like projection. Length of test approximately equal to the width, and 3½ times as great as the height. Apical disc excentric posteriorly.

Petals very tumid, broad and completely closed externally; the outer end is broad and well rounded. The petals are long, and reach about three-fourths of the distance from apical area to the ambitus. The anterior ambulacrum is longer than those of the parietal series.

Periproct large, circular, and close to the margin.

Granules of interporiferous ridges about four on each ridge.

Dimensions.

	Specimen from Urmi.	Specimen figured by Abich.	*C. turritus*, Phil.		
	mm.	mm.	mm.	mm.	mm.
Height	23	45	37	37	67
Length	82	120	55	75	119
Width	81	112	52	64	112

Affinities.—A large specimen of this species was figured by Abich as *Clypeaster turritus*, Philippi, a species which was admirably figured and described by its founder [*]. The specimen referred to *C. turritus* by Abich seems to me a very distinct form. In *C. turritus* the height is almost exactly half the length, whereas in Mr. Günther's specimen it is less than a third the length; in Abich's specimen it is almost a third the length. A still more important difference is in the length of the petals. In *C. turritus* the ratio of the length of the petal to the non-petaloid portion of the ambulacrum between the petal and the ambitus is as 2 : 1. In *C. Guentheri* the ratio is as 3 : 1.

C. turritus is one of the conical, pyramidal species of *Clypeaster*. *C. Guentheri*, on the contrary, is one of the flat-topped, depressed species. Its nearest ally is *C. gibbosus* (Risso) [†], which differs in having a higher and longer test and fewer granules on the interporiferous ridges.

Fischer [‡] has already suggested that Abich's *C. turritus* should be included as a synonym of *C. gibbosus*. But Fischer figured as *C. gibbosus* an echinid which is distinct from Abich's *C. gibbosus*; Fischer's *C. altus* [§] is, however, probably the same as *C. Guentheri* and *C. turritus* of Abich.

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[*] R. A. Philippi, "Ueber *Clypeaster altus, C. turritus,* und *C. scillæ,*" Palæontogr. vol. i. 18—, p. 323, pl. xxxviii. figs. 1–5.

[†] *Scutella gibbosa*, Risso, Hist. Nat. Europe mérid. 1826, v. p. 284; Michelin, *op. cit.* p. 120, pl. xxii. figs. *a–g*, pl. xxiii. figs. 1, *a–c*.

[‡] P. Fischer in Tchihatcheff, "Asie Mineure," Paleontologie, 1866–69, p. 306.

[§] *Ibid.* p. 308, pl. vii. fig. 1.

Pomel[*] has founded a species, *C. suboblongus*, on some specimens from Corsica and Algeria, which are closely allied to *C. Guentheri*, but they appear to me to be closer to *C. gibbosus*. *C. suboblongus*, at any rate, differs from *C. Guentheri* by having a longer and more gradual posterior slope, without the separation into the steep upper part and thin basal foot. In *C. Guentheri*, moreover, the petals are proportionately longer, and the interporiferous granules less numerous, and there are fewer plates in the petaloid portions of the ambulacra (about 40 instead of about 60).

Abich included *C. altus* in his synonyms of *C. turritus*; but in his explanation of plates he quoted the specimen as *C. altus*, Lam., var. *turritus*, Philippi. That he was right in identifying *C. turritus* with *C. altus* I have urged previously[†]. Later on, Abich figured another specimen of *C. altus*; the specimen cannot be determined satisfactorily from the figure, but the echinid is certainly not a *Clypeaster*, and is probably a *Conoclypeus*.

3. CLYPEASTER MARTINI, *Desmoulins*[‡].

Abich, in 1882, figured an echinid from the Lower Miocene of Mamachatun which he referred to this species; the specimen is imperfect, and the ambulacra are so badly shown that the identification might have been questioned. But Mr. Günther's collection includes three specimens which must, I think, be referred to *C. Martini*, and thus support Abich's identification. Mr. Loftus's collection in the British Museum includes another specimen (E. 2446) which may be included in the same species, though the petals are more tumid than in the other specimens.

The five specimens in question are by no means identical in form. One of Mr. Günther's specimens is too fragmentary to be of service; but the dimensions of the other four specimens and of Michelin's figured specimen of *C. Martini* are given on the opposite page. The dimensions for *C. melitensis*, Mich., and *C. Michelotti*, Ag. (*fide* Michelin) are also added.

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[*] A. Pomel, 'Paléontologie de l'Algérie: Zooph., Fasc. 2. Échinodermes,' Livr. 2, 1887, pp. 192–3, pl. B xxiii. figs. 1–6.

[†] J. W. Gregory, "The Maltese Fossil Echinoidea," Trans. R. Soc. Edinb. vol. xxxvi. pt. 3, 1891, p. 594.

[‡] C. Desmoulins, "Études sur les Échinides," Mém. 3, Actes Soc. Linn. Bordeaux, vol. ix. 1837, p. 64; Michelin, *op. cit.* p. 134, pl. xxxv. fig. 1.

	Figured by Abich.	Mr. Günther's specimens.		Loftus Collection.	Michelin's type.	*C. melitensis.*	*C. Michelotti.*
Height	14 mm.	21 mm.	26 mm.	32 mm.	19 mm.	45 mm.	20–35 mm.
Length	100 ,,	? 100 ,,	101 ,,	90 ,,	98 ,,	170 ,,	90–145 ,,
Width at anterior angle..............	85 ,,	89 ,,	88 ,,	75·5 ,,	84 ,,	150 ,,	
,, posterior ,, ...	83 ,,	77 ,,	—	72 ,,	78 ,,		80–130 ,,
Ratio of length of petal to radius of the test	—	3 : 5	3 : 4·9	3 : 4·3	3 : 4·8	3 : 4	3 : 4·1
Number of granules on interporiferous ridge	—	6	8	–	5–8	10	9

The main difference between the three specimens of *C. Martini* from Guverchin Kala is in the tumidity of the ambulacra. This character is least developed in the more broken of Mr. Günther's specimens, and most pronounced in the specimen in the Loftus Collection, which presents an approach to *C. crassicostatus*, Agassiz.*

Among the specimens of *Clypeaster* from the Indian Cainozoic this species is closest to *C. faloriensis*, Dunc. & Sladen †, which has the same long open petals and depressed test; but in the Indian specimen the margin is tumid and the height of the test less.

FOSSIL CORALS.

By J. W. Gregory, D.Sc., F.G.S.

(Plate 28.)

The fossil corals in Mr. Günther's collection from Lake Urmi number 19 specimens, of which 6 came from the conglomerates at Seir, 6 or 8 miles west from the lake, and 8 came from the island of Koyun Daghi; the exact locality of the remainder is not stated. One of the specimens from Seir and one from Koyun Daghi are indeterminable. The rest may be divided among eight species, which have been previously recorded or described from Lake Urmi by Abich ‡. The corals are Miocene, and mainly Helvetian in affinities. The *Ostrea-Virleti* beds which yield *Thamnaræa polymorpha* are shown by the Mollusca, according to Mr. R. B. Newton, to be Tortonian in age.

1. Orbicella Defrancei (*Edwards & Haime*), 1849.

One of the best-preserved corals in Mr. Günther's collection is a fragment of a flat tabular corallum, about 15 mm. thick, in which the septa number three orders with rarely a rudimentary septum of the fourth order; the septa are thick near the margin, but have no paliform lobes; the columella is parietal, but strong

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* Michelin, *op. cit.* p. 115, pl. xvii. figs. 1, *a–f*.

† Duncan & Sladen, "Fossil Echinoidea of Kachh and Kattywar," Pal. Indica, ser. XIV. vol. i. pt. 4, 1883, p. 50, pl. xii. fig. 15.

‡ H. Abich, 1859, "Ueber das Steinsalz und seine geologische Stellung im Russischen Armenien," Mém. Ac. Imp. Sci. St. Pétersb. ser. 6, vol. ix. pt. 1, Mém. Sci. Math.-Phys. vol. vii. pp. 89–102; and 1882, 'Geologische Forschungen in den Kaukasischen Ländern,' Abth. ii. Geologie des Armenischen Hochlandes, i. Westhälfte, pp. 270, 273, 274, 281–283.

and rod-like; the exotheca develops as horizontal layers, and is not vesicular; the costæ are long and prominent on the surface; the calices are 5–6 mm. in diameter, and are separated by exothecal bands from 2–6 mm. in width.

The coral is accordingly an *Orbicella*, and agrees very closely in structure with the corals from Urmi figured by Abich [*] in 1859 as *Astrea Guettardi*. That the coral is identical with that so determined by Abich I have no doubt; but his naming of the species is open to question. *Orbicella Guettardi* was founded by Defrance [†] on a figure by Guettard [‡]; the species has been admirably refigured by von Reuss [§], and described by Edwards and Haime [||]. Von Reuss's figures confirm those of Guettard in showing that the exotheca is vesicular, that the septa are four cycles in number, that at least the primary septa have paliform thickenings, and that the diameter of the calices is over 10 mm. In all these characters the Urmi specimens are different; the septa belong to 3 cycles, there are no paliform lobes, the exotheca is lamellar, and the calices are from 5–6 mm. in diameter. The Persian specimens must therefore be transferred to *O. Defrancei* (Ed. & H.) [¶], a Lower Miocene species from Dax and Northern Italy, which has been recorded from Asia Minor by Fischer [**], whose figures agree with those of Abich and with Mr. Günther's specimen. Michelin [††] has figured the species from Northern Italy under the name of *A. argus*, Lam., and von Reuss [‡‡] has given excellent figures of it. The specimens figured by Abich [§§] as *Astrea Defrancei* are different, and one of them is here described as a new species.

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[*] H. Abich, *op. cit.* 1859, p. 89, pl. ii. fig. 4, pl. v. fig. 5.

[†] Defrance, 1826, Dict. Sci. Nat. vol. xlii. p. 379.

[‡] Guettard, Mém. sur differ. Parties Sci., vol. iii. 1770, pl. xlviii. figs. 2–4.

[§] Von Reuss, "Pal. ält. Tertiärsch. Alpen," Denkschr. Akad. Wiss. Wien, vol. xxviii. 1869, p. 245, pl. xxiii. figs. 1, 2.

[||] Milne-Edwards & Haime, Hist. Nat. Cor. vol. ii. 1857, p. 462.

[¶] Milne-Edwards & Haime, Mém. Astr. pt. 3, Ann. Sci. Nat., Zool. ser. 3, vol. xii. 1849, p. 106.

[**] P. Fischer in Tchihatcheff's 'L'Asie Mineure,' Paléont., 1866–1869, p. 314, pl. xvi. figs. 4–6.

[††] H. Michelin, Icon. Zooph. 1842, p. 59, pl. xii. fig. 6.

[‡‡] Von Reuss, "Foss. Kor. öster.-ung. Mioc.," Denk. Ak. Wiss. Wien, vol. xxxi. 1871, p. 239, pl. ix. fig. 3, pl. x. fig. 1.

[§§] Abich, 1859, *op. cit.* p. 93, pl. ix. fig. 6; 1882, *op. cit.* pp. 272, 273, pl. vii. figs. 15–20.

2. **Orbicella Guentheri**, n. sp.

Diagnosis. Corallum massive, and growing apparently in tabular expansions.

Corallites of medium size; closely packed, and therefore appearing angular in shape, and usually hexagonal. Exotheca narrow but dense, forming a stout wall.

Septa three complete orders, and an imperfect fourth order represented. Seen from the exterior, the six primary septa are especially conspicuous.

Columella large, appearing substyliform.

Dimensions.

	From Abich's figure.	Specimen from Seir.
	mm.	mm.
Diameter of corallites	8–9	5–7
Diameter of calice	5–6	3–4
Width of wall	1½–2	½–1½

Affinities. This species is founded on three corals—one figured by Abich * as *Astrea Defrancei,* and the other two collected by Mr. Günther in the conglomerate of Seir, 6 to 8 miles west from Lake Urmi. The corals agree very closely, the only difference between them is the somewhat smaller diameter of the corallites in the specimens from Seir.

The coral differs from *O. Defrancei* in three important characters:—The corallites are smaller in diameter; the wall is narrower, denser, and not lamellar; the corallites are polygonal, and they are not divided by valleys or depressions between the raised calycinal margins. Hence the coral appears to me quite distinct from *O. Defrancei.* It may be distinguished from *O. vesiculosus* (Ed. & H.) † owing to the absence of the vesicular endotheca and exotheca.

In 1882 Abich figured two additional Armenian astreans as *Heliastræa Defrancei.* Of these the first variety ‡ is probably

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* Abich, 1859, *op. cit.* p. 93, pl. ix. fig. 6; ? also 1882, *op. cit.*, *Heliastræa Defrancei*, var. 1, p. 273, pl. vii. fig. 20.

† M.-Edwards & Haime, Mém. Astr. pt. 3, Ann. Sci. Nat., Zool. ser. 3, vol. xii. 1849, p. 107.

‡ Abich, 1882, *op. cit.* p. 273, pl. vii. fig. 20.

a specimen of *O. Guentheri*; the transverse section looks different from that of Abich's figure (pl. ix. fig. 6 *a*) of 1859, but that figure was probably based on an altered specimen in which the true internal structure was obscured. The second variety is no doubt a worn fragment of *O. Haimei* (d'Archiac) *.

3. Orbicella Haimei (*d'Archiac*) †, 1866.

This species was founded for a specimen said to come from the Lower Tertiary of Thrace. D'Archiac's figure agrees so closely with two specimens from the Seir conglomerate, that I feel doubt as to the correctness of the Thracian horizon. The two specimens agree in all essential characters; but the smaller specimen has been rolled and worn so that the corallites are left separated by a raised wall, instead of by intercalicular depressions.

The dimensions of the type and of the specimens from the Seir conglomerate are given herewith:—

	Type.	Specimens from Seir.	
	mm.	mm.	mm.
Length of corallum	130 by 75	80 by 50	70 by 50
Thickness „	—	70	30
Diameter of corallites	9–20 (average about 15).	8–15	15

The coral figured by Abich in 1882 ‡ as *Heliastræa Defrancei* var. 2, is probably a specimen of this species.

4. Solenastræa turonensis (*Michelin*), 1847 §.

This widely distributed Helvetian coral is represented by two specimens—a large mass 130 mm. in diameter from the conglomerate at Seir, and a rolled specimen from Koyun Daghi. In reference to the latter, it should be noted that the lithological condition of the fossil is very different from that of the other specimens from that island. As usual in fossil specimens of *Solen-*

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* Abich, *ibid.* p. 274, pl. vii. fig. 15.

† *Heliastræa Haimei*, d'Archiac in Tchihatcheff's 'L'Asie Mineure,' Paléont., 1866–69, p. 191, pl. xv. figs. 5, 6.

‡ Abich, 1882, *op. cit.* p. 274, pl. vii. fig. 15.

§ *Astræa turonensis*, Michelin, 1847, Icon. Zooph. p. 312, pl. lxxv. figs. 1, 2; *Solenastræa turonensis*, Edwards & Haime, 1857, Hist. Nat. Cor. vol. ii. p. 498.

astræa, the septa are seldom preserved; but they are shown in a few corallites of the Koyun Daghi example. The species occurs in Egypt[*], but has not, so far as I am aware, been previously recorded from Asia Minor or Persia. Abich[†] quotes a *Solenastræa astroites* from Lake Urmi, and that record may have been based on *S. turonensis*. Abich did not give figures, and accepted the species for the *Sarcinula astroites* (Goldf.)[‡], which, according to Milne-Edwards & Haime[§], is a synonym of *Orbicella Ellisi* (Defr.). That determination is quite consistent with Goldfuss's instructive figure. Abich quoted as a second reference the *Solenastræa columnaris* (Rss.)[||], which appears quite distinct both from "*Sarcinula astroites*" and from *Solenastræa turonensis*.

5. PRIONASTRÆA IRREGULARIS (*Defrance*), 1826[¶].

This species has been recorded from Armenia by Abich, who has figured a specimen collected between Malu and Khoi, which shows the deep steep-walled calicular fossa of this species. Mr. Günther's collection includes two specimens from Lake Urmi, exact locality not stated.

6. PHYLLOCŒNIA ARCHIACI, *Edwards & Haime*, 1848[**].

This species was recorded by Abich from Koyun Daghi, but his figures alone are not convincing of the specific identification. Mr. Günther has collected two other specimens from the same locality, which enable the characters to be more fully determined. The Armenian specimens differ from Milne-Edwards and Haime's diagnosis in the more solid nature of the exotheca and in the apparent absence of the numerous granulations on the costæ, which are said to be visible on worn specimens. The specimens from Koyun Daghi are extremely worn, and it may be that the

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[*] J. W. Gregory, "Egypt. Foss. Madrep.," Geol. Mag. dec. 4, vol. v. p. 247.

[†] Abich, 1882, *op. cit.* p. 282.

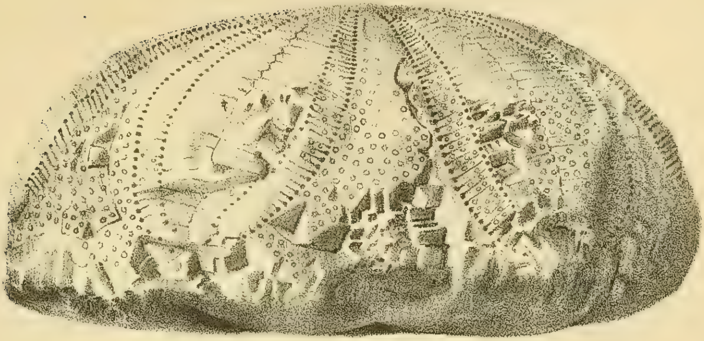
[‡] Goldfuss, Petref. Germ. vol. i. p. 73, pl. xxiv. fig. 12.

[§] Milne-Edwards & Haime, Hist. Nat. Cor. vol. ii. 1857, p. 467.

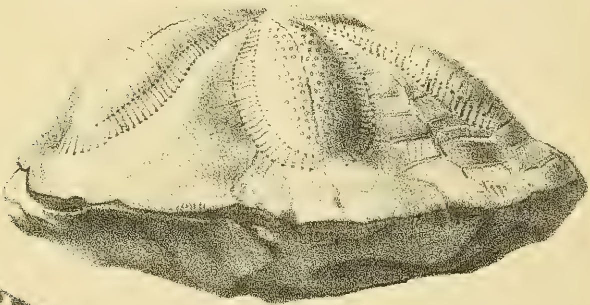
[||] Von Reuss, "Pal. ält. Tertiärsch. Alpen," pt. i. Denkschr. Ak. Wiss. Wien, vol. xxviii. 1868, p. 170, pl. xi. figs. 7–9.

[¶] *Astræa irregularis*, Defrance, 1826, Dict. Sci. Nat. vol. xlii. p. 381; *Cellastrea irregularis*, de Blainville, 1830, *ibid.* vol. lx. p. 342. Figured by Michelin, 1842, Icon. Zooph. p. 61, pl. xii. fig. 9, but the figure is indefinite.

[**] Milne-Edwards & Haime, Mon. Astr. pt. i., Ann. Sci. Nat., Zool. ser. 3, vol. x. 1848, p. 303.



1. $\frac{1}{1}$



2. $\frac{1}{1}$

3b. $\frac{10}{1}$

3a $\frac{10}{1}$

E. Drake ad nat. lith.
West, Newman imp

FOSSIL ECHINOIDEA AND CORALS, FROM LAKE URMI.

granulations have been thus obliterated. In the compactness of the exotheca the corals approach Abich's *Astrea grandistella* *, which, owing to the absence of columella, is probably also a *Phyllocœnia*; but as the nature of the exotheca and union of the corallites is not shown by the figures, its generic position cannot be absolutely determined.

The two specimens from Koyun Daghi are flat-topped, tabular coralla, and in the larger specimen the corallites show a tendency to become elliptical or subtriangular.

There is a third specimen in Mr. Günther's collection from Koyun Daghi referable to *Phyllocœnia*; it has well raised calicular margins, as in *P. irradians*, Ed. & H. †, but the fragment is too small and worn for satisfactory determination.

7. THAMNARÆA POLYMORPHA (*Abich*) ‡, 1859. (Plate 28. fig. 3.)

This interesting coral was well figured by Abich, whose specimens came from Lake Urmi and Malischent or Maku. Their specific identity with specimens collected on Koyun Daghi by Mr. Günther is unquestionable. The horizon of the coral on this island is settled by the fact that one of them is attached to an *Ostrea* which Mr. R. B. Newton has identified as *O. Virleti*.

The generic position of the coral is a matter of some interest, as *Thamnaræa* has not previously been recorded from Miocene or even Cainozoic deposits. That the coral is not a *Porites* is shown by three characters: the absence of pali, the strongly developed, imperforate septa, and the presence of the conspicuous synapticular platforms, which are well shown in Abich's figures. On casual inspection the coral appears spongiform rather than corallian in structure.

Thamnaræa was founded by Thurmann & Etallon § in 1864, and has recently been discussed by Dr. Ogilvie ||, who includes it in the Madreporidæ; but, with Etallon, von Zittel, and Duncan, I include it among the Microsolenidæ.

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* Abich, 1859, *op. cit.* p. 92, pl. ii. fig. 3.

† This species has been recorded from the Oligocene of Erivan by Abich, 1882, *op. cit.* p. 257, pl. vii. fig. 16.

‡ *Porites polymorpha*, Abich, 1859, *op. cit.* p. 100, pl. ix. figs. 1, *a–e*.

§ "Leth. Brunt.," Neue Denk. schweiz. Ges. Naturw. vol. xx. p. 411.

|| M. M. Ogilvie, "Kor. Stramb. Sch.," Palæontogr. Suppl. ii. pt. 7, p. 153.

8. ? PORITES LEIOPHYLLA, *von Reuss*[*], 1847.

The collection includes a large nodular corallum 100 mm. long by 80 mm. wide and 40 mm. thick, which is a cast of a *Porites*. It agrees in characters with Abich's[‡] description of the coral from the islands of Lake Urmi referred to *P. leiophylla*. It differs from von Reuss' type of that species by the greater size of the corallites. This feature may only be the result of the greater size of the corallum. The coral is only a cast, so that its determination is difficult, and it may be provisionally left in the species to which Abich assigned it. The corallites in the present specimen vary from 7–10 mm. in diameter.

EXPLANATION OF PLATE 28.

Fig. 1. *Clypeaster imperialis*, Mich., side view, nat. size.

2. *Clypeaster Guentheri*, n. sp., side view, nat. size.

3. Transverse and radial sections of *Thamnaræa polymorpha*, × 10 diam. Tortonian, Koyun Daghi, Lake Urmi.

   a. Transverse section across a series of corallites, × 10 diam.

   b. Section across part of a transverse section of a branch, showing the corallites cut longitudinally, with the synapticular platforms.

MARINE TERTIARY [MIOCENE] MOLLUSCA.

By R. BULLEN NEWTON, F.G.S., of the British Museum (Natural History).

(PLATES 29 & 30.)

INTRODUCTION.

THIS communication deals with a number of Marine Tertiary Mollusca obtained from Lake Urmi and its vicinity by Mr. R. T. Günther, who has generously presented the specimens to the Geological Department of the British Museum.

The specimens are mostly casts and frequently much water-worn, yet of considerable interest since they serve to increase the number of species already recorded from this area.

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[*] Von Reuss, "Foss. Polyp. Wien. Tertiärb.," Haid. Naturw. Abh. vol. ii. pt. 1, p. 28, pl. v. fig. 4.

[†] Abich, 1859, *op. cit.* p. 101.

One Lamellibranch, which appears to differ from every known form, is here described (p. 447) as a new species under the name of *Meretrix persiensis.*

Speaking generally, the collection consists of Miocene species, although a few of its members assume a facies indicative of the Aquitanian division of the Tertiary rocks, which by some authors (*e. g.* Gümbel and Fuchs) is regarded as Lower Miocene, and by Lapparent and others as Upper Oligocene.

From palæontological evidence it would appear that the Tertiary rocks of Lake Urmi form part of an extensive series of deposits which is traceable through Asia Minor, Southern Europe (Greece, Vienna Basin, Italy, and Spain), Egypt (Siwa Oasis, Pyramids, Geneffe), Northern Africa, and Madeira.

The following remarks on the localities represented in the collection may be of interest.

The majority of the specimens were obtained from the beach and cliffs of the Island of Koyun Daghi, which, according to Abich, has an elevation of 5258 feet above sea-level, and in section is seen to be composed entirely of Miocene rocks resting on a Palæozoic base—(*a*) the highest bed contains *Alectryonia Virleti*; (*b*) beds of marble appearance with Corals; (*c*) concretionary limestones with *Turritella Archimedis, T. turris, T. gradata*, &c.; (*d*) Palæozoic rocks.

The following species from this locality are represented in Mr. Günther's Collection:—

Alectryonia Virleti, *Ostrea pseudodigitalina*, *Ostrea lamellosa*, *Pecten suburmiensis*, *Pecten* allied to *Burdigalensis*, *Pecten* (*Flabellipecten*) sp. indet., *Chlamys* (*Æquipecten*) *Malvinæ* affin., *Chlamys* sp. indet., *Cardita* sp. indet., *Strombus* like *Bonelli*, *Conus* sp. indet., *Turritella Archimedis*, *Turritella gradata* var., *Turritella rotifera* affin., *Latirus crispus.*

In considering the zone or zones of the Miocene system to which these forms should be referred, it may be observed that the presence of *Alectryonia Virleti*, *Latirus crispus*, *Ostrea lamellosa*, &c., would suggest a later age than that represented by *Turritella Archimedis*, *T. gradata* var., *Pecten* allied to *Burdigalensis*, &c. It is therefore quite possible that these older species are of Helvetian age, whereas the others are probably Tortonian, or even later, as they occur also in Pliocene deposits. The specimens from Koyun Daghi are in a cream-coloured marly calcareous rock; those found on the beach being very much rounded and thickly impregnated with salt.

Another of Mr. Günther's localities is that of Guverchin Kala (see sections made by Mr. Loftus in 1855), from which the following species have been identified in his collection:—

Pecten convexocostatus, *Pecten suburmiensis*, *Venus Aglauræ*, *Meretrix persiensis*, *Meretrix* like *incrassata*, *Pyrula cingulata*, *Cassis* sp. indet.

This assemblage of forms is suggestive of two horizons—one, represented by *Pecten convexocostatus* and *P. suburmiensis*, which is probably Helvetian; the other, on account of such species as *Venus Aglauræ*, *Meretrix Persiensis*, *M.* like *incrassata*, *Pyrula cingulata*, *Cassis* sp. indet., is most likely of Burdigalian age or even older, as the shells referred to exhibit the Aquitanian facies before mentioned, besides being lithologically distinct. The Pectiniform species are in a light-coloured limestone; whereas the supposed older specimens are preserved as casts of reddish-brown colour, and came probably from near the base of the "Loftus Section" (? about no. 7 bed), having been collected and given to Mr. Günther by the Rev. C. Labaree, of the American Mission Station.

Some further specimens have been obtained from other localities close by, which are referred to in the body of this paper and do not call for any special reference now, except that, judging from their characters, they indicate a Lower Miocene age, and belong either to the Helvetian or Burdigalian stages of that period.

A summary of previous work on the invertebrate palæontology of Lake Urmi and neighbourhood may now be given.

In 1855 W. K. Loftus [*] published his geological researches on the Turko-Persian frontier, in which is described the "White Limestone" promontory (regarded by Loftus as of Upper Nummulitic age) bearing the ancient fortress of Guverchin Kala (=Castle Rock), situated at the northern extremity of Lake Urmi. A detailed section of this point, where the rocks rise perpendicularly to a height of more than 400 feet, is given thus (taken from p. 305 of the paper by Loftus):—

"The following is a careful descending section of the Castle

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[*] Loftus, W. K.—"On the Geology of Portions of the Turko-Persian Frontier and of the Districts adjoining," Quart. Journ. Geol. Soc. 1855, vol. xi. pp. 247–344, & Geological Map.

Rock. The beds are all conformable to each other, and dip at an angle of 7° towards the E.S.E., which dip is of course due to the igneous rocks of the Wurgowiz spur on the north.

"1. Compact, hard, crystalline, white limestone, becoming concretionary in passing downwards, afterwards marly.	
2. Light-blue marl, with hard flesh-coloured flints and nodules, and irregular fragments of limestone. It contains abundant Corals *in situ* and in layers, below which are numerous specimens of *Clypeaster*, *Echinolampas*, *Pecten*, *Serpula*, and casts of various Univalve and Bivalve shells.	
3. Compact mass of highly crystalline coralline nodules in hard marls.	
The thickness of the above three beds is about..	250 feet
4. Fine reddish gravel, or coarse sand-conglomerate, much hardened, and filled with fragments of fossils	18 ,,
5. Friable yellow sandstone, very finely grained, with fragmentary fossils	15 ,,
This bed passes into	
6. Hard and compact, grey, marly limestone, filled with Corals and casts of shells	6 ,,
7. Hard reddish marl, abounding in shells	21 ,,
8. Brownish-yellow, friable sandstones, with several thin layers of gravel and conglomerate, of variously-sized rounded pebbles	100 ,,
Total thickness of Section	410 ft."

Dr. H. Abich * issued his first paper on the palæontology of this region in 1858, accompanying it with an excellent geologically coloured map taking in the whole of the islands on Lake Urmi, and recognizing them as belonging to the "Miocène inférieur." His determinations of the fossils inclined him to consider that they should be referred to the "Molasse Moyen"

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* Abich, H.—"Tremblement de Terre observé à Tébriz en septembre 1856, Notices physiques et géographiques de M. Khanykof sur l'Azerbeidjan," Bull. Classe Physico-Math. Ac. Imp. Sci. Saint-Petérsbourg, 1858, vol. xvi. pp. 340–341, pl. iii. (=Geological Map: coloured).

or "Falunien" (Orbigny) age of the Mediterranean Basin, which he stated was identical with the "Calcaire Moëllon" of Marcel de Serres and very similar in characters to the Leithakalk of Austrian geologists.

This author also called attention to the great extent of the Miocene deposits, which he stated could be traced from Marocco through Greece to Lake Urmi.

The following fossils, collected by M. Khanykof from the islands on Lake Urmi, were listed without descriptions or figures as follows:—

Actinozoa (Corals):
- *Porites dendroidea*, n. sp.
- *Astræa Guettardi*, Defr.
- —— *Ellisiana*, Defr.
- —— *Defrancei*, M.-Edw.
- *Phyllocœnia Archiaci*?, M.-Edw.

Echinodermata:
- *Clypeaster altus*, Lam.
- —— *crassicostatus* affin., Ag.
- *Echinolampas complanatus*, n. sp.

Bryozoa:
- *Cellepora gracilis*, Münst.
- *Ceriopora palmata*, Orb.
- —— *anomala*, n. sp.
- *Polytrema spongiosa*, Orb.
- *Diastopora gemmifera*, n. sp.
- *Membranipora fenestrata*, Eichw.

Lamellibranchiata:
- *Ostrea Virleti*, Desh.
- —— *excavata*, Desh.
- —— *lamellosa*, Lam.
- *Pecten benedictus*, Lam.
- —— *flabelliformis*, Brocchi.
- —— *simplex*, Mich.
- *Spondylus bifrons*, Goldf. (Münst.).

Gasteropoda:
- *Haliotis Philberti*, Serres.

Much more systematic work on the fossils of this locality was carried out by Abich* in the same year, when he figured and described the following species as having been obtained from the "Bryozoen und Foraminiferen-Kalkstein" division of his "Supra-Nummulitenkalk" series, at Urmi and neighbourhood.

FORAMINIFERA:
- *Polystomella quaterpunctata*, n. sp.

ACTINOZOA (Corals):
- *Astræa Guettardi*, Defr.
- —— *Ellisiana*, Defr.
- —— *Defrancii*, M.-Edw.
- —— *grandistella*, n. sp.
- *Phyllocœnia d'Archiaci*, M.-Edw.
- *Porites polymorpha*, n. sp.
- —— *leiophylla*, Reuss.

ECHINODERMATA:
- *Clypeaster altus*, var. *turritus*, Phil.
- —— *diversicostatus*, n. sp.
- *Echinolampas complanatus*, n. sp.

BRYOZOA:
- *Ceriopora palmata*, Orb.
- *Polytrema spongiosa*, Phil.
- *Cellepora gracilis*, Münst.
- *Diastopora gemmifera*, n. sp.
- *Membranipora fenestrata*, Eichw.
- *Ceriopora anomala*, n. sp.

LAMELLIBRANCHIATA:
- *Pecten planicostatus*, n. sp., *P. convexocostatus*, n. sp., *P. benedictus*, Lam., *P. maximus*, Linn., *P. burdigalensis*, Lam., *P. flabelliformis*, Brocchi, *P. simplex*, Michelotti, *P. varius*, Linn.
- *Spondylus bifrons*, Goldfuss.
- *Ostrea Virleti*, Desh., *O. excavata*, Desh., *O. lamellosa*, Lamarck.

GASTEROPODA:
- *Haliotis Philberti*, Serres.

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* ABICH, H.—"Ueber das Steinsalz und seine geologische Stellung im Russischen Armenien," Mém. Ac. Imp. Sci. St. Petérsbourg, 1858, ser. 6, vol. vii. pp. 61–150, pls. 1–10. Although read December 14, 1856, and issued as an author's copy in 1857, this paper was not published until 1858.

During 1873 Dr. W. T. Blanford * published his views regarding the Salt swamps and lakes of Persia, including the lake of Urmi; and in 1876 the same author †, in his 'Eastern Persia,' gives a special chapter on the geology of Persia generally with an exhaustive *résumé* of all previous work on the subject.

A distinct advance was made by Dr. Abich ‡ in his great work of 1882, which includes a geological profile section of the islands (p. 275) on Lake Urmi, representing them to be composed of Miocene rocks resting on a Palæozoic base, having the *Ostrea Virleti*-beds at the top of the series. The elevation of the principal island, that of Koyun Daghi, is stated to be 5258 feet above sea-level.

In this work the following species of Miocene age are described and (mostly) figured as having been collected on the "Urmia Plateau":—

ACTINOZOA (Corals):
- *Phyllangia grandis*, Reuss.
- —— *alveolaris*, Catullo.
- *Cyathomorpha gregaria*, Catullo.
- —— *conglobata*, Reuss.
- *Astrangia princeps*, Reuss (allied).
- *Solenastræa astroites*, Goldfuss.
- *Heliastræa Guettardi*, Defr.
- *Porites polymorpha*, Abich.

ECHINODERMATA:
- *Clypeaster turritus*, Phil.
- —— *Scillæ*, Desm.
- *Echinolampas complanatus*, Abich.

LAMELLIBRANCHIATA:
- *Venus Aglauræ*, Brongn.
- *Pecten suburmiensis*, n. sp.
- —— *convexocostatus*, Abich.
- —— *lychnulus*, Fontannes.

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* BLANFORD, W. T.—"On the Nature and probable Origin of the Superficial Deposits in the Valleys and Deserts of Central Persia," Quart. Journ. Geol. Soc. 1873, vol. xxix. pp. 493–503.

† BLANFORD, W. T.—'Eastern Persia, an Account of the Journeys of the Persian Boundary Commission, 1870–1872': 1876, vol. ii. p. 439–506.

‡ ABICH, H.—'Geologie des Armenischen Hochlandes.' 1882.

Pecten Tournali, Serres.
—— *subopercularis*, n. sp.
—— *Malvinæ* (allied), Dubois.

GASTEROPODA:

Turritella Archimedis, Brongn.
—— *turris*, Orbigny.
—— *rotifera*, Desh. (allied to).
—— *gradata*, Menke, var.
—— *margarita*, n. sp.

These species are additional to those cited in Abich's work of 1858, which were mostly obtained from the islands on Lake Urmi; with the following alterations in nomenclature: *Pecten maximus* to be *P. Tournali*, Serres; *P. simplex* to be *P. Holgeri*, Geinitz.

Dr. Rodler * in 1888 reported the occurrence of Jurassic fossils at the following localities off the eastern side of Lake Urmi:—Aktahu-dere, Tazeh-kend, Ilditsch, Guschaisch, and the Karangu Valley. The genus *Harpoceras*, which was found in the Karangu Valley, he regarded as indicative of Middle or Upper Lias; whereas *Perisphinctes* from the other localities might belong to either the *P. polyplocus*-zone of Kimeridge age or the *P. curvicosta*-zone, which is Callovian. Rodler's researches also includes a chapter on the origin of Lake Urmi.

This was followed in 1890 by a memoir from Dr. K. Anton Weithofer † on the Jura and Cretaceous rocks of North-western Persia, in which the following Mollusca are described and partially figured, as having been collected to the east of Lake Urmi (Guschaisch and Tazeh-kend) in the neighbourhood of Maragha:—

UPPER LIAS:

Harpoceras cf. *radians*, Reinecke.
—— cf. *kurrianum*, Oppel.
Belemnites sp. indet.
Pecten cf. *disciformis*, Schübler.
Pleuromya sp. indet.

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* RODLER, Dr. ALFRED.—"Einige Bemerkungen zur Geologie Nordpersiens," Sitzunsgb. K. Akad. Wiss. (Wien), 1888, vol. xcvii. pt. i. pp. 203–212.

† WEITHOFER, Dr. K. ANT.—"Ueber Jura und Kreide aus dem nordwestlichen Persien," Sitzungsb. K. Akad. Wiss. (Wien), 1890, vol. xcviii. pt. i. pp. 756–773, pls. i. & ii.

UPPER OOLITE (Lower Kimeridge):

Perisphinctes Lothari, Oppel.
—— cf. *polyplocus*, Reinecke.
Belemnites persicus, n. sp.
Goniomya Rodleri, n. sp.

CRETACEOUS (Neocomian):

Olcostephanus tetrameres, n. sp.
—— *Straussi*, n. sp.
—— new form indet.
—— (*Hoplites*?) cf. *narbonensis*, Pictet.

Dr. Georg von dem Borne* in 1891 contributed a valuable monograph on the fossils from the Eastern side of Lake Urmi (Guschaisch, Chanajan, Aktahu-dere, Scurgan and Tazeh-kend), which were described and figured from the following horizons:—

(1) Kelloway (*anceps*-zone).
(2) Kelloway? (*macrocephalus*-zone).
(3) Upper Lias (*Jurensis*-zone).

His identifications may be thus tabulated:—

CEPHALOPODA:

Belemnites cf. *calloviensis*, Oppel.
—— *Persicus*, Weithofer.
—— sp. (=*B. acuarius*-group).
Ludwigia nodosa, Quenst., sp.
—— *krakoviensis*, Neumayr, sp.
—— *gigas*, Quenst., sp.
—— *lunula*, Zieten, sp.
—— cf. *punctata*, Stahl, sp.
—— spp. indet.
Macrocephalites sp. indet.
Stephanoceras stenostoma, n. sp.
Perisphinctes curvicosta, Oppel.
—— *paneaticus*, Nötling.
—— *cyrus*, n. sp.
—— *tetrameres*, Weithofer, sp.
—— *poculum*, Leckenby, sp.
—— *Xerxes*, n. sp.
—— spp. indet.
—— *balinensis*, Neumayr.

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* BORNE, GEORG VON DEM.—'Der Jura am Ostufer des Urmiasees.' [Dissertation Thesis.] Halle, 1891; with several plates of fossils.

Reineckia Straussi, Weithofer, sp.
—— sp.
Harpoceras Atropatenes, n. sp.
—— *kapautense*, n. sp.
—— *mediæ*, n. sp.

GASTEROPODA:
Spinigera, n. sp. indet.
Pleurotomaria sp.

LAMELLIBRANCHIATA:
Pecten cf. *disciformis*, Schübler.
Mytilus Matianus, n. sp.
Trigonia Roxanæ, n. sp.
—— sp.
Pleuromya urmiensis, n. sp.
—— like *arata*, Brauns.
Gresslya sp.

ANNELIDA:
Serpula sp.

DESCRIPTION OF THE SPECIES.

The synonymy here employed is not intended to be exhaustive; only the principal works are enumerated, and these must be referred to for more complete details. For the sake of brevity, the following memoirs, quoted in the synonymy, are mentioned under the name of the "Serial" in which they originally appeared:—

ABICH, H.—Ueber das Steinsalz und seine geologische Stellung im Russischen Armenien: *Mém. Ac. Imp. Sci. St. Pétersbourg*, 1858, ser. 6, vol. vii.

BASTEROT, B. de.—Description Géologique du Bassin Tertiaire du Sud-ouest de la France (Mollusques Fossiles): *Mém. Soc. Hist. Nat. Paris*, 1825, vol. ii. pt. 1.

FUCHS, T.—Ueber die von Dr. Tietze aus Persien mitgebrachten Tertiärvesteinerungen: *Denkschr. K. Akad. Wiss.* (*Wien*), vol. xli. pt. 2.

FUCHS, T.—Beiträge zur Kenntniss der Miocänfauna Aegyptens und der Libyschen Wüste: *Palæontographica*, 1883, vol. xxx.

HÖRNES, M.—Die fossilen Mollusken der Tertiär-Beckens von Wien (Univalven und Bivalven); *Abhandl. k.-k. Geol. Reichs.*, 1856–1870, vols. iii. & iv.

LAMELLIBRANCHIATA.

OSTREA PSEUDODIGITALINA, *Fuchs*.

Ostrea pseudodigitalina, Fuchs, Denkschr. K. Akad. Wiss. 1879, vol. xli. pt. 2, pl. 3. figs. 4–6, p. 107.

This species is of elongate shape, pointed at the summit and rounded basally; it is related to *O. digitata* of Eichwald, but appears to differ in possessing costæ of considerably less digitiform character. The upper valve is flat and ornamented with prominent growth-lines. Other closely allied species are *O. Rholfsi* of Fuchs, from the Siokuh mountains in Persia, and *O. digitalina* var. *Rholfsi* of the same author, from the Miocene beds of Egypt. The specimens are fragmentary; representing four lower valves and three upper valves.

Fuchs first recorded this species from the Miocene (=Schio-Schichten) of the Siokuh mountains in Persia.

Locality. In a grey marly matrix from the beach of the island of Koyun Dāghi.

Formation. Miocene (Helvetian ?).

OSTREA LAMELLOSA, *Brocchi*.

Ostrea lamellosa, Brocchi, Conch. Foss. Subapennina, 1814, vol. ii. p. 564; Abich, Mém. Ac. Imp. Sci. St. Pétersbourg, 1858, ser. 6, vol. vii. pl. 5. fig. 3, p. 126 (68); Hörnes, Abhandl. k.-k. Geol. Reichs. 1870, vol. iv. pl. 71. figs. 1–4, pl. 72. figs. 1, 2, p. 444.

A single fragmentary upper valve is all that represents this shell; and it seems to agree remarkably well with Abich's interpretation of the species as illustrated in his "Steinsalz" monograph. It is slightly convex near the summit, and the external surface exhibits the regular concentric and lamellose striations characteristic of this species. It has been previously recorded from Italy (Brocchi); Urmi (Abich); Vienna Basin (Hörnes); Asia Minor (P. Fischer in Tchihatcheff); Greece (Gaudry), &c.

Locality. In a grey marly rock from the beach of the island of Koyun Daghi.

Formation. Miocene (Tortonian or Helvetian).

The species is distributed through the Miocene and Pliocene periods, and still survives in the Mediterranean.

ALECTRYONIA VIRLETI, *Deshayes*.

Ostrea Virleti, *O. excavata*, *O. pseudoedulis*, Deshayes, Expéd. Sci. Morée, 1833, vol. iii. (Zool.), pl. 21. figs. 1–6, pp. 122–124.

Ostrea Virleti, *O. excavata*, Abich, Mém. Ac. Imp. Sci. St. Pétersbourg, 1858, ser. 6, vol. vii. pl. 2. figs. 1, 2; pl. 3. figs. 1, 2; pl. 5. figs. 1, 2; pp. 124 (66), 125 (67).

Ostrea Virleti, Fuchs, Denkschr. K. Akad. Wiss. 1879, vol. xli. pt. 2. pl. 4, p. 106; and Palæontographica, 1883, vol. xxx. pl. 9. (4), pl. 10. (5), p. 43 (25).

Ostrea (*Alectryonia*) *Virleti*, R. B. Newton, Geol. Mag. 1899, p. 205.

This is a most abundant species in Persia, occupying the topmost bed of the Miocene section at Koyun Daghi island, as given by Dr. Abich in his 1882 work. It is a form of somewhat variable shape, though exhibiting external plications on both valves, which places it in the genus *Alectryonia*. These plications may sometimes be more or less obsolete according to age and wear; the valves are mostly depressed, though the *excavata* form has a very convex lower valve. Mr. Günther's specimens are fairly typical of the species and correspond with Dr. Abich's figures of the same.

The species has been previously recorded from the Miocene rocks of Morea (Deshayes); Siokuh Mountains, Persia (Fuchs); Egypt (Fuchs); Azores &c. (Mayer-Eymar); Crete (Raulin); Cyprus (Gaudry); Malta (Wright); and a variety of this species is recorded from the Pliocene deposits of Altavilla, Italy, by Gregorio (Boll. Soc. Mal. Italia, 1884, vol. x.).

Localities. Several specimens were obtained from the beach of the island of Koyun Daghi; and one fragmentary valve came from the cliff-section of the same island.

Formation. Miocene, probably about the age of the Leithakalk, which is Tortonian.

PECTEN BEUDANTI, *Basterot*. (Plate 29. fig. 2.)

Pecten Beudanti, Basterot, Mém. Soc. Hist. Nat. Paris, 1825, vol. ii. part 1, pl. 5. fig. 1, p. 74; Hörnes, Abhandl. k.-k. Geol. Reichs. 1867, vol. iv. pl. 59. figs. 1–3, p. 399; T. Fuchs, Denkschr. K. Akad. Wiss. 1879, vol. xli. pt. 2. p. 105; R. B. Newton, Geol. Mag. 1899, p. 207.

A large convex lower valve, contained in this collection, appears to be referable to *P. Beudanti*. The fine, striated sculpture of the surface, however, through erosion by water or weathering, so conspicuous a feature of this species, is almost obliterated, although it can be obscurely traced in places. In every other respect it agrees with Hörnes' interpretation of Basterot's shell. It is very transverse (dimensions in millimetres = height 87, length 110, depth 35), and bears about 16 wide plano-convex costæ separated by grooves of rather less width. Sacco has recorded this species from the Helvetian Beds of Piedmont (Boll. Soc. Geol. Italiana, 1889, vol. viii. p. 331).

The species has been previously known from Bordeaux (Basterot); Portugal (J. de C. Sowerby); Constantine (Coquand); Sardinia (Meneghini); Piedmont (Sacco); Persia (Fuchs); Egypt (Newton).

Locality. In a matrix of compact, cream-coloured foraminiferal limestone; from the neighbourhood of Urmi.

Formation. Miocene (Helvetian).

PECTEN CONVEXO-COSTATUS, *Abich.*

Pecten convexo-costatus, Abich, Mém. Ac. Imp. Sci. St. Pétersbourg, 1858, vol. vii. pl. 1. figs. 4*b*, 4*c*, p. 188; Geol. Armenischen Hochlandes, 1882, pl. 1. figs. 6, 6 *a*, pl. 8. fig. 2, p. 276; Fuchs, Palæontographica, 1883, vol. xxx. pl. 21 (xv.). figs. 1, 2, p. 40 (58).

Two lower valves of this species are attached to a piece of yellowish-white limestone. They are much weathered so that the fine concentric striæ are almost obsolete, but the characteristic convex and narrow costæ numbering from 20–22 are prominently shown. This is a fairly distinct species, and not to be confused with Eichwald's *P. aduncus* of 1830, from Poland, which has wider, fewer, and more depressed ribs, and which Hörnes regarded as synonymous with *P. convexo-costatus*, uniting both under the older name.

Abich's original specimens were obtained from the neighbourhood of Urmi; the species is also recorded from Egypt by Fuchs.

Locality. Guverchin Kala, north end of Lake Urmi.

Formation. Miocene (Helvetian).

PECTEN SUBURMIENSIS, *Abich.*

Pecten suburmiensis, Abich, Geol. Armenischen Hochlandes, 1882, pl. 8. figs. 1–8*a*, p. 276.

This species is represented by a number of lower valves, which although rather fragmentary show the characteristic wide, curved, and depressed costæ crossed by obscurely fine striations; the umbonal region is rounded and incurved. The original specimens were described by Abich as from the Urmi Plateau.

Localities. Two examples are in a drab-coloured limestone, and were found at Guverchin Kala, northern end of Lake Urmi; two others are in a greyer rock localised as from the same place;

the remaining specimens are considerably water-worn, having been obtained from the beach at the island of Koyun Daghi.

Formation. Miocene (Helvetian).

PECTEN (AMUSSIOPECTEN) like BURDIGALENSIS, *Lamarck.*

Pecten Burdigalensis, Lamarck, Annales du Muséum, 1809, vol. viii. p. 355; Goldfuss, Petrefacta Germaniæ, 1833, vol. ii. pl. 96. fig. 9, pp. 66, 80; Abich, Mém. Ac. Imp. Sci. St. Pétersbourg, 1858, vol. vii. p. 120 (62); Hörnes, Abhandl. k.-k. Geol. Reichs. 1867, vol. iv. pl. 65, p. 418.

Amussiopecten Burdigalensis, Sacco, Moll. Terz. Piemonte, &c., 1897, pt. 24, pl. 15. figs. 1–7, p. 53.

Pecten (*Amussiopecten*) *Burdigalensis,* R. B. Newton, Geol. Mag. 1899, p. 209.

This form is represented by a very much worn specimen, with rather imperfect margins. It shows wide and slightly raised costæ; and the surface is covered with numerous obsolete concentric striations. Dr. Fuchs' Persian shell from the Siokuh mountain, *P. placenta*, appears to be closely related to it (Denkschr. K. Akad. Wiss. 1879, vol. xli. pl. 2, figs. 1, 2, p. 104).

The true *Burdigalensis* is a well-known Miocene species, being found in both the Helvetian and Burdigalian divisions of that period, and it forms the type of Sacco's sub-genus *Amussiopecten.*

Locality. From the beach of the island of Koyun Daghi.

Formation. Miocene (Helvetian ?).

PECTEN (OOPECTEN) ROTUNDATUS, *Lamarck.* (Plate 29. fig. 1.)

Pecten rotundatus, Lamarck, Hist. Nat. Anim. sans Vert. 1819, vol. vi. pt. 1, p. 179; T. Fuchs, Denkschr. K. Akad. Wiss. 1879, vol. xli. pt. 2, pl. 2. figs. 1, 2, p. 104; Fontannes, Hist. Periode Tert. Rhône, 1880, vol. vi. pl. 1, fig. 1, p. 161.

Oopecten rotundatus, Sacco, Moll. Terz. Piemonte, &c., 1897, pt. 24, pl. 15. figs. 14, 15, p. 54.

Original specific description:—"*P. testa suborbiculari, utrinque convexa*; *radiis* 14 *ad* 16 *distinctis, convexis, versus limbum planulatis.*

"Largeur 75 millimètres. Il est moins bombé que le *P. multiradiatus* et que le *P. rugosus.*" (Lamarck.)

A small block of a light brown calcareous sandstone obtained from a conglomerate contains remains of this species; the best preserved valve having a height of 60 millimetres and a length of rather more than 70 millim.

It agrees with the original diagnosis as given above, and corresponds with Dr. T. Fuchs' later interpretation of the same, this author having identified it among some Persian fossils obtained from the Siokuh mountains. Lamarck's original specimen is localised as from Vence, near Grasse in France, which Fuchs considers as belonging to the "Horner Schichten" division of the Miocene; it has been well figured by Fontannes, who tabulates it as of Lower Helvetian age. This species forms the type of Sacco's sub-genus *Oopecten*, and its range in Italy, according to the same author, is from the top of the Aquitanian into the Helvetian.

Locality. Seir Hill, 6–8 miles west of Urmi.

Formation. Miocene (Helvetian or Burdigalian?).

PECTEN (FLABELLIPECTEN) sp. indet.

This determination refers to a fragmentary pectinoid shell exhibiting a very slightly convex lower valve, with about 16 rounded radial costæ separated by very wide interspaces, some obscure concentric striations on the ribs and grooves being discernible in places.

It is probably an example of *P. Besseri*, Andrejowski, from the Polish Miocene (Bull. Soc. Nat. Moscou, 1830, vol. ii. pl. 6. fig. 1, p. 103), but the intercostal grooves are mostly filled with matrix, and the specimen is otherwise so poorly preserved that a more definite identification is not possible.

There is no doubt as to its belonging to Sacco's sub-genus *Flabellipecten*, of which the type is *P. flabelliformis*, Brocchi, sp.

Locality. From the beach of the island of Koyun Daghi.

Formation. Miocene (Helvetian).

CHLAMYS (ÆQUIPECTEN) MALVINÆ, *Dubois de Montpéreu* affin., *H. Abich.* (Plate 29. fig. 4.)

Pecten Malvinæ, affin., Abich, Geol. Armenischen Hochlandes, 1882, pl. 8. fig. 7, p. 278.

The collection contains five fragments of a Pectinoid shell which appear to be the equivalent of that form regarded by Dr. Abich as allied to *P. Malvinæ* of Dubois de Montpereux (Conch. Foss. Wolhyni-Podolien, 1831, pl. 8. figs. 2, 3, p. 71). The most complete example has from 18–20 narrow, rounded costæ, extremely fine at the umbone, but afterwards widening, and separated by deep grooves; the lateral ribs having a tendency to curve. The entire surface is covered by fine, equidistant, transverse, imbricating or squamose striations. The shell is probably a oun form, as there is no indication of the ribs dichotomizing.

The true *P. Malvinæ* possesses a greater number of ribs, which radiate in straight lines from the umbone without any apparent curvature on the lateral areas. The present Persian specimens are probably more closely allied to *P. opercularis* of Linnæus, from which they are most difficult to separate after comparison with the Pliocene representatives of this species contained in the "Searles Wood" collection in the British Museum. This particular form of *Pecten* belongs to P. Fischer's sub-genus *Æquipecten*, founded in 1886 on *P. opercularis*, Linnæus, sp.

Locality. Beach specimens from the island of Koyun Daghi; Dr. Abich's specimens were obtained from the "Urmia Plateau."

Formation. Miocene (Helvetian).

CHLAMYS sp. indet.

Two specimens have been determined as above. One consists of an impression of a valve in a small block of limestone. It possesses numerous radial, almost contiguous costæ, which are divided up into twos and threes such as are typical of *P. gloria-maris* of Dubois from the Polish Miocene, but without the echinations on the ribs distinguishing the European form. It is of ovately oblong shape, and from the character of the costæ clearly belongs to the genus *Chlamys*. The other specimen has similar costal details, and was obtained from the island of Koyun Daghi.

Locality. In a cream-coloured limestone with foraminifera and other small organisms, found on the road from Sujbulak to the Plain of Solduz; and from the cliff of the island of Koyun Daghi.

Formation. Miocene (Helvetian).

CHLAMYS sp. indet. (Plate 29. fig. 3.)

This specimen has about 16 rounded costæ divided by deep and wide grooves which are feebly marked by extremely fine oblique striations; the costæ show obscure indications of dividing besides being ornamented with numerous slightly elevated scabræ or spines. There is only one example of this form in the collection; it has both valves attached and is considerably worn so that the sculpture is difficult to define; its dimensions in millimetres=height 42, length 38, and depth 18. The specimen is probably related either to *P. gloria-maris*, Dubois, *P. opercularis*, Linnæus, sp., or to *P. pusio*, Linnæus, all of which are included under the genus *Chlamys* of Boltem, 1798 (type *Ostrea varia*, Linnæus), by Sacco and other authorities.

Locality. Neighbourhood of Urmi.

Formation. Miocene (? Helvetian).

CARDIUM sp. indet. (Plate 29. fig. 5.)

This is a sandstone-cast of a valve belonging to the genus *Cardium*, measuring the same both in its height and length, viz. 19 millimetres, and in depth 8 mm. Where preserved, the vertical striations on the surface are numerous and very close together; in the ventral area obscure lines of growth can be traced.

Without more material it is difficult to speak of the nearest ally of a specimen of this description. It slightly resembles a Lower Tertiary form from Asia Minor figured by d'Archiac in Tchihatcheff's 'Asie Mineure,' 1866–69, pl. xi. figs. 6, 7, p. 162, under the name of *Cardium* indet., which however is longer than high and scarcely so convex as the Persian shell.

Locality. Found in the same brown calcareous sandstone accompanying *P. rotundatus* at Seir, 6 to 8 miles west of Urmi.

Formation. Miocene (Helvetian or Burdigalian).

VENUS AGLAURÆ, *Brongniart.* (Plate 30. figs. 1, 2.)

Corbis? Aglauræ, Brongniart, Mém. Séd. sup. Calc.-Trapp. Vicentin, 1823, pl. 5. fig. 5, p. 80.

Venus Aglauræ, Hörnes, Abhandl. k.-k. Geol. Reichs. 1861, vol. iv. pl. 14. figs. 1–4, p. 122; P. Fischer, "Faune Tert. Moyen," in Tchihatcheff's 'Asie Mineure,' 1866–69, p. 290; Abich, Geol. Armenischen Hochlandes, 1882, pl. 4. fig. 5, p. 278.

Original diagnosis.—*Transversim fere elliptica, ventricosa, cancellata, lamellis transversis crebris ad latera plicato-crispis, serratis.* (Brongniart.)

This well-known species is represented by a single specimen with closed valves somewhat imperfect and worn. The original sculpture of the shell can be fairly seen in places, exhibiting the close characteristic concentric lamellose structure crossed by fine longitudinal striations. The specimen is of typical shape, being transversely elliptical, having a short rounded anterior region and an obliquely curved postero-dorsal margin; the lunule and escutcheon are a good deal obscured by matrix.

Dimensions (in millimetres). Height = about 60; length = 68; depth = 38.

Brongniart's original example of this species was obtained from the Oligocene (Tongrian) rocks of Castel Gomberto of North Italy (this correlation being according to Lapparent, 'Traité de Géologie,' 1893, p. 1292). Under the name of *V. granosa* it has been recorded from the Miocene (Gaj series) deposits of Cutch, India (J. de C. Sowerby); it occurs in the Vienna Basin at Gauderndorf &c. (Hörnes), in the Lower Miocene or Burdigalian stage; "Urmia Plateau" (Abich); Asia Minor (P. Fischer); Saucats; Turin, &c.

Locality. Guverjin Kala, north end of Lake Urmi. Specimen having a reddish-brown colour externally; the matrix within appearing to be a grey, marly, calcareous rock. (Collected by the Rev. C. Labaree.)

Formation. Miocene (Burdigalian or Aquitanian).

MERETRIX PERSIENSIS, n. sp. (Plate **30.** figs. 3–5.)

Shell transversely ovate, inequilateral, anterior end truncate and short, posterior extremity rounded and produced; valves convex, dorsal margin rounded and long, surface ornamented with concentric sulcations; beaks very anterior, incurved, having beneath a small, fairly deep, cordiform lunule; escutcheon lanceolate.

Dimensions (in millimetres). Height = 28; length = 45; depth = 29.

This species is represented by one specimen having both its valves united. It appears to differ from other forms of this genus in its transverse shape, the very anterior position of the umbones (which come beyond the shell-margins below), and the very convex rounded valves, which slope obliquely to the posterior and ventral margins.

The specimen is quite free from external matrix, its lithological aspect being similar to that observed in the forms of *Venus Aglauræ* and *Meretrix* like *incrassata*.

Locality. Guverchin Kala. (Collected by the Rev. C. Labaree.)

Formation. Miocene (Burdigalian or Aquitanian).

MERETRIX allied to INCRASSATA, *J. Sowerby.* (Plate **30.** figs. 6 & 7.)

Venus incrassata, J. Sowerby, Mineral Conchology, 1817, vol. ii. pl. 155. figs. 1, 2.

Cytherea incrassata, Deshayes, Desc. Coq. Foss. Paris, 1825, vol. i.

pl. 22. figs. 1–3, p. 136; Abich, Geol. Armenischen Hochlandes, 1882, pl. 2. fig. 8, p. 289.

Meretrix incrassata, R. B. Newton, Syst. List British Oligocene and Eocene Mollusca, 1891, p. 64.

A single specimen, consisting of a cast showing both valves, appears to have the form and thickness of *Meretrix incrassata*, as figured by Deshayes from the Paris Basin Oligocene; and, in addition, it is very similar to Abich's figure of this species, which depicts a specimen obtained from the Upper Eocene of Achalzik, in the northern part of the Armenian highlands. Our cast also shows obscure indications of a deep pallial sinus on the left valve.

Its dimensions are:—Height=35 millimetres; length=29; depth=23.

Locality. Guverchin Kala; of the same colour and aspect lithologically as observed in the *Venus Aglauræ* and *Meretrix Persiensis*. (Collected by the Rev. C. Labaree.)

Formation. Miocene (Burdigalian or Aquitanian).

CARDITA sp. indet. (Plate 29. figs. 6, 7.)

This determination refers to a single specimen having both valves attached. It is inequilateral, somewhat depressed, and possesses about 20 radial, rather arched costæ, which are ornamented with a bead-like, squamulose structure, the prominences of which have been eroded by aqueous action. The anterior margin is short and rounded, whilst posteriorly it is oblique and produced; lunule small and cordate.

The specimen is in bad preservation, with the umbonal surfaces fractured. It appears to represent a new species, but without more material the present reference will suffice, although it may be said to bear a curious resemblance to the figure of *Cardita mutabilis* of d'Archiac & Haime ('Descr. Anim. Foss. Nummulitique de l'Inde,' 1854, vol. ii. pl. 21. figs. 3–6, p. 256), from the Eocene of Subathoo, North-west India.

Dimensions (in millimetres). Height=16; length=20; depth=10.

Locality. Beach of the island of Koyun Daghi.

Formation. Miocene (Helvetian).

GASTEROPODA.

STROMBUS like BONELLI, *Brongniart*.

This specimen consists of a fragmentary water-worn cast which appears to be referable to this species. Only the two latest whorls are present, the spire being absent. In the upper part of the last whorl there are undoubted indications of the thick tubercles which ornament that region in this species.

S. Bonelli was originally described by Brongniart from the Miocene (Helvetian) beds of Turin (Mém. Terr. Séd. Calc.-Trapp. Vicentin, 1823, pl. 6. fig. 6, sp. 74).

Locality. In a grey marly rock from the beach of the island of Koyun Daghi.

Formation. Miocene (Helvetian).

CONUS sp. indet.

Two casts of this genus are present in the collection, but they are much broken, water-worn examples, and therefore not determinable.

Locality. In a grey marly rock from the beach of the island of Koyun Daghi.

Formation. Miocene (Helvetian).

PYRULA CINGULATA (*Bronn MS.*), *Hörnes*. (Plate 30. figs. 8, 9.)

Pyrula clathrata, Lamarck, Hist. Nat. Anim. sans Vert. 1822, vol. vii. p. 141.

Pyrula reticulata, Hörnes, Abhandl. k.-k. Geol. Reichs. 1853, vol. iii. pl. 28. figs. 1–3, p. 268, *non* Lamarck, 1822.

Pyrula cingulata, Hörnes, Abhandl. k.-k. Geol. Reichs. 1856, vol. iii. p. 676.

Represented by a brown-coloured natural cast exhibiting the shape and sculpture of this species. It has a long oval aperture, an acute and outwardly-curved labrum, a moderately excavated columella, and a very short convex spire. The large body-whorl is ornamented with broad and rather distant transverse bands, these being crossed obscurely by finer lines. The anterior canal is absent, most probably through fracture though the end is now rounded from wear. The broad spiral bands seem to separate this species from *P. condita*, Brongniart.

Dimensions (in millimetres). Length=50; diameter=34.

This species, under the name of *P. clathrata*, Lamarck, was first known from the Miocene of the Touraine district of France, although mistaken by that author for a Paris Basin form. It has been recorded also from Italy (Bronn); Poland (Eichwald); Rhône Basin (Matheron); Portugal (G. B. Sowerby); Vienna Basin (Hörnes), &c.

Locality. Guverchin Kala. (Collected by the Rev. C. Labaree.)

Formation. Miocene (Burdigalian or Aquitanian).

Cassis sp. indet. (Plate 30. figs. 10, 11.)

This specimen is an imperfect cast with a general resemblance to *C. subharpæformis*, d'Archiac & Haime (Descr. Anim. Foss. Numm. l'Inde, 1854, vol. ii. pl. 31. fig. 6, p. 317), from the Eocene rocks of India; but differing from that form in being much shorter and broader, in the *non*-bifurcate character of the vertical ribs, and the presence of some obscure concentric markings on the principal whorl. The aperture is narrowly elliptical and oblique; spire only slightly elevated.

Dimensions (in millimetres). Length = 27; diameter = 27.

Locality. Guverchin Kala. Of similar lithological appearance to the specimen of *Pyrula cingulata.* (Collected by the Rev. C. Labaree.)

Formation. Miocene (Burdigalian or Aquitanian).

Latirus crispus, *Borson.* (Plate 29. fig. 8.)

Fusus crispus, Borson, Mem. R. Accad. Sci. Torino, 1821, vol. xxvi. p. 317; Deshayes, Appendix to Lyell's 'Principles of Geology,' 1833, pl. 1. fig. 8, p. 30; Michelotti, Desc. Foss. Mioc. l'Italie Sept., 1847, pl. 9. figs. 17, 18, p. 272; Hörnes, Abhandl. k.-k. Geol. Reichs. 1853, vol. iii. pl. 32. fig. 3, p. 291.

Original diagnosis.—*Testa costata transversim sulcata; plicis longitudinalibus fornicatis; labio intus sulcato.* (Borson.)

A somewhat water-worn example is all that represents this species. It shows the characteristic longitudinal, elevated and rounded costulations, of which there are about eight on the principal whorl, separated by deep corresponding sulcations; the transverse sculpture consisting of numerous regular striations. The anterior canal is broken and the spire is incomplete; otherwise it preserves the fusoid and elongate shape of this form.

Dimensions (in millimetres). Length = 27; diameter = 15.

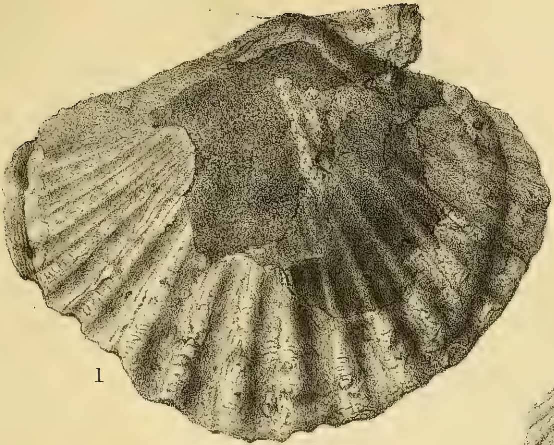
Borson's original example is localised as Piedmont, and belongs to the Tortonian stage of the Miocene, Hörnes' specimen from the Vienna Basin (Möllersdorf) being of similar horizon.

Locality. From the beach of Koyun Daghi island.

Formation. Miocene (Tortonian) The specimen has a reddish tinge similar to what is present in some of the examples of *Alectryonia Virleti*, and probably came from the same bed.

Turritella Archimedis, *Brongniart.* (Plate 29. fig. 11.)

Turritella Archimedis, Brongniart, Mém. Terr. Séd. sup. Calc.-Trapp. Vicentin, 1823, pl. 2. fig. 8, p. 55; Hörnes, Abhandl. k.-k. Geol. Reichs.



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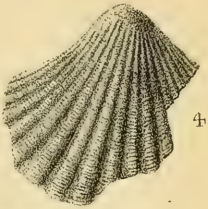

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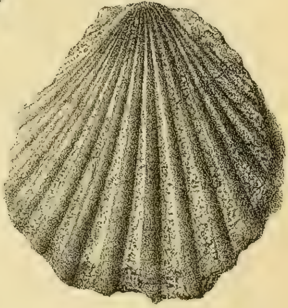

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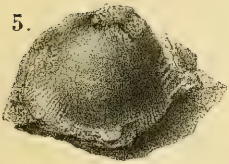

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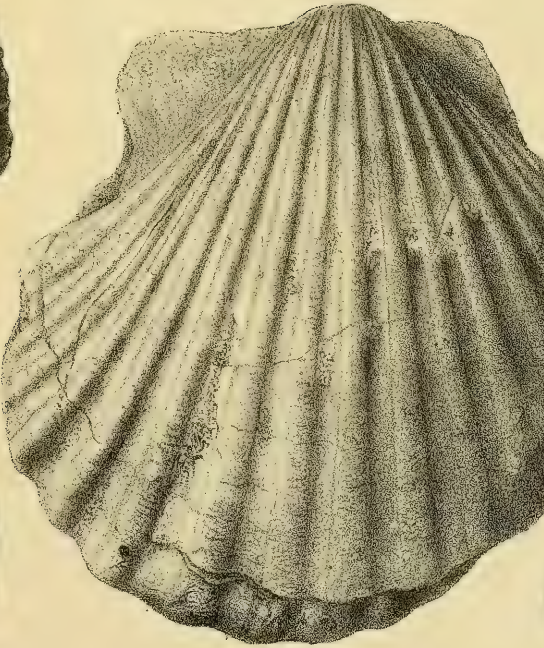

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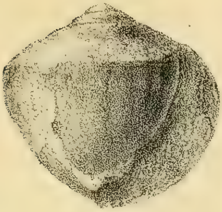
Mintern Bros imp.

MIOCENE SHELLS FROM LAKE URMI.


8.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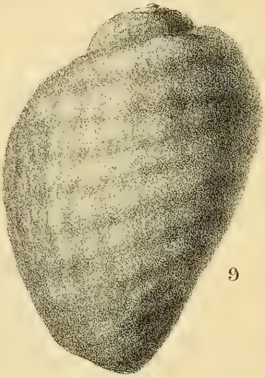
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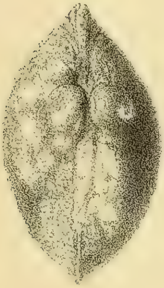
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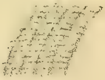
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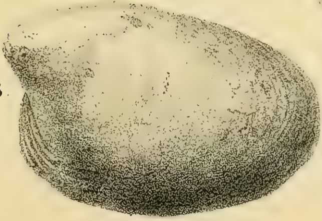
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J. Green del. et lith.

Mintern Bros. imp.

MIOCENE SHELLS FROM LAKE URMI.

1855, vol. iii. pl. 43. figs. 13, 14, p. 424; Abich, Geol. Armenischen Hochlandes, 1882, pl. 8. fig. 14, p. 279.

This species is represented by a fragment exhibiting three whorls of the upper part of the spire, with depressed, spirally-striated surfaces and margined by prominent bicarinations.

The species occurs in Northern Italy (Brongniart); Vienna Basin (Hörnes); Egypt (Fuchs); "Urmia Plateau," north-western Persia (Abich), &c.

Locality. Koyun Daghi (beach specimen).

Formation. Miocene (Helvetian).

TURRITELLA GRADATA, *Hörnes.* Var., *Abich.* (Plate 29. fig. 9.)

Turritella gradata, var., Abich, Geol. Armenischen Hochlandes, 1882, pl. 8. fig. 12, p. 280.

This consists of a water-worn fragment showing three whorls with depressed surfaces, the spiral sculpture being nearly obsolete, but having a prominent elevated keel at the base of each. Abich regarded his shell as a variety of Hörnes' *T. gradata* from the Vienna Miocene (Abhandl. k.-k. Geol. Reichs. 1855, vol. iii. pl. 43. fig. 3, p. 420), with which it seems to be closely related; his specimen was from the "Urmia Plateau."

Locality. Beach of the island of Koyun Daghi.

Formation. Miocene (Helvetian).

TURRITELLA ROTIFREA, *Deshayes*, affin. *Abich.* (Plate 29. fig. 10.)

Turritella rotifera affin., Abich, Geol. Armenischen Hochlandes, 1882, pl. 8. fig. 11, p. 279.

This is a fragmentary specimen which undoubtedly belongs to the form determined by Abich as above. On account of the turreted whorls, their spiral sculpture and the equidistant prominent keels, Abich regarded this form as related to *T. rotifera* of Deshayes (Desc. Coq. Foss. Env. Paris, 1832, vol. ii. pl. 40. figs. 20, 21, p. 275), from the Paris Basin Eocene. Abich's specimen was found on the "Urmia Plateau."

Locality. From the beach of the island of Koyun Daghi.

Formation. Miocene (Helvetian),

EXPLANATION OF THE PLATES.

PLATE 29.

Fig. 1. *Pecten (Oopecten) rotundatus.* Seir Hill.
2. *Pecten Beudanti.* Neighbourhood of Urmi.
3. *Chlamys* sp. indet. Neighbourhood of Urmi.

Fig. 4. *Chlamys* (*Æquipecten*) *Malvinæ* affin. Koyun Daghi.
5. *Cardium* sp. indet. Seir Hill.
6, 7. *Cardita* sp. indet. Koyun Daghi.
8. *Latirus crispus.* Koyun Daghi.
9. *Turritella gradata,* var. Koyun Daghi.
10. *Turritella rotifera* affin. Koyun Daghi.
11. *Turritella Archimedis.* Koyun Daghi.

Plate 30.

Figs. 1, 2. *Venus Aglauræ.* (Fig. 2=sculpture magnified.) Guverchin Kala.
3, 4, 5. *Meretrix persiensis,* n. sp. Guverchin Kala.
6, 7. *Meretrix* allied to *incrassata.* Guverchin Kala.
8, 9. *Pyrula cingulata.* Guverchin Kala.
10, 11. *Cassis* sp. Guverchin Kala.

The figures on both Plates are drawn natural size, with the exception of fig. 2 on Plate 30.

NOTE ON A PALÆOZOIC LIMESTONE.

By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

Among Mr. R. T. Günther's geological specimens from North-western Persia is a fragment of dark slate-coloured limestone, highly crystalline, and intersected with numerous calcite veins, which was obtained from the island of Shazalan on Lake Urmi.

A microscopical examination of this rock proves that its structure is largely made up of foraminiferal remains which, with the kind assistance of Mr. Frederick Chapman, have been determined as *Endothyra Bowmanni*, Phillips, *Valvulina bulloides*, Brady, and *Nodosaria radicula*, Linnæus.

Generically, the most interesting of these forms is *Endothyra*, being essentially Carboniferous, the other genera having a far wider range in geological time.

The nearest habitat to Shazalan which has hitherto yielded *E. Bowmanni* appears to be Sloboda, in the province of Toula, European Russia, reported some years ago by V. von Möller *.

So far as can be ascertained, there is only one species of Palæozoic foraminifera yet recorded from this region, viz.,

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* Möller, V. v.—"Die spiral-gewundenen Foraminiferen des Russischen Kohlenkalks," Mém. Ac. Imp. Sci. St. Pétersbourg, 1878, ser. 7, vol. xxv. no. 9, p. 96, pl. iv. fig. 3, & pl. xii. fig. 2.

Fusulina sphærica, described and figured as a new form by Abich * in 1859 from the Bergkalk (=Carboniferous) formation of the Armenian and Persian plateaux, which shows resemblances to *Fusulina cylindrica* of Fischer, a characteristic species of European Russia.

In reference to the distribution of the older rocks in this area, attention may be called to the geological plan of the islands on Lake Urmi published by Abich † in 1882, which is of considerable value. By this we can trace the extension of these ancient deposits through Koyun Daghi and Isbir to the western shores of Lake Urmi, where in each case they form the fundamental structure on which repose the various beds of the Miocene system. Mr. Günther states, in some manuscript notes on this area, that a similar limestone as that occurring at Shazalan is to be seen at the northern end of Koyun Daghi, and possibly also on the neighbouring island of Arzu.

There appear to be no references in literature to the geology of this small island of Shazalan; so that the example of limestone brought home from that place by Mr. Günther is of great interest, not only in adding to the list of Palæozoic Foraminifera from this neighbourhood and in establishing as Carboniferous the age of the rock in which they occur, but in extending farther northwards the distribution of this Palæozoic formation, so important an addition to the geological history of Lake Urmi.

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* Abich, H.—"Vergleichende geol. Grundzüge der Kaukasusischen, Armenischen und Nordpersischen Gebirge," Mém. Ac. Imp. Sci. St. Pétersbourg, 1859, vol. vii. pl. 3. fig. 13, p. 439.

† 'Geologie des Armenischen Hochlandes,' 1882, p. 275.

On the Hyobranchial Skeleton and Larynx of the new Aglossal Toad, *Hymenochirus Boettgeri*.

By W. G. Ridewood, D.Sc., F.L.S., Lecturer on Biology at St. Mary's Hospital Medical School, London.

[Read 2nd November, 1899.]

(Plate **31**.)

Xenopus and *Pipa* have for many years been to herpetologists a fruitful source of discussion, by reason of the structural peculiarities which mark them off so sharply from the other Anura, and also on account of the great differences which exist between themselves. They are isolated types which fail to show any marked affinity with any of the Phaneroglossal Anura, and the relatively few features in which they resemble one another some writers would explain away as due to convergence and adaptation to similar conditions of life. The discovery of a third genus of Aglossal Toads marks the beginning of a new era in the history of this little suborder; and it is to *Hymenochirus* that attention will now be turned with the object of ascertaining how far the Anura Aglossa constitute a natural assemblage.

A single specimen of this new form was discovered in 1896 at Ituri, in German East Africa, and was described by Tornier as *Xenopus Boettgeri* (7. p. 163). Several specimens have since been collected from the Benito river, in the French Congo; and the skeletal and other characters detailed by Boulenger in the present year (2) go to show that this writer was fully justified in the claim which he put forward in 1896 (1) that Tornier's new species of *Xenopus* was entitled to generic rank.

Having already made an exhaustive study of the hyobranchial skeleton and larynx of *Xenopus* and *Pipa* (4), I applied to Mr. Boulenger for permission to examine these parts in one of the specimens of *Hymenochirus* belonging to the Natural History Museum. The request was graciously acceded to, and a male and a female specimen were placed at my disposal. For these my thanks are hereby gratefully tendered.

There are certain features in the hyobranchial and laryngeal skeleton of *Xenopus* and *Pipa* which may be regarded as distinctive, occurring in both of these genera and not in any of the Phaneroglossal Anura. The features in question are:—

The presence of a hyoglossal foramen, transmitting the reduced hyoglossal muscle, and originating by a secondary union of the hyoidean cornua.

The presence of a pair of large backwardly directed cartilaginous wings, developed from the branchial skeleton of the larva.

The large size and complexity of the larynx, and the incorporation of the thyrohyal bones into the laryngeal apparatus.

The absence of vocal cords.

It is a singular fact that all these five characters are exhibited by *Hymenochirus*.

It does not follow, however, that the hyobranchial skeleton of *Hymenochirus* bears, on the whole, any close resemblance either to that of *Xenopus* or that of *Pipa*. In certain features the hyobranchial skeleton of *Hymenochirus* is unique. The hyoidean cornua, for instance, are very large and strongly ossified. Ossification of the hyoidean cornua, though not uncommon in the Urodela, has hitherto been unknown to occur in the Anura. That Boulenger (2), describing a dried skeleton in which the larynx had not been preserved, should have mistaken these bones of *Hymenochirus* for the thyrohyals is thus quite excusable, seeing that in all other forms of Anura the only strongly ossified parts of the hyobranchial skeleton are the thyrohyals.

The hyoid bones (Pl. **31.** fig. 1, *ch*) are thinnest at about one-third of their length from the posterior end, and are flattened in the horizontal plane anteriorly. The hinder part slopes outward and upward; and the swollen extremity, which is not tipped with cartilage, is bound by a short, strong ligament to the inferior surface of the large otic capsule. Projecting horizontally from the mesial surface of each bone is a thin lamella of cartilage, with a convex free border, which is evidently the counterpart of the similarly placed lamella of the unossified hyoidean cornua of *Xenopus* (see **4.** pl. 8. fig. 1). Anteriorly the flattened hyoid bones terminate in epiphysial plates which are cartilaginous in the female, but exhibit an irregular endochondral ossification in the male.

Lying antero-internally to these latter is a median element, strongly ossified in both sexes, which is unique among adult Anura (fig. 1, *ca*). It is roughly pentagonal in shape, and from its relations to the surrounding parts might be regarded as the equivalent of the basihyal of Fishes. It is most important to note that it is not homologous with the median cartilage which is lodged between the two hyoidean cornua in the larval *Xenopus* (**4.** pl. 11. figs. 1 and 2, *bh*); for the latter, by coalescence with surrounding parts, develops into a plate of cartilage which is *behind* the hyoglossal foramen. The median bone of *Hymenochirus* would correspond rather with the anterior of the two cartilages which occupy the median line in the hyobranchial skeleton of the larval *Alytes* (see **6.** figs. 1 and 2, *ca*). It is possible that this anterior copula of the Discoglossid larva may later prove to be the true basihyal element; but, for reasons already stated (**5.** p. 583), it is preferable, for the present, to apply the term basihyal to the posterior copula, or to avoid the use of the word altogether, until further research has satisfactorily demonstrated the homologies of the constituent parts of the hyoid apparatus of the Anura.

The hyoidean skeleton is completed in front by two plates of cartilage, each exhibiting a small area of calcification (*pa*). These plates are doubtless the equivalents of the *processus anteriores* of the common Frog (see **5.** fig. 11, *pa*), and represent also the thin lamellæ of cartilage which project from the anterior edges of the hyoidean cornua in *Xenopus* (see **4.** pl. 8. fig. 1).

The front part of the hyobranchial skeleton is quite detached from the hinder part, and the relative positions of the two parts to one another and to the mandible and larynx are preserved in fig. 1, Plate **31.** The front part undoubtedly belongs to the hyoidean arch exclusively, but it is possible that in the hinder part there is also some cartilage of hyoidean origin. This proposition is based upon the fact that in *Xenopus* and *Pipa* the hyoglossal foramen is formed by the coalescence of the right and left hyoidean cornua in front of the hyoglossal sinus (**4**). The hyoglossal foramen of *Hymenochirus* (figs. 1 and 3, *h*) is small in size, but its identity is unmistakable, since it transmits a reduced hyoglossal muscle, running from the ventral surface of the larynx to the pharyngeal mucous membrane in front of the glottis. The tract of cartilage which lies anteriorly to this foramen (*ch'*) may, therefore, be considered as a hyoid derivative. It corresponds with the pointed rod of cartilage which in *Pipa* projects in front of the hyoglossal foramen (**4.** pl. 9. fig. 1, *ch'*).

In the presence of hyoidean cornua *Hymenochirus* differs from *Pipa* and resembles *Xenopus*. In fact, one may say that no portion of the front half of the hyobranchial skeleton of *Hymeno-*

chirus is represented in the adult *Pipa*. The other half, however, will bear a detailed comparison with the entire hyobranchial skeleton of the adult *Pipa*. The great alary cartilages (*a*), so characteristic of the Aglossa, slope outward and backward, and terminate in inwardly directed expansions, which partially overlie the thyrohyals. They extend some distance behind the posterior epiphyses of the thyrohyals in the female, but not in the male (*cf.* figs. 1 and 3). The external geniohyoid muscle is inserted about midway between the hyoglossal foramen and the postero-lateral extremity of the alary cartilage (fig. 1, *ge*), whereas in *Xenopus* it is inserted much nearer the foramen, and in *Pipa* quite close to the postero-lateral border of the cartilage. Lying antero-laterally to the insertion of this muscle is a thin lamellar extension of the cartilage, which finds its exact counterpart in *Xenopus*, but not in *Pipa*. The antero-lateral processes of the basal plate of *Xenopus* (4. pl. 8, fig. 1, *ap*) are not represented, unless they are included in the semicircular tract of cartilage which lies in front of the hyoglossal foramen. The alary portion of the hyobranchial skeleton differs somewhat in shape in the two specimens examined, but the paucity of material precludes one from deciding whether these are normal sexual differences.

In both sexes of *Hymenochirus* the thyrohyal bones have the form of tapering rods, as they have in the female *Xenopus*; and they are brought into intimate relation with the cricoid cartilage of the larynx, as is characteristic of both *Xenopus* and *Pipa*. The posterior ends terminate in large epiphysial cartilages; the anterior ends converge, and are connected with one another by a small tract of cartilage, which in the female is continuous with the transverse bar of cartilage running behind the hyoglossal foramen, but which is bound to the latter by a short stout ligament in the male. These last relations are exactly those obtaining in the two sexes of *Pipa* (see 4. pl. 9, fig. 1, *i*, and fig. 5, *i'*).

The larynx is considerably smaller in the female than in the male, and the thyrohyal bones are shorter, more slender, and set at a wider angle. The floor or ventral wall of the larynx of the female (fig. 3) is largely composed of membrane. It is supported by a horizontal ring of cartilage, from which there project postero-laterally a pair of slender cartilaginous bars. These expand at their extremities into the bronchial cartilages (*br*), and are confluent with the posterior epiphyses of the thyrohyals.

The ring of cartilage is produced into a blunt point in front, while from the sides there rise vertically upwards, internal to the thyrohyal bones, but quite free from them, a pair of cartilaginous bars, which end at the sides of the arytenoid cartilages on the upper surface of the larynx (fig. 4, *bl*). The dorsal extremities of these cartilages appear to be the equivalents of the "Scheuklappenartige Fortsätze" described by Henle (3) in the female *Xenopus*.

As seen from above, the larynx bears a striking resemblance to that of the young *Pipa* (see 4. pl. 11. fig. 11). The dorsal part of the cricoid cartilage has the form of an arched band, running transversely between the posterior epiphyses of the thyrohyals, and fused with them at its extremities. The arytenoids are simple, concavo-convex cartilages, constructed upon the type normal for the Phaneroglossal Anura. They each exhibit a small centre of ossification at the point where the tendinous extremity of the laryngeal dilator is inserted.

There are no vocal cords in either sex, neither are there bronchial tubes. The wall of the lung is quite smooth, and exhibits no sacculation. It is as strongly vascular in the parts connected with the larynx as over the general surface; and it is worthy of notice that the bronchial cartilages of *Hymenochirus* are not more extensively developed than in such a phaneroglossal form as *Bombinator* (see 4. pl. 11. fig. 13, *br*). As in *Pipa* and *Xenopus*, the lung is bound to the abdominal wall by a stout pleural fold, which does not quite reach to the posterior extremity.

In the male, the floor or ventral wall of the larynx is composed entirely of cartilage, but the cartilaginous lamellæ projecting from the inner borders of the thyrohyal bones (fig. 1, *t'*) are not confluent with the median cricoid. The latter terminates anteriorly in a sharp point, concealed in a ventral view by the meeting of the thyrohyal lamellæ just mentioned. The vertical bars of the cricoid cartilage, which in the female lie internal to the thyrohyal bones, are also present in the male, and are similarly placed; but they can only be seen by cutting open the larynx. Their dorsal extremities are not free, but are fused with the roofing part of the cricoid cartilage. The cricoid cartilage extends much farther forward on the upper surface of the larynx than it does in the female. It conceals the anterior part of the thyrohyals, and is confluent in front with the tract of cartilage which has been regarded above as the united anterior epiphyses of the thyrohyals. The actual roof, *i. e.* the part of the cricoid behind the arytenoids, is saddle-shaped, and differs from that of the female in being longer than broad, and in the greater thickness of its cartilage. The arytenoids are completely ossified, no cartilage remaining; and the glottis appears in the prepared skeleton as a rectangular hole. The sides of the glottis are formed by thick folds of mucous membrance occupying the right and left halves of this rectangle. The arytenoids are not confluent with one another as they are in the male *Xenopus*, nor are they backwardly produced into the interior of the larynx as in the male *Pipa*.

The larynx of both sexes is thus of simpler construction than those of the two sexes of *Pipa* and *Xenopus*; but in its hyobranchial skeleton *Hymenochirus* exhibits a most conflicting set of features. It is quite impossible to conclude, from evidence derived from this source, whether *Hymenochirus* is more primitive than the two previously known aglossal toads, or with which of these forms it is the more closely allied. Inconclusive, however, as the results are for this purpose, they constitute a strong argument in support of the view that the Aglossa are a natural group, and that the three genera now composing it have had a common ancestry. The discovery of *Hymenochirus* binds *Pipa* and *Xenopus* more closely together than before.

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EXPLANATION OF PLATE 31.

Fig. 1. *Hymenochirus Boettgeri*, male. Hyobranchial, laryngeal, and mandibular skeleton, ventral view. (× 6.)
2. Laryngeal skeleton of same, dorsal view.
3. *Hymenochirus Boettgeri*, female. Laryngeal skeleton, and hinder part of hyobranchial skeleton, ventral view. (× 6.)
4. Laryngeal skeleton of same, dorsal view.
5. Carpal skeleton of same, dorsal view. (× 12; see page 462.)

Reference Letters.

So far as has been possible, the lettering used in Plates **8** and **9**, Linn. Soc. Journ., Zool., xxvi. 1897, has been adopted in the present instance.

a. Ala, or great wing of the hyobranchial skeleton.
ar. Arytenoid.
as. Angulosplenial bone.
bl. Dorsal extremity of vertical cricoid rod.
br. Bronchial cartilage.
c. Dorsal or roofing portion of the cricoid cartilage.
c'. Antero-ventral portion of cricoid.
c''. Postero-ventral portion of cricoid.
ca. Ossified copula (*cf.* **6**. pl. 2. figs. 1 & 2, *ca*).
ch. Ceratohyal or hyoidean cornu.
ch'. Median cartilage formed by the secondary union of the hyoidean cornua.
d. Dentary bone.
ep. Posterior epiphysis of the thyrohyal.
ge. Area of insertion of the m. geniohyoideus externus.
gl. Position of the glottis.
h. Hyoglossal foramen.
i. Isthmus between the anterior and posterior portions of the branchial skeleton.
i'. Ligament equivalent to the cartilaginous isthmus of the female.
pa. Anterior plate of the hyoidean skeleton (*cf.* **5**. pl. 35. fig. 11, *pa*).
pm. Outline of anterior part of lung.
t. Thyrohyal bone.
t'. Lamella of cartilage projecting from the thyrohyal bone in the male.

Note on the Carpus of the new Aglossal Toad, *Hymenochirus Boettgeri*. By W. G. Ridewood, D.Sc., F.L.S.

(Plate **31**. fig. 5.)

Whereas the carpus of *Xenopus* is comparatively normal, and does not differ in any very essential respect from that of *Discoglossus* or *Bombinator*, the carpus of *Pipa* is remarkable from the fact that the ulna is separated from the fifth metacarpal by a single bone, and not two bones as in all other Anurous Amphibians.

While investigating the hyobranchial skeleton of *Hymenochirus,* an account of which appears in the pages immediately preceding, it occurred to me that it would be of considerable interest to determine, while the material was still in my hands, whether the carpus of this new genus could throw any light upon the question of the affinities of this form with the two previously known Aglossal Toads.

An examination of the carpus of *Hymenochirus* disclosed the fact that in this genus, as in *Pipa*, a single bone intervenes between the ulna and the fifth metacarpal. In view of the great variation to which the carpus of the Anura is subject, it is perhaps unwise to attach much importance to this fact; but it is certainly remarkable that the *Hymenochirus* of Africa should thus depart from the generalized type of carpus found in *Xenopus* (African), and should approach the hitherto unique variety exemplified by the American *Pipa.*

The carpus of *Hymenochirus* (fig. 5, Pl. 31) consists of five elements, not including the radial sesamoid (*s*). This last occurs also in both *Pipa* and *Xenopus*. In a joint paper on the Anuran Carpus and Tarsus by Prof. G. B. Howes and myself, the ventral surface of the carpus of *Xenopus* and *Pipa* is unfortunately figured as the dorsal surface, and the radial sesamoid is stated as occurring ventrally to the lunatum *—mistakes which were pointed out by Jungersen † in 1891. The sesamoid in question is dorsal in position in all three genera, and is lenticular in shape. In *Hymenochirus* it occupies a more proximal position than in *Pipa* and *Xenopus*, and lies over the epiphysis of the radius,—a fact somewhat destructive to the theory put forward by Emery ‡ that this element, in *Pipa*, is an "intermedium carpi." Since the dorsal radial sesamoid has been shown by Zwick § to occur also in the Frog and Toad, it cannot be regarded as distinctive of the Aglossa.

The largest bone of the carpus is that which extends from the ulna to the fifth metacarpal (*pk*). It represents the pyramidale

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* Proc. Zool. Soc. Lond. 1888, pl. vii. figs. 1, 2 & 4, and p. 162.

† Ann. Mag. Nat. Hist. [6] viii. pp. 193–206.

‡ Ricerche Lab. Anat. Norm. Roma, iv. 1894, p. 10.

§ Zeitschr. für wiss. Zool. lxiii. 1898, p. 102.

or ulnare, confluent with the post-axial centrale, as in *Pipa*. The distal carpal of the fifth digit is probably absent and not included in this bone. The fourth carpal is free. Seen from above, it articulates with a part of the third metacarpal as well as the fourth, but an examination of the palmar surface of the carpus suffices to show that this element belongs exclusively to the fourth digit.

In *Pipa* the third carpal is free, while that of the second digit is (presumably) fused with the naviculare or pre-axial centrale, but there is no distinct carpal to either the second or third digit in *Hymenochirus*. Whether the carpals of these digits have dwindled away and left no traces, or whether they have fused with the naviculare, it is impossible to say. The appearances rather suggest that the latter is the more correct interpretation.

The lunatum (*l*) is normal, and calls for no comment.

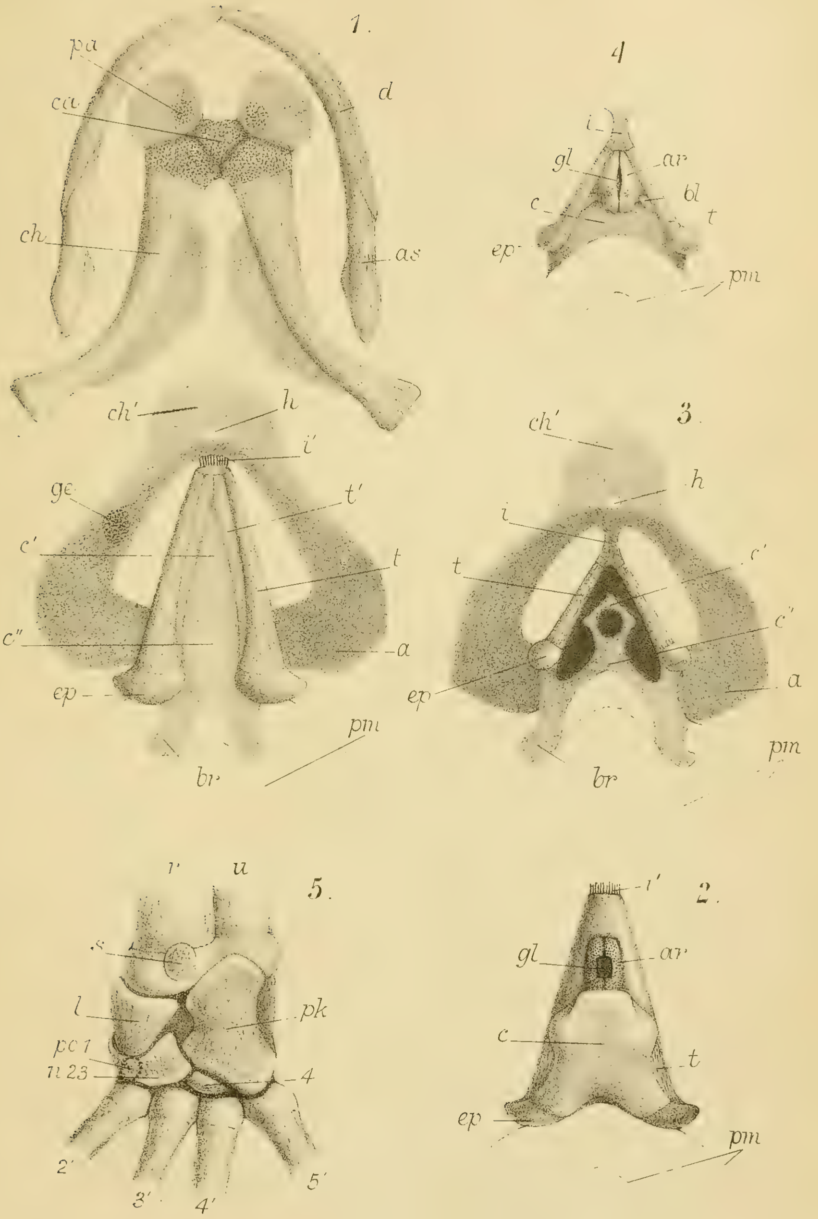
The pollex is represented by a single lenticular bone, probably carpale 1, which lies on the ventral surface of the naviculare. It is concealed by the latter in a dorsal view, but its position is indicated in the figure by a dotted line (*po.* 1).

The terminology used in this note is the same as that employed by Prof. Howes and myself in 1888. The arguments propounded by Perrin, Emery, and Zwick do not appear to be of sufficient weight to warrant the relinquishing of the opinions we then held as to the morphological value of the parts of the Anuran manus.

EXPLANATION OF FIG. 5, PLATE 31.

Carpal skeleton of *Hymenochirus Boettgeri*, dorsal view (× 12).

l.	Lunatum.
n. 2, 3.	Naviculare confluent with the carpals of the second and third digits.
pk.	Pyramidale confluent with the post-axial centrale.
po. 1.	Carpal of the pollex.
r.	Radius.
s.	Radial sesamoid.
u.	Ulna.
4.	Carpal of the fourth digit.
2′, 3′, 4′, 5′.	Metacarpals of the second, third, fourth, and fifth digits.



W.G.R. del. J. Green lith.   Mintern Bros. imp.

HYMENOCHIRUS BOETTGERI.

Hyobranchial Skeleton and Carpus.

On the Eye-spot and Flagellum in *Euglena viridis*.

By HAROLD WAGER, F.L.S.

[Read 2nd November, 1899.]

(PLATE 32.)

EUGLENA VIRIDIS is commonly found in stagnant water which contains a considerable amount of organic matter. It is often found abundantly in the liquid which runs from manure heaps, forming at certain periods a dense green scum on its surface. It is found sometimes in water troughs, and on mud in roadside gutters in places where refuse water from houses is thrown; and it is often very abundant on sewage farms.

Under ordinary conditions it is a free swimming organism, capable of moving very rapidly through the water by means of a cilium, or flagellum, which is placed at the anterior end of the body; but it can exist for a long time in a non-motile condition in an encysted state, surrounded and protected by a very thick cell-membrane. It is, however, capable of passing again into the motile condition as soon as the environment becomes favourable.

General Structure.

An excellent account of the general structure and life-history of the genus *Euglena* is given by Klebs *, whose memoir records the literature on the subject up to the date of its publication. A large amount of information concerning the structure of the various species of *Euglena* and allied genera is given by Stein †, Bütschli ‡, Saville Kent §; and, more recently, a good general account of the group will be found in the first volume of the

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* "Ueber die Organisation einiger Flagellaten-Gruppen und ihre Beziehungen zu Algen und Infusorien." Unters. aus dem bot. Inst. zu Tübingen, Bd. I., 1881–85.

† Der Organismus der Infusionsthiere, III. Der Organismus der Flagellaten. Leipzig, 1878.

‡ Bronn's Classen und Ordnungen des Thierreichs, I. Protozoa, 1883–87.

§ A Manual of the Infusoria. London, 1880–82.

'Traité de Zoologie Concrète' by Yves Delage and Edgard Hérouard [*].

A memoir by Khawkine [†] also contains valuable information on the structure and physiology of *Euglena viridis*. For further information concerning the numerous memoirs in which the structure of *Euglena* is dealt with, the reader is referred to the papers quoted above, which contain complete bibliographical lists of the literature on the subject.

Without attempting to give a complete account of the structure of *Euglena viridis*, it may be useful to briefly summarize what is contained on the subject in the memoirs already published, which my own observations enable me to confirm.

In the free swimming condition, the animal is elongate and cylindrical in shape, slightly larger in the middle than at the ends; the anterior end being truncated, the posterior usually pointed. It is a unicellular organism, protected on the outside by a thin skin or layer of modified protoplasm which is striated obliquely by slightly elevated ridges. These can be made visible by crushing the cell and squeezing out the protoplasmic contents under a cover-glass. Under certain conditions, of which one appears to be malnutrition, I find that the cells, while still retaining their power of movement, become curiously distorted and deformed, and might easily be mistaken for distinct species. This apparently accompanies a process of slow disintegration.

The protoplasm contains numerous chlorophyll-bodies, sometimes scattered all over the cell, with the exception of a short space at the anterior end which always remains colourless, but more often radiating from the centre, leaving both anterior and posterior ends free. In many cases, especially in cells freshly collected, it is not easy to distinguish the separate chlorophyll-bodies; and this led Saville Kent (*loc. cit.*) to regard the chlorophyll as diffused through the protoplasm; but it is only necessary to keep such cells in obscurity for a short time, in ordinary tap-water, or to examine them under a high power of the microscope, to see that the chlorophyll-bodies are really definite organs of the cell [‡].

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[*] Vol. I. La Cellule et les Protozoaires. Paris, 1896.

[†] "Recherches biologiques sur l'*Astasia ocellata* n. s. et l'*Euglena viridis*." Ann. des Sci. Nat. 7th series, vol. i., 1886.

[‡] Klebs, *l. c.* p. 264. See also Jessie A. Sallitt, "On the Chlorophyll Corpuscles of some Infusoria," Q. J. M. S. 1884.

I find that the chlorophyll-bodies are capable of assuming different shapes—spherical, oval, elongate, and ribbon-like; and to this may be due the different views as to their nature taken by various observers.

The cell usually contains a large number of grains of a starch-like composition (*paramylum*), which are not coloured blue by iodine, and are therefore not pure starch. They possess a very definite and characteristic structure, which is correctly figured by Klebs *, presenting some resemblance to the structure of a typical starch grain in being composed of laminæ, but differing from the starch grain in this, that the laminæ are not concentric, and present the appearance of flat plates laid one upon the other.

These paramylum grains may be found in any part of the cell, but under normal conditions are generally more numerous in the region of the chlorophyll-bodies. In cells kept in the dark, in a good nutrient solution such as a dilute solution of potato-starch †, the chlorophyll-bodies become pushed to the posterior end of the cell, whilst the anterior two-thirds of the cell become filled with a mass of paramylum grains. This results in the production of the so-called "white" or "colourless" forms.

The nucleus is usually found at the posterior end of the cell, but it may occur in the middle, or very rarely at the anterior end; in the "white" forms just described, it is found between the chlorophyll-bodies and the paramylum grains. In normal cells the nucleus is posterior to the chlorophyll-bodies; in the "white" forms it is anterior to them. It can be very easily seen in the living cell, and with care its structure can be made out. In osmic acid, and other hardening and preserving fluids, the structure is brought out very clearly. It consists of a central spherical nucleolus surrounded by a granular network.

The anterior end of the cell has a depression leading into a narrow tube or gullet, out of which the flagellum passes. On the dorsal side of the gullet is a distinct eye-spot, and near it is a large clear space, called the principal vacuole; and on one side of this a single, pulsating vacuole.

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* *Loc. cit.* See plate ii. figs. 8 *a*, 8 *b*, 8 *c*.

† Khawkine, *l. c.*

The Vacuole System and Gullet.

At the anterior, colourless end of all species of *Euglena* and allied genera there is a sharply defined space, which was known to Ehrenberg, and has been described by Klebs * as the "principal vacuole," into which open one or more pulsating vacuoles †. In *Euglena viridis* there is only one pulsating vacuole, but in other species there may be two or more, and in some cases the single pulsating vacuole is formed by the fusion of several smaller ones ‡. The principal vacuole possesses the power of slowly contracting, by which the liquid contained in it is discharged; but it is not to be regarded as a true contractile vacuole, but rather as a reservoir for liquid; and as a part of this liquid is poured into it by the true pulsating vacuoles, it would probably be better to describe it as an "excretory reservoir." The gullet is a conical or tube-like depression in the blunt anterior end of the cell, and it is usually described and figured as terminating in the neighbourhood of the excretory reservoir, from which it is separated by a thin layer of protoplasm only.

According to the view at present held, the excretory reservoir discharges its contents into the gullet through an opening which is made, at the moment when the contraction begins, by the rupture of the thin layer of protoplasm which separates the reservoir from the gullet §. Klebs ||, however, states that no opening can be observed in the excretory reservoir; it always remains sharply defined, and its slow contraction shows that such an opening is improbable.

I found, however, upon a careful examination of *Euglena viridis*, that, contrary to the observations described above, there is a permanent communication between the excretory reservoir and the gullet. This is not easy to observe in the living cells, but is very clearly seen when they are placed in a half to one per cent. solution of osmic acid for several hours, or even days, then mounted in dilute glycerine and observed under a $\frac{1}{12}$th inch oil-immersion objective, with the aid of a good sub-stage condenser.

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* *Loc. cit.* p. 246.

† Carter, "Additional Notes on the Freshwater Infusoria in the Island of Bombay," Ann. & Mag. Nat. Hist. ser. 2, vol. xx. p. 34. Stein, *l. c.*

‡ Klebs, *l. c.*

§ Traité Zool. Concrète, i. p. 346.

|| *Loc. cit.* p. 248.

It is then seen that the external opening of the depression at the anterior end of the cell is slightly funnel-shaped, that it leads into the gullet, a narrow tube-like passage, which is curved towards the dorsal side of the animal, and opens at its distal end into the so-called principal vacuole or excretory reservoir (Pl. 32. figs. 2–8).

The cavity of the excretory reservoir is thus in communication with the exterior; and this affords a more satisfactory explanation of the discharge of the liquid poured into it by the pulsating vacuole than that given by previous observers.

This connection between the excretory reservoir and the gullet does not appear to have been recognized by previous observers; although Stein (*l. c.*) figures what appears to me to be a distinct connection between them in *Euglena deses*, Ehrbg., *E. Spirogyra* and *Colacium calvium*, Stein.

As to the function of this anterior cavity we know very little. The flagellum arises in it, and it is often stated that the ingestion of solid food material can take place through it, small particles of solid matter being forced down into the protoplasm at the base of the opening by the continual movement of the flagellum, where they become digested in the same way as in *Amœba* *.

But it is doubtful whether this can be definitely proved, and the evidence at present brought forward in favour of it is not altogether satisfactory. I have constantly repeated the experiment, which is commonly taken as a demonstration that *Euglena* possesses the power of absorbing solid food-material, of putting finely powdered carmine in water containing *Euglena*-cells in active movement; and have observed that the motion of the flagellum causes a rapid and violent movement of the carmine grains, often sweeping them up to and past the mouth-opening in large numbers; but I have never been able to satisfy myself that any of them ever get into the gullet. Dangeard † states that the nutrition in the whole group is distinctly vegetal in character; and that no solid particles penetrate the interior of the body. The gullet, according to him, certainly does not serve for the introduction of solid matter.

Khawkine (*l. c.*) suggests that liquid nutriment may be

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* See, for example, Parker's 'Elements of Biology,' p. 40.

† "Recherches sur les Cryptomonadinæ et les Euglenæ." Le Botaniste, i. 1889, p. 1.

absorbed through the gullet, and he brings forward the following observation in support of this view. When *Euglenæ* are kept in dilute potato-starch solution in the dark, paramylum grains are produced in great abundance, gradually filling up the whole cell, and pushing the chlorophyll granules to the posterior end of the cell. The smallest paramylum grains are found at the anterior end of the cell in the neighbourhood of the gullet; and they gradually increase in size towards the middle of the cell, where they are much crowded together and nearly all of the same size. Khawkine's explanation of this is that the small size of the grains near the gullet indicates that they begin to form in this region, and that it is probably through the gullet that the substances are absorbed which are necessary for their production.

This is a very interesting observation; but it is obvious that we require further evidence before we can say definitely that liquid nutriment is absorbed wholly, or even partly, through the gullet.

So far, then, all we can say concerning the function of this anterior cavity in the cell of *Euglena* is that it serves for the excretion of liquid from the pulsating vacuole; but that it serves for the ingestion of either solid or liquid food has not been proved. In a later part of this paper I shall refer to its connection with the flagellum.

Structure of the Eye-spot.

It is well known that many motile cells of both animals and plants possess a red pigment-spot which is sharply defined from the protoplasm; and, from its apparent resemblance to the eye of *Cyclops* and Rotifers, was called by Ehrenberg an eye-spot.

Our knowledge of its structure depends upon the researches of Leydig, Kunstler, Klebs (*l. c.*), Schilling, Franzé *, Overton †, Pouchet, Johnson ‡, and others, for an account of which reference

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* Franzé, "Zur Morphologie und Physiologie der Stigmata der Mastigophoren." Zeit. f. Wiss. Zool. 1893, vol. lvi. p. 138.

† Overton, "Beitrag zur Kentniss der Gattung *Volvox*." Bot. Centralbl. vol. xxxix. p. 65, 1889.

‡ Johnson, "Observations on the Zoospores of *Draparnaldia*." Bot. Gaz. vol. xviii. p. 294, 1893.

may be made to Zimmermann[*], and to the memoirs of Klebs and Franzé.

The eye-spot was at first supposed to be a homogeneous red spot or disc; but Leydig[†] in 1856 described it in *Euglena* and some other forms as consisting of scarcely measurable, strongly refractive granules; and this has since been confirmed by many other observers.

According to Klebs (*l. c.*) the eye-spot of *Euglena* is a well-characterized body, both in form, inner structure, and chemical behaviour. Its form varies with the species, but is very constant for one and the same species. Its structure is apparently the same in all species, consisting of two substances—a plasmatic ground-mass forming a fine network, and a pigment which occurs in the form of drop-like bodies embedded in it. The presence of a plasmatic substance can only be inferred from the fact that the eye-spot can be caused to expand under pressure or by the action of swelling reagents, which results in the separation of the pigment-drops from one another.

Franzé (*l. c.*) states that, in addition to the pigment, the eye-spot contains one or few to many strongly refractive bodies which are, in *Euglena*, composed of paramylum, grouped in a more or less regular manner, consisting of a central or excentric "crystal body," with smaller and always more numerous "lens bodies" surrounding it. Both the crystal body and the lens bodies serve to concentrate the light, and the pigment not only absorbs light but is also sensitive to light.

I have been quite unable to confirm Franzé's observations either as to the crystal body or the lens bodies, although it is very easy to observe the granular structure described by other observers. I have examined several species of *Euglena* and *Phacus*; I have had *Euglena viridis* under observation in all its stages and under many different conditions of its existence, but I have never seen anything of the nature of paramylum bodies in or on the eye-spot. Nevertheless I have sometimes noticed, when examining the eye-spot with a magnifying-power of 500 or 600 diameters, an appearance something like that figured by Franzé, which seems to be due, however, to the irregular outline of the eye-spot (it is very rarely as regular in outline as Franzé's

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[*] Zimmermann, "Sammel. Referate &c., 10. Der Augenfleck (Stigma)." Beihefte zum Bot. Centralbl. vol. iv. p. 160, 1894.

[†] Leydig, Lehrbuch der Histologie. (See Franzé, *l. c.*)

figures would indicate), and to the fact that it is curved around the gullet and is sometimes sharply turned in here and there at the edge. The eye-spot has thus not only an irregular contour, but its surface is very uneven, and under a low power with poor definition it may sometimes present an appearance of colourless granules embedded in the pigment. Under a high magnifying-power with good definition, this appearance vanishes completely, and the eye-spot is resolved into the simple granular structure to which reference has already been made.

The pigment granules are brightly refractive and have a very distinct outline. They form a single layer, and in *Euglena viridis* are easily separated from each other, especially when the cells are in the enycsted condition. In some eye-spots the granules are spherical and all of the same size, but in others they are more irregular in shape and of different sizes, and in such cases the eye-spot is more homogeneous in appearance, especially near the middle.

By the action of strong potash solution the eye-spot swells up, and the pigment granules become separated from one another *. The arrangement of the granules is not very definite, but now and then they were found to be grouped in rows, sometimes radiating from the centre (fig. 1, *a*). The number of granules present varies, but not to any great extent: in a fairly large number of cases which I counted, I found that between 30 and 40 granules were the most frequent. If the action of the potash is continued for some time, the eye-spot disintegrates more or less completely into a number of granules (Pl. 32. fig. 1, *d*). Even in the living condition, the eye-spot sometimes breaks up into a number of separate granules which become distributed through the protoplasm. This is frequently found to be the case in cells which have become encysted and surrounded by a thick wall. I have never seen it in elongate motile cells, although I have often noticed in the surrounding protoplasm a number of granules of the same size and colour as those in the eye-spot, and looking as if they had been separated from it. They can be easily distinguished from the rusty-red granules, which appear in the protoplasm as a result of the disintegration of the chlorophyll grains, by their bright red or orange colour and greater refractive power. The nature of this colouring-matter has not been fully

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* Klebs, *l. c.*

investigated, but the few observations which have been made seem to show that it is a chlorophyll derivative. According to Cohn, with whom Klebs agrees, the red pigment is hæmatochrome, and stands in genetic relationship to chlorophyll; whilst Rostafinski * regards it as reduced chlorophyll. The rusty-red granules and the pigment of the eye-spot are similar in their behaviour towards alcohol, which in both cases, immediately it comes into contact with them, causes the granules to run together to form a homogeneous red mass or drop of oily substance, from which two colouring-matters at once become separated out—an orange-coloured substance which forms the main mass of the drop, and one or two small bright red droplets in the centre of it. The red colour soon disappears entirely, and the orange colour changes to yellowish green, then to green, and at the same time becomes smaller and smaller until it suddenly disappears, and in its place a small vacuolar-like body is left, surrounded by an irregular ring of some refractive substance.

This reaction, although not conclusive by any means, indicates that the rusty-red granules which are derived from the chlorophyll and the red pigment of the eye-spot have something in common, and supports Cohn's statement that the latter is genetically connected with chlorophyll. It has been suggested that the pigment of the eye-spot is identical with the red colouring-matter, carotin, which occurs in the roots of *Daucus Carota* and in the orange or red chromatophores of many fruits and flowers, from the fact that it shows the characteristic blue colour with sulphuric acid †.

Guignard ‡ has shown that in the Fucaceæ the orange-coloured chromatophores possess the same chemical reactions as the orange-coloured eye-spot; and he further shows that the eye-spot is formed from a colourless chromatophore found on one side of the nucleus, which at first becomes rapidly coloured yellow, then orange.

In *Euglena* the eye-spot is found both in the motile and in the resting cells, and new eye-spots arise by division, as Klebs has also shown. Whether there is any formation of eye-spots *de novo* at any stage in the life-history of *Euglena*, such as occurs in

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* Klebs, *l. c.*

† See Zimmermann, Botanical Micro-technique.

‡ Revue Gén. de Bot. i. 1889.

the motile cells of Fucaceæ [*] and Algæ [†], is doubtful. The breaking-up of the eye-spot which has been observed in old encysted cells may simply be a part of the general disintegration of the cell; if not, it would appear that a new formation of the eye-spot must take place on the resumption of the motile condition. This, however, requires further investigation.

Without entering into any further discussion of these facts, it is clear, I think, that the eye-spot is a definite organ of the cell possessing a characteristic, but simple structure; that it is probably a derivative of chlorophyll; that it is present in the motile cells only of those Algæ in which it has been described and is formed *de novo* when they are produced; and that even in *Euglena*, although it is present both in the motile and in the resting condition, it disappears, or becomes broken up, in cells which remain long in the encysted condition. We are probably justified, therefore, in concluding that the eye-spot is an organ of the motile stage of both animal and plant cells, specially connected with their power of movement.

The Flagellum.

The flagellum is an organ of the cell especially connected with its rapid movement through the water. If it is absent, the *Euglena* is only capable of a slow creeping movement which is caused by a peculiar contraction of the body, characteristic of the organism. This contraction appears to originate in the protoplasm, but the different forms assumed are probably to some extent dependent upon the elasticity of the limiting layer or cell-wall; and Khawkine (*l. c.*) suggests that contractile fibres are present—longitudinal ones over the whole of the cell, and transverse ones in the anterior region only. These, however, have not yet been seen, the only indication of any such contractile fibres being the oblique striæ found on the cell-wall; and so far we have no evidence that these play any part in causing the contraction of the cell.

The free movement of the cell through the water is entirely due to the flagellum, which by its rapid motion draws the cell after it, causing it at the same time to rotate around its longitudinal axis. Very little is known of the actual mechanical means by which this is accomplished, but an interesting discussion

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[*] Guignard, *l. c.*

[†] Overton, *l. c.*, and Johnson, *l. c.*

of the question will be found in the first volume of the 'Traité de Zoologie Concrète' * by Delage and Hérouard.

It is usually stated that the flagellum arises either on the dorsal wall of the gullet or from the protoplasm at its base. This, however, is not correct. The flagellum not only does not terminate in the gullet, but actually passes into the excretory reservoir, with which, as I have shown, the gullet is in open communication, and it becomes attached to its dorsal wall, or occasionally to its ventral, by a bifurcate base (Pl. 32. figs. 2 to 8). This bifurcation extends as far as the anterior edge of the eye-spot, at which point the single whip-like portion of the flagellum begins (fig. 2). This mode of attachment of the flagellum has not, so far as I am aware, been observed before; it probably serves to give it a much firmer support, and may be of mechanical advantage to it in its movement.

In addition to this bifurcation, we find another interesting structure connected with the flagellum. On one of the branches of the bifurcate base there occurs an oval swelling or enlargement, immediately in front of the eye-spot, and just below the point where the bifurcation begins (Pl. 32. figs. 2, 8). It is in close contact with the eye-spot when the cell is in the elongate motile condition; but it is not actually in organic connection with it, as shown (Pl. 32. figs. 7, 8), and in numerous cases which were observed of *Euglena*-cells in the resting condition, it was completely separated from it (fig. 9). In some cases, this enlargement appears in the position indicated in figs. 3 to 6, just above, or at, the point of bifurcation of the flagellum; but from a careful examination of numerous specimens in which this appearance was seen, it seems to me that it is an effect due to the second branch of the bifurcation passing below the enlargement, and so becoming hidden from view (compare figs. 7 and 8).

Although both the bifurcation and the enlargement are visible under favourable conditions, in the living cell, it is necessary in order to see them clearly to resort to the use of reagents. The best reagent for the purpose is a 1 per cent solution of osmic acid. This kills motile *Euglena*-cells at once, and leaves them in an expanded condition with their flagella distinctly visible. They should remain in this solution from three to forty-eight hours or more, and may be examined in dilute glycerine. In order to preserve them for future investigation, they may be kept in a

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* La Cellule et les Protozoaires, p. 305.

50 per cent. solution of alcohol. Dilute glycerine is the best mounting medium, but fairly satisfactory preparations may be made either in glycerine-jelly or canada balsm.

In good preparations the contents of the cell appear black, the eye-spot black and sharply defined, and the flagellum with its enlargement dark grey.

I have occasionally succeeded in staining the flagellum and enlargement light green in a mixture of methyl-green and fuchsin. Fig. 2 is from a preparation made in this way and mounted in dilute glycerine.

The Effect of Light on Euglena.

In common with many other unicellular motile organisms which contain chlorophyll, *Euglena* is extremely sensitive to light. Our knowledge of the phenomena is mainly due to the investigations of Stahl [*], Strasburger [†], and Engelmann [‡]. They find that in general the cells are attracted by a light of moderate intensity and repelled by an intense light; but that the degree of sensitiveness which they exhibit varies considerably even in individuals of the same species. Further, both Klebs and Strasburger have shown that they do not lose their sensitiveness to light either in the dark or at a higher temperature; and Englemann has also shown that this power is independent to a high degree of a variation in the oxygen pressure.

The effects produced by the action of light upon the motile cells of *Euglena* are very striking. They are strongly attracted by a bright light such as that of a gas-flame or incandescent burner focussed, by means of a substage condenser, upon a microscope-slide on which a drop of water containing *Euglenæ* has been placed. Such a spot of light will attract, in the space of about one minute, the majority of the cells in the field of the microscope, as seen by a one-inch objective; and in two minutes only very few will be found outside the light area. If a large number of cells are present, they will form a seething mass in

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[*] "Ueber den Einfluss von Richtung und Stärke der Beleuchtung auf einige Bewegungserscheinungen im Pflanzenreiche." Bot. Zeitung, 1883.

[†] "Wirkung des Lichtes und der Wärme auf Schwärmsporen." Jena. Zeitschr. xii., 1878.

[‡] "Ueber Licht und Farbenperception niederster Organismen." Pflüger's Archiv, Bd. 29, 1882 (see J. R. M. S. 1883, p. 81).

the light space, perhaps two or three layers deep, all of them with the anterior end pointing downwards towards the source of light. On turning down the condenser so as to get the light spread evenly over the whole field of the microscope, they begin at once to move away rapidly in all directions, and in one or two minutes are found in all parts of the field. If the light is again focussed upon a small portion of the field, the *Euglenæ* turn round suddenly and make for it; and a steady stream of them will be seen moving up to the light from all parts of the field. When the light space is shifted from place to place in the field of the microscope, the *Euglenæ* follow it; and if the mirror be moved backwards and forwards in such a manner that the light space is made to pass continually from one side of the field to the other, the *Euglenæ* arrange themselves all across the field in the area marked out by the passage to and fro of the light space. The rapidity with which they move up to the light space is much greater when there is no diaphragm over the condenser than when one is present. The diffuse light outside the bright spot apparently guides them.

It is interesting to watch the movements of the *Euglenæ* in the light space. The majority of them move about freely, but appear to be unable to get out; for directly the anterior end of an individual passes into the shade, it turns round completely and goes back again into the light. Some of them, however, may pass completely into the shade, and may even swim for some distance into the dark part of the field before turning round; others again do not turn round completely at once, but move round the edge of the light space in a tangential direction for some distance before passing in again.

Some of the cells which are strongly attracted to the light space move straight across it, and pass out again on the opposite side into the dark part of the field. After traversing this for some distance, they turn round and repeat the performance; and they may do this three or four times in succession before they come to remain in the light space.

If a drop of water containing motile *Euglenæ* be placed on a glass slip and exposed to bright sunlight, the *Euglenæ* move to that side which is farthest from the sun. If the slip is turned round, they at once begin to move towards the opposite side, that which is now farthest from the sun; and in the space of three minutes a large number of *Euglenæ* are able to pass from one side to the other, across a drop of water a quarter of an inch in diameter. If in their passage across, the sun becomes obscured by clouds, or if a sheet of note-paper is placed between the sun and the drop of water, they stop at once, and either remain moving about in the middle of the drop or go back again to the side nearest the source of light.

If they are kept in bright sunlight for any length of time, they come to rest and round themselves off; and if they remain in a good light for some days, the cells gradually become encysted. The effect of a strong light is always to produce encystment.

In a light of moderate intensity, the cells may remain motile for a very long time; but they always become rounded off at night, and may then lose their flagella and undergo division into two. Until they lose their flagella, however, they may be always brought into the motile condition again by exposing them to the light of a lamp or gas. This shows, as Klebs* has pointed out, that they do not lose their sensitiveness even in the dark so long as they can move.

These experiments are sufficient to show that *Euglena* possesses a very definite light-perception. Engelmann has also shown that it is the colourless anterior end of the cell which is sensitive to light, and it is only when this comes into contact with light or shadow, that the cell reacts to the light by altering the direction of its movements. If the shadow falls upon the posterior chlorophyll-containing end of the cell, there is no reaction. He has further shown that *Euglena* prefers the blue portion of the spectrum, the following being the percentage distribution of a typical case:—

Red to Orange	1·4	per cent.
Orange to Green	0	,, ,,
Green	11·2	,, ,,
Green to Blue	70·4	,, ,,
Blue to Indigo	16·8	,, ,,
Indigo to Violet	2·1	,, ,,

It has also been shown that swarmspores are more sensitive to the blue rays of the spectrum than to other parts.

According to Franzé (*l. c.*) and Wildeman † motile *Euglenæ* are sensitive to heat, but they do not respond to it either so quickly or so intensely as to light.

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* *Loc. cit.* p. 263.

† "Sur le thermotaxisme des Euglènes," Bull. Soc. Micros. Belg. 1894.

To determine the effect of heat, Franzé placed *Euglenæ* in a thin glass tube which was closed at both ends, and kept warm at one end by allowing a stream of hot water to flow over it. The tube was kept in the dark. At a temperature of 55° C. the *Euglenæ* became immobile from the effects of heat, but at a lower temperature, 30°–40° C., they mostly approached the source of heat.

Wildeman obtained somewhat similar results. He placed *Euglenæ* in a tube with wet sand, in order to avoid convection-currents. It was then placed in the dark in a horizontal position, and warmed at one end, and he found that the *Euglenæ* accumulated at the warmer end of the tube at a temperature of 30° C. On exposing tubes to light as well as heat, he found a considerable modification in the effects produced. If they were placed at right angles to the rays of light, the *Euglenæ* avoided the warm end of the tube. If they were placed in the same direction as the rays of light they moved towards the light, even when the opposite end of the tube was heated.

My own experiments confirm in a general way the results obtained by these observers; but the *Euglenæ* are so slightly sensitive to heat as compared with light, that the subject requires further investigation before any very definite conclusions can be arrived at.

The Function of the Eye-spot.

It is commonly stated that the eye-spot is a light-perceiving organ. This does not imply that it possesses an actual visual function, but simply that it is connected in some way with those changes in the direction of the movements of the cell which are due to light. There is no direct proof of this, but we have a sufficient amount of indirect evidence to show that the statement is probably a correct one.

Ehrenberg regarded the pigment-spot in *Euglena* as a light-perceiving organ on account of its general resemblance to the eyes of Rotifers and *Cyclops*; and it has since been shown that it resembles them in some respects both in structure and in its behaviour towards solvents and other reagents, such as iodine and sulphuric acid *.

Further, in all those chlorophyll-containing unicellular organisms which are very sensitive to light and capable, by means

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* Klebs, *loc. cit.*

of their flagella or cilia, of responding quickly to changes in its direction or intensity, an eye-spot is present. Those motile cells which do not possess an eye-spot are either not sensitive to light at all, or only to a slight extent. Even in the zoospores of *Chytridium*, which according to Strasburger * are sensitive to light, it is interesting to note that at the base of the cilium there is a conspicuous orange-coloured oil-globule, which may act in the same way as an eye-spot.

Again, Engelmann has shown for *Euglena* and Strasburger for swarmspores of Algæ, that the rays of light which are most active in their influence upon the movements of these organisms are found in the region of the blue portion of the spectrum, and these are just the rays which, as indicated by the colour of the eye-spot, are absorbed by it. We conclude from this, therefore, that it is the light absorbed by the eye-spot, and not that transmitted through it, which is concerned in these movements.

Finally, it has been shown by Engelmann that it is the colourless anterior end of *Euglena* that is sensitive to light. "Hence, in this case, a certain part of the body functions to a certain extent as an eye"†. In this colourless anterior end of the cell, both the eye-spot and the apparatus which directly causes the movement of the cell—the flagellum—are placed.

Having thus briefly stated the evidence we possess in favour of the conclusion that the pigment-spot of *Euglena* is a definite light-perceiving organ, we must now attempt some explanation of the way in which the light acts.

It is obvious that, whatever may be the action of light, the movements of the cell, as well as any change in direction of its movements, are dependent directly upon the flagellum. Without it, as we have seen, the cell is only capable of a very slow contractile movement, of its body from place to place. It is evident therefore that those rays of light which are capable of exerting a material influence upon the movements of the cell can only do so by controlling or modifying in some way the mechanism by means of which the flagellum is caused to move. Now we have already seen that the flagellum and eye-spot are closely related to each other. The flagellum arises near the eye-spot and, on its

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* Jena. Zeitschr. xii. 1878, p. 568.

† Hertwig, 'The Cell,' p. 100.

way to the exterior, passes quite close to it. Moreover it possesses an enlargement on one of its basal supports which is placed immediately in front of, and in close contact with, the inner concave surface of the eye-spot.

The presence of this enlargement of the flagellum in such a position at once suggests the simple explanation that the light-rays which are absorbed by the eye-spot cause a stimulation of the enlargement in some way; and this stimulation reacting upon the flagellum causes its movements to become modified, and so results in a change in the direction of the movement of the cell.

We have thus a combination of two structures, which may, if my explanation be correct, be regarded as an extremely simple form of eye, consisting of a specialized portion of the cell (*protoplasm* ?) possessing great sensitiveness to light-rays of a particular kind, and a pigment-spot, as a light-absorbing organ, in close contact with it.

Whether it is the light absorbed by the pigment-spot which actually effects the change in the movements of the flagellum; or whether the pigment-spot simply prevents these rays from reaching one side of the enlargement, whilst the other side is left freely exposed to them, thus producing a difference of intensity on the two sides of the enlargement, it is at present impossible to say. We know that protoplasm itself is sensitive to light, and responds to it without the intervention of any such structure as a pigment-spot. It may be therefore that the arrangement just described in *Euglena* is one by which the active rays are, under certain conditions, cut off on one side of the enlargement, while the other is left exposed to them. This would result in a definite unequal illumination of the sensitive portion of the cell; and consequently the organism would tend to move into such a position that it would be more or less equally illuminated all round, and would be brought ultimately into the light-ray.

I put forward this explanation tentatively, as the only one which appears to me at present to afford an adequate interpretation of the facts observed. It is evident, however, that it is a question which demands a more extended and laborious investigation than I have so far been able to undertake, before any very definite conclusions can be formulated.

Summary.

(1) The structure of the eye-spot in *Euglena viridis*, *E. Ehrenbergii,* and *Phacus pyriforme* is not as Franzé has described it. The so-called "crystal body" and "lens bodies" were not found in any of the individuals of the species examined by me. As earlier observers have stated, the eye-spot consists simply of a mass of pigment granules arranged in a single layer, and probably embedded in a protoplasmic framework, but the latter could not be seen, and its presence was only inferred from the fact that the pigment granules must be held together in some way, that the eye-spot as a whole is capable of expansion, and that the pigment granules can be separated from each other.

(2) The gullet at the anterior end of the body does not end blindly, as was formerly supposed, near the principal vacuole, but actually opens into it, thus forming one continuous cavity open to the exterior.

(3) The eye-spot is in close contact with the gullet at the point where it opens into the excretory reservoir, and curves around it slightly.

(4) The flagellum is not attached to the wall of the gullet, but arises from near the posterior or basal side of the excretory reservoir, to which it is attached by a bifurcate base. The bifurcation begins at about the level of the eye-spot, and in this region an enlargement of one of the basal supports takes place. This, which is oval in shape, is in close contact with the eye-spot, on its inner concave side. It is in the same position as that described by Franzé for his "crystal body," and may have been mistaken for this by him.

(5) An explanation of this structure suggested by the author is that the light which is absorbed by the eye-spot in some way stimulates this enlargement, which in turn reacts upon the flagellum and causes its movements to become modified. This is supported by the facts which are stated in the three following paragraphs.

(6) The rays of light which are absorbed by the eye-spot—those in the region of the blue of the spectrum—are the same as those which are active in modifying the direction of movement of the *Euglena*-cell.

(7) These rays can only influence the movements of the cell by acting upon or controlling in some way the mechanism by which the flagellum moves.

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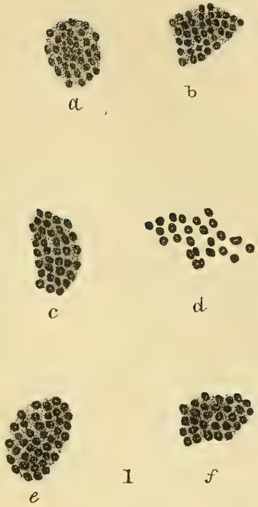

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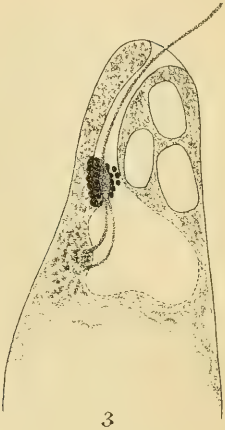

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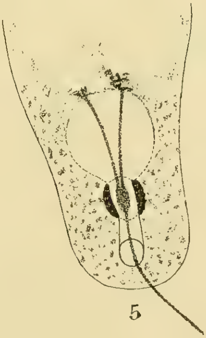

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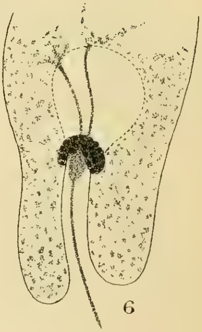

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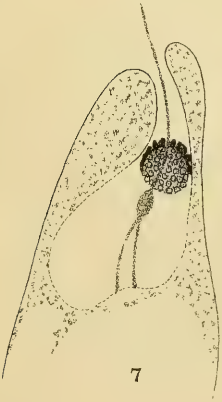

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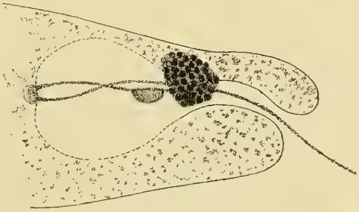

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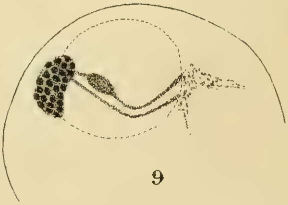

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H. Wager del.
M.P. Parker lith.

Geo. West & Sons imp

EUGLENA VIRIDIS.

(8) All those chlorophyll-containing motile cells which are very sensitive to light contain an eye-spot. Many other organisms which do not possess an eye-spot are sensitive to light, but not to so high a degree.

(9) If the explanation given in par. 5 is correct, we have in *Euglena* an extremely simple form of light-organ, consisting of a specialized sensitive portion of the cell—the enlargement on the flagellum—and a light-absorbing pigment-spot in close contact with it.

EXPLANATION OF PLATE 32.

The figures have been drawn, unless otherwise stated, with the aid of the Camera lucida, and the $\frac{1}{12}$th oil-immersion of Leitz or the 2 mm. 1·4 apert. apochromatic objective of Zeiss and ocular 18.

Fig. 1. Eye-spots from different individuals, showing the arrangement of the pigment-granules.

Fig. 2. Side view of the anterior end of a motile cell, showing the flagellum and its enlargement in front of the eye-spot. This specimen was stained in methyl-green and fuchsin for two hours, then washed in water and mounted in dilute glycerine. The whole of the red colour was washed out, the flagellum and its enlargement were stained light green; the eye-spot was left brown.

Fig. 3. This shows the attachment of the bifurcate base of the flagellum to the dorsal wall of the excretory reservoir. The protoplasm formed a slight projection at the point of attachment, and was slightly more hyaline or refractive than the rest.

Fig. 4. The flagellum is attached to the excretory reservoir nearer the base than in fig. 3, and each of its arms is slightly expanded at the base. The enlargement appears just at the place where the bifurcation begins.

Fig. 5. A view of the anterior end of a cell as seen from below.

Fig. 6. A slightly oblique view of the anterior end of a cell seen from above.

Figs, 7 & 8. Two views of the same cell, showing the enlargement at some distance from the eye-spot.

Fig. 9. A freehand sketch of a portion of a cell in the resting condition. The excretory reservoir, the eye-spot, and the bifurcate base of the flagellum and its enlargement are shown.

On some New Zealand Schizopoda.

By Geo. M. Thomson, F.L.S.

[Read 7th December, 1899.]

(Plates **33** & **34.**)

Though so many species of Crustacea have been described from New Zealand from time to time, yet the amount of collecting which has been done in the Colony, and especially in the North Island, is really very small. The result is that only a few individuals, representative of whole families, have in many cases been recorded.

Trawling is now becoming common, and the opportunity of securing material in this manner will no doubt be more or less utilized. But up to the present, and excluding the fragmentary collections made during the 'Challenger' Expedition, nearly all the material hitherto studied has been obtained by shore collectors. The specimens described in this paper come under the same heading: they are the only Schizopod crustaceans which have yet been found in New Zealand waters, but probably the group will be found to be well represented.

SCHIZOPODA.

Fam. Mysidæ.

Genns Siriella, *Dana*.

Siriella denticulata. (Pl. **33**. figs. 1–5.)

Mysis denticulata, Thomson, Ann. & Mag. Nat. Hist. ser. 5, vol. vi. p. 1, 1880; Trans. N. Z. Inst. vol. xiii. p. 205, pl. vii. fig. 6, 1881.

This species appears to be intermediate in most of its characters between *S. Thompsoni*, M.-Edwards, and *S. gracilis*, Dana. I had provisionally included it in the former; but Prof. G. O. Sars, to whom I sent specimens, considers it to be a new species.

It resembles *S. Thompsoni* in the acutely pointed frontal projection, in the large eyes with greatly expanded cornea, in the general form of the telson, and in size.

On the other hand, its affinities with *S. gracilis* are seen in (1) the slender form of the body, (2) in having the last joint of the antennular peduncle rather short and stout, as in fig. 1, (3) in the form of the antennal scale, (4) in the divided propodal joints of the legs, (5) in having the last caudal segment as long as the two preceding taken together, and (6) in the form of the apex of the telson.

The adult specimens attain a length of fully 10 mm. The *antennal scale* (fig. 2) is about three times as long as broad, the apex is obliquely truncate, and the outer margin is produced into an acute spine or denticle. The *legs* (fig. 3) have the propodal joint distinctly divided into two articulations, the proximal being the shorter. The *telson* (fig. 4) is rather slender, and tapers considerably towards the apex; the latter is very narrow and obtusely truncate, and bears three short spines between the rather long terminal spines of the margin, in this respect somewhat resembling *S. gracilis*. The *uropods* (fig. 5) project considerably beyond the telson. The inner plate is narrow-lanceolate, with the auditory apparatus very fully developed and the inner edge spinose. The outer plate is somewhat longer than the inner, and has the outer edge of the basal joint armed with spines, which in large specimens are from ten to twelve in number, and which increase in size posteriorly.

Hab. I have only met with this species in Otago Harbour, though it is probably common; but Mr. Suter has sent me one (mutilated) specimen from Lyttelton Harbour. In the Report on the Schizopoda of the 'Challenger' Expedition, Prof. G. O. Sars states that both species of *Siriella* (*S. Thompsoni* and *S. gracilis*) were taken at the surface of the sea. The former has a very wide range, having been taken in the Atlantic and Pacific Oceans, and in the Tasman Sea; the latter occurs in the seas of the Indian Archipelago and in the Pacific Ocean. My specimens were taken in the dredge in 6 fathoms of water. I have only met with the species once.

Genus TENAGOMYSIS, nov. gen.

Generic characters.—Body slender, as in *Mysis*. Dorsal shield short, not covering more than half of the cephalothorax; front obtusely pointed. Antennary scale narrow-lanceolate, setose on both margins. Mandibles with well defined molar tubercle palp with a much dilated second joint (Pl. 34. figs. 9 & 10) Maxillæ and maxillipedes as in *Mysis*. Feet rather slender and weak.

Marsupial pouch in the female formed of three pairs of laminæ increasing in size posteriorly, the first very small. Pleopoda in the female small and narrow, very feebly developed; in the male they are well-developed and two-branched ; in the first pair the inner ramus is very small and one-jointed, the outer of the usual natatory form; the remaining pairs have both rami long and subequal. Telson short, deeply cleft at the apex.

Uropods narrow; inner plate much shorter than outer, both densely furnished with marginal setæ. Auditory apparatus well-developed.

This genus appears to be intermediate between *Leptomysis* and *Heteromysis*, resembling the former in general structure and especially in the pleopoda and limbs. It differs from it, however, in the form of the front of the carapace, in the telson, and in a less marked degree in having the antennary scale one-jointed, instead of distinctly two-jointed. The resemblance to *Heteromysis* lies particularly in the dilated second joint of the mandibular palp.

The genus is formed to contain a species which is not uncommon on the coasts of New Zealand.

TENAGOMYSIS NOVÆ-ZEALANDIÆ, n. sp. (Pl. 33. figs 6–8; Pl. 34. figs 9–17.)

Form of the body linear, tapering slightly to the telson; length about six times the greatest breadth.

Dorsal shield short, obtusely pointed in front in the median line; evenly rounded on the posterior margin, only slightly produced backwards on the lateral portions.

Eyes large, cornea hemispherical, peduncles short and stout.

Peduncle of the *superior antennæ* with the basal joint subequal in length with the 2nd and 3rd together; the appendage in the male is produced into a rounded process, furnished with a dense bunch of hairs at its base; inner flagellum less than half as long as the outer, very slender, destitute of hairs, and rather densely pigmented in great portion of its length (figs. 6 & 7).

Scale of the *inferior antennæ* obliquely lanceolate, more than twice as long as the peduncle, maximum width about one fifth of the length, densely furnished with plumose setæ, which are very long on the curved inner margin; both the scale and the peduncle of the antennæ are more or less ornamented with black stellate or frondose markings (fig. 8).

Maxillæ of the first pair are normal. The second pair of maxillæ have the terminal joint broadly obovate, and furnished with numerous strong setæ on the outer margin. The *maxillipedes* and *gnathopods* present no very distinctive features.

The *legs* are rather slender in structure, the propodos ending in a tuft of fine setæ; the exopodites are all well-developed, with a broad basal joint, bearing a ten- or eleven-jointed setose branch (fig. 12).

The *marsupial pouch* in the female is formed of three pairs of lamellæ, the anterior of which are very small, and the posterior very large.

The *pleopoda* are rudimentary in the females. In the males the first pair has the inner ramus very short and one-jointed, obtuse at its apex, and with a lateral process produced across the long outer ramus; the latter is normally six-jointed (figs. 13 and 14). The succeeding pairs have both rami well-developed, subequal in length and natatory, but the inner is always furnished with a process near its base which is produced more or less across the outer branch (fig. 15). *Telson* short, only about half as long as broad, slightly narrowing at the sides, which are furnished with about twelve spines including the terminal one; the apex is deeply cleft, the sides of the notch being furnished with fine close-set pectinate spines and the centre defined by two long plumose setæ (fig. 17).

The *uropods* have the outer plate long and slender, somewhat obliquely truncate at the apex; the inner is about two-thirds as long as the outer, broadly lanceolate in form, and tapering to an obtuse apex, its inner margin has numerous spines between the setæ; both plates are densely setose on both margins (fig. 16).

Length of the adult females, 10–16 mm.

Hab. In the Kaikorai lagoon (brackish water), estuary of the Waikouaiti River, and rock-pools at Brighton,—all near Dunedin. Also dredged in the Bay of Islands from a depth of 8 fathoms.

Fam. EUPHAUSIIDÆ.

Genus NYCTIPHANES, *G. O. Sars.*

NYCTIPHANES AUSTRALIS, *G. O. Sars.*

Nyctiphanes australis, G. O. Sars, Report on the 'Challenger' Schizopoda, p. 115, pls. xx. & xxi. figs. 1–7.

Numerous specimens of this species were gathered by Dr. Benham and Mr. A. Hamilton at Port Chalmers.

The specimens originally described by Sars were all taken on the south and east coasts of Australia, "in the surface-net, and in most instances at night."

EXPLANATION OF THE PLATES.

Plate 33.

Siriella denticulata × 43.

Fig. 1. Eye and peduncle of antennule.
2. Antennal scale, denuded of most of its setæ.
3. Leg of the 2nd pair.
4. Telson.
5. Uropod, denuded of setæ.

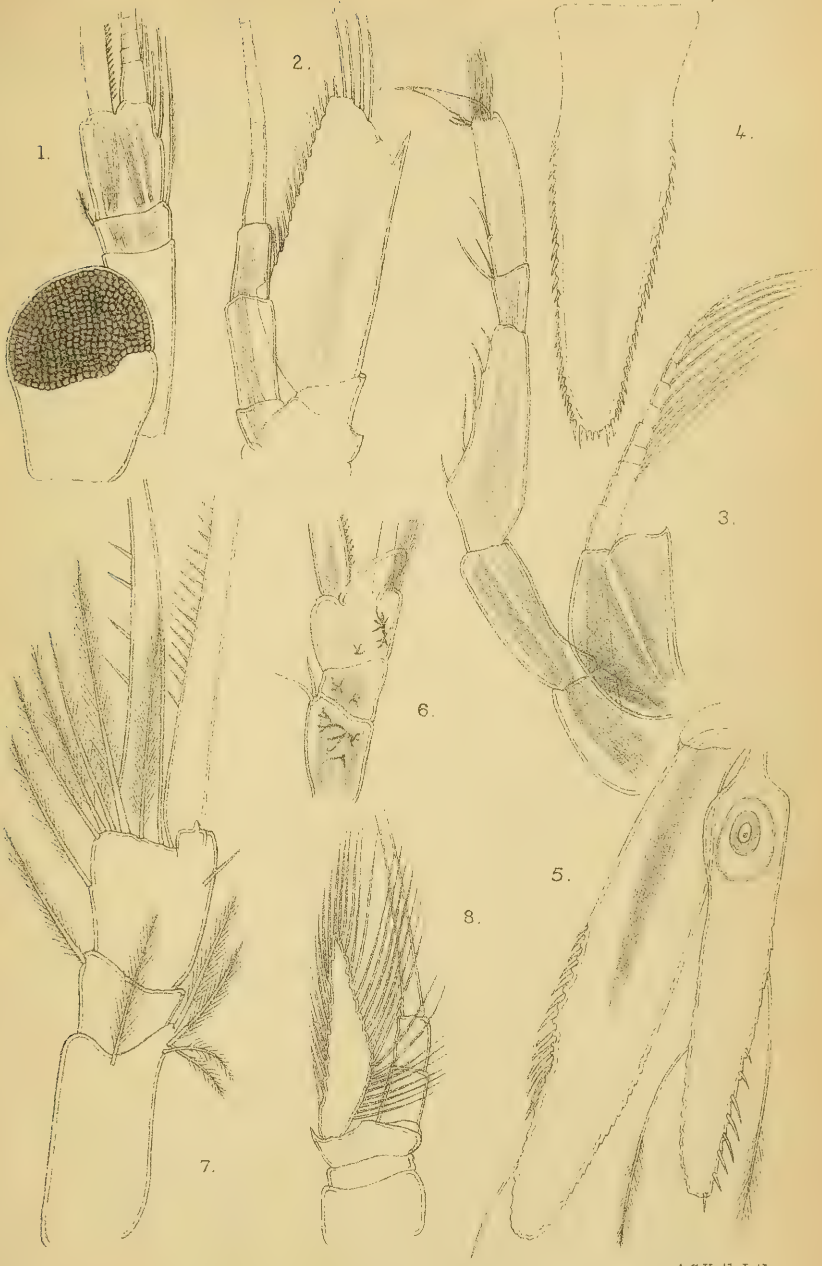
Tenagomysis novæ-zealandiæ.

Fig. 6. Peduncle of antennule of ♂, from below × 43.
7. ,, ,, of ♀, ,, × 56.
8. Antennal scale, × 43.

Plate 34.

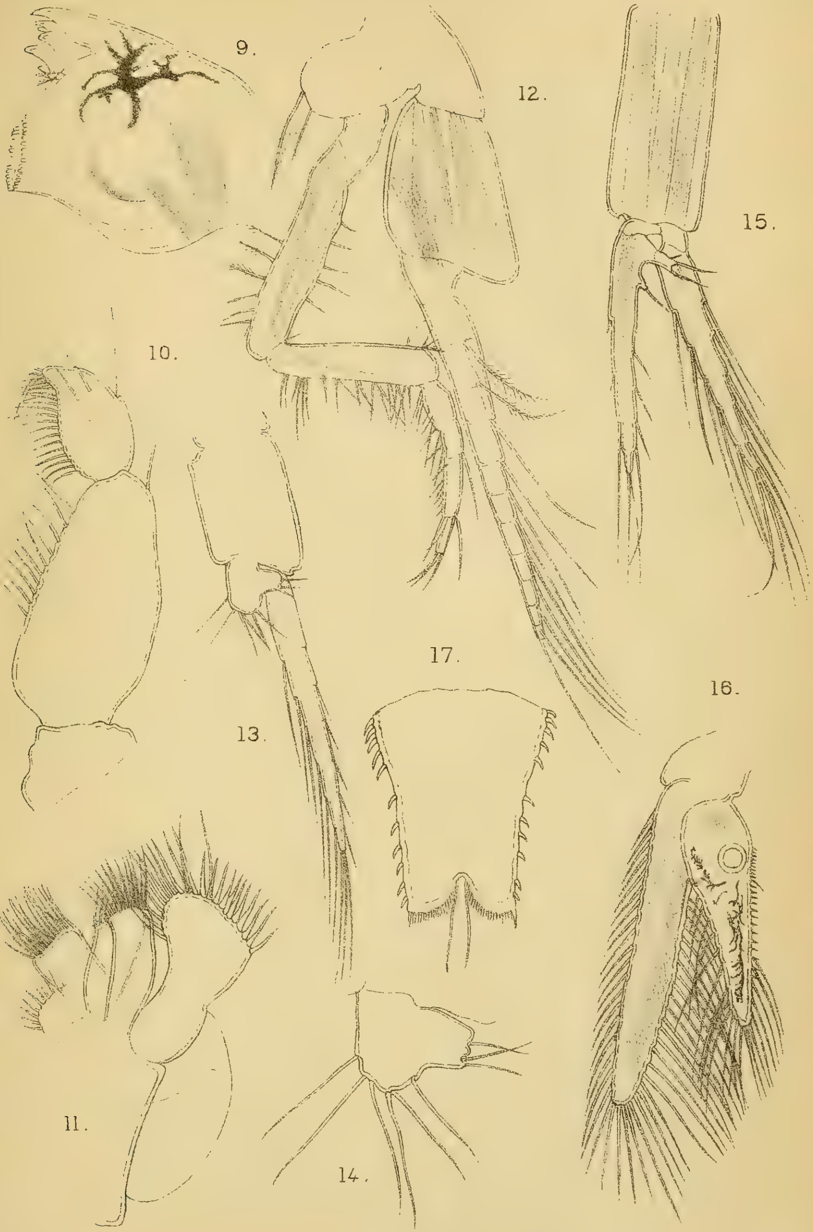
Tenagomysis novæ-zealandiæ.

Fig. 9. Mandible.
10. Mandibular palp. } × 125.
11. Second maxillæ.
12. Leg of the third pair of ♂, × 56.
13. 1st pleopod, ♂, × 56.
14. External ramus of same, × 125.
15. 5th pleopod, ♂, × 125.
16. Uropod, × 43.
17. Telson, × 56.



A.S.Huth, Lith.

1-5, SIRIELLA DENTICULATA.
6-8, TENAGOMYSIS NOVÆ-ZEALANDIÆ.



A.S. Huth, Lith.

TENAGOMYSIS NOVÆ ZEALANDIÆ.

On the Structure of *Porites*, with Preliminary Notes on the Soft Parts. By HENRY M. BERNARD, M.A. Cantab., F.L.S.

[Read 7th December, 1899.]

(PLATE 35.)

IN a paper lately read before this Society*, I endeavoured to ascertain the position of *Porites* in the Madreporarian system. A brief sketch of the structure was then given, sufficient to make the rest intelligible. The conclusion arrived at was that *Porites* resulted from a tendency towards very early budding, already noted in the Madreporidæ. This tendency, pushed still further, has produced a genus in which the budding takes place while the skeleton is still immature. In this way, the small size and the shallowness of the calicle, the perforation of the septa, and the reticular nature of the whole skeleton, which may be regarded as retrograde characters, can be reconciled with the presence of a flattened epitheca which, as elsewhere † explained, is characteristic of the highest Madreporarian specialization.

In the present paper I propose to give an account of the structure of *Porites* in greater detail. During the year which has elapsed, my specimens have been examined and re-examined, and new structural details have come to light. One of them, namely, the discovery of the directive plane, and the bilateral symmetry of the calicle, will largely help to rescue the genus from the obscurity to which the smallness of its calicles and the complexity of its reticular skeleton have necessarily condemned it.

I have also been able to cut sections of the polyps of a West-Indian form, one of the many from that region with low thick knobbed stems, alive only for a few centimetres at the top. A few brief notes on the first results of the microscopical examination of these are here appended.

The Skeleton.

Wall and Cœnenchyma.—The distinction often drawn between these two ‡ has been due to the absence of any clear conception as to what the wall really is. I have already explained in my last paper how, in the Madreporidæ, the primitive epithecal

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* This vol., p. 127.

† Journ. Linn. Soc., Zool. xxvi. p. 495.

‡ Compare, for example, Klunzinger's statement that, in *Porites*, the calicles are united by the walls and not by a cœnenchyma (Corallenthiere, ii. p. 39). The same is repeated by Martin Duncan, Linn. Soc. Journ., Zool. xviii., 1884.

wall became flattened out, and a secondary internal septal wall took its place, the living tissues clothing the whole of this septal wall down to the remains of the epitheca. This wall was primitively built up of the radially arranged laminate septa and their synapticular junctions. Secondary modifications occur, and the stiff radial arrangement of plates joined concentrically together dissolve down and change into a sponge-work in which the primitive elements are only just traceable. We then have a reticular wall which may be thick or thin. When a coral with such a septal wall buds, to form a stock, the reticular walls of parent and bud flow together. *These combined walls form the cœnenchyma.* The cœnenchyma can only be said to be absent when it is reduced to a minimum, *i. e.*, when the calicles are separated by a single perforated plate. But, in reality, no sharp line can be drawn between the many degrees of thickness resulting from the fusion of the walls.

It is true that an apparent distinction exists between the wall and the cœnenchyma in certain cases, but in none will it bear examination. In *Madrepora*, the upper parts of the calicles (when young) project above the cœnenchyma, that is, above the fused basal parts of their walls. But as these calicles get older, the fusion usually rises, till, in the basal or older parts of most Madrepores, the calicles are quite submerged, and the fused walls and the cœnenchyma are one and the same structure *.

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* It will be noticed that this description tends to limit the meaning of the word 'cœnenchyma' to the fused outer or costal surfaces of purely septate thecæ. Its component elements, therefore, are septal and synapticular,—one might have said costal and synapticular. But, in these porous thecæ, division of radial structures into septal and costal portions can only be artificial. And it seems to me that the word 'costa' had better be reserved for external ribs which are somewhat more naturally separate from the septa.

If the term 'cœnenchyma' is so limited, it not only excludes such tissues as that in which the calicles of *Galaxea* are embedded, which is epithecate in origin, but also all the stray proliferations of the skeleton which are frequently met with in the Madreporidæ and elsewhere. For instance, in *Alveopora* there can be no costæ at all, the walls between adjoining calicles being morphologically equivalent to interlacing septal spines (Journ. Linn. Soc., Zool. xxvi. p. 495). And yet, in rare cases, on the undersides of stocks, a curious proliferation of the walls sometimes takes place, so that the calicles may be separated by a coarse reticulum almost like a normal cœnenchyma. All such adventitious proliferations of skeleton I propose to call a 'pseudo-cœnenchyma.' They are mostly found in the basal parts of stocks, where normally, as is well known, the basal skeleton merely thickens without forming any additional framework.

In *Montipora* and in *Porites*, the calicle-walls fuse for their whole height, and the fossæ are merely sunk into the common reticular skeleton. In *Montipora* it is impossible to assign definite portions of this reticulum to the individual calicles; but in many *Porites* this can be done, the surface being marked off into polygonal areas, each area being in close contact with those adjoining it, and with its surface often sloping inwards towards the fossa in the centre. Hence it has been stated that *Montipora* has a cœnenchyma, but *Porites* little or no cœnenchyma (Milne-Edwards and Haime *; see also quotation from Klunzinger, *ante*, p. 487, footnote). An extended survey of *Porites* shows that this distinction is quite artificial. On many of the forms with these thick-walled calicles marked off into polygonal areas, these areas become gradually invisible in the older parts of the stock; while forms in which no areas are traceable at all, and in which the calicles are sunk straight into a reticular skeleton as they are in *Montipora*, are quite common. Milne-Edwards suggested that perhaps these latter should be placed in a new genus. This suggestion was carried out by Verrill †, and further emphasized by Klunzinger, who placed *Synaræa*, Verr., at the very end of the Poritidæ, because it alone had a cœnenchyma; whereas, as above stated, calicles marked off into areas and calicles sunk in a level cœnenchyma can frequently be found on one and the same stock ‡.

Passing in review the various walls found in *Porites*, we shall see again how impossible it is to separate a group as a new genus merely on account of the great thickness and level tops of their walls.

Thin Membranous Walls.—These walls have very different appearances according as the intrathecal skeleton rises to the level of the wall or sinks down below that level. In the former case we have a surface like that shown in fig. 5, Pl. **35**; only here the skeletal elements are somewhat thickened. In these cases it is common to find the edge of the wall incomplete, the calicles communicating freely one with the other. These communications doubtless become perforations as the stock thickens.

In these thin-walled forms the wall itself is composed of a

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* Ann. Sci. Nat. 3rd ser., xvi. 1851, p. 24.

† Bulletin Mus. Comp. Zool. i. 1864, p. 42.

‡ For another supposed generic distinction between *Porites* and *Synaræa* ee p. 494 footnote.

single ring of synapticular bars or plates, and these may be arranged either zigzag round the calicle or in straight lines. In the latter case, the lines form the sides of polygons. These straight walls are, I expect, secondary; for, regarding the reticular wall as primitive, the zigzag wall would be the more natural derivative of such a reticulum. The zigzag line is formed by single synapticular bars joining the alternating costal edges of adjacent calicles. All stages of the straightening of this line can be found. It is the straight wall which rises above the surface as a thin membrane-like edge, and, in extreme forms, may give the whole surface an alveolate appearance. The whole intrathecal skeleton may remain deep down in the base of the membranous pits, or septal striæ may slightly thicken the walls and serrate their edges.

Reticular Walls.—Of these there is an immense variety, and again the appearance is very different according as the intrathecal skeleton rises to the level of the wall or is sunk down below that level. They are thick and thin, round-topped or with a sharp median ridge; or again, if the calicle-depressions are cylindrical, the intervening angles may be thick and reticular, while at the points where the calicles touch one another, the wall may be reduced to a single lattice-work. Of the thick walls, we have already referred to the variety in which straight median ridges mark off in polygonal lines the areas belonging to each calicle. These areas may sink inwards funnel-shaped towards their central fossæ. Or, again, they may be quite level. In this case, the median ridge frequently disappears, and we have the cœnenchymatous group (formerly *Synaræa*, Verrill). The most interesting section of these is formed by those in which the thick walls rise up secondarily into ridges or papillæ (fig. 6, Pl. 35), very similar to those found in *Montipora*. This is an interesting case of similar specialization arising under similar conditions. But, in *Montipora*, the thick reticular walls are characteristic of the genus: hence these cœnenchymatous developments on the tops of the walls are far richer and more varied than they are in *Porites*, in which the thick reticular wall is confined to a group only. I have so far found no traces of the 'tuberculate' specialization * of the cœnenchyma which is so widely developed in *Montipora*.

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* *Cf.* Brit. Mus. Madrep. iii., Introd. p. 9: also for figures, Ann. & Mag. Nat. Hist. xx. (1897) p. 117, pl. ii.

These secondary cœnenchymatous developments have given rise to some confusion, their morphology not being always clear, especially when the calicles are crowded and the ridges appear as mere upward extensions of the walls. In the 'Challenger' Report on the Reef Corals (xvi., 1886), two new forms, *P. crassa* and *P. latistellata*, Quelch, are described; but, according to the classification there adopted, they should have been placed in the genus *Synaræa*, which was established to contain all the Poritid forms with ridges or papillæ rising from the walls between the calicles. *P. latistellata* was so named because the individual calicles were measured as if these secondary cœnenchymatous ridges were the tops of the walls; and in an allied form, where the ridges ran so as to separate the calicles into short linear series in the bottoms of narrow valleys, such series were thought to be the result of intracalicinal gemmation. This led Mr. Quelch to found a new genus, *Napopora*. Recent acquisitions by the British Museum have supplied us with links sufficient to connect the types of the new genus specifically with *P. latistellata*.

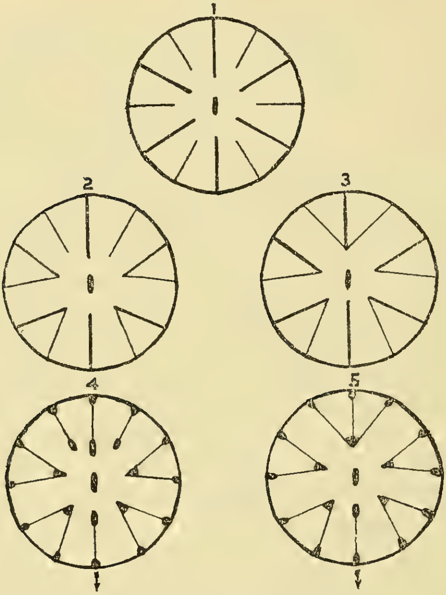
A few of these different types of wall will be seen in Plate 35. Representatives of the two extremes can be seen and compared in figs. 5 and 6. How impossible it is to make generic distinctions between them, may be gathered from the fact that specimens occur in which part of the stock has walls even thinner than those shown in fig. 5; while another part of the same stock has walls as thick as those shown in fig. 6, although without the special cœnenchymatous papillæ.

The finer texture of the walls can be best discussed in connection with the septa.

The Septa.—The number usually assigned to *Porites* is twelve, and it seems quite possible to separate *Porites* from *Goniopora* mainly on this point, *Goniopora* having typically 24. Dr. Verrill ascribed "12, sometimes 12 to 20, rarely 24" septa to *Porites*; but I have found it better to class every Poritid with more than 12 septa in the genus *Goniopora*, as Dana proposed. Mr. Quelch, again, claimed 24 septa for *Porites* (Chall. Rep. xvi.), on account of his species *P. mirabilis*, in which calicles occur with 3 cycles of septa. These, however, are obviously the large double calicles, one or two of which can be found on almost any stock and must be regarded as abnormalities. One is seen in fig. 5, Pl. 35.

With regard to the development of the septa in *Porites* no comprehensive survey has ever yet been attempted. Milne-Edwards and Haime described them as usually hardly distinct from the pali.* I give, in the accompanying diagrams, a series of their more important variations. These are found so intimately linked together, more than one being observable on the same stock, that no generic distinctions can possibly be built upon them.

1. Twelve distinct septa end freely and separately round the fossa.



Diagrams showing the principal variations in the septal and palic formulæ in *Porites*.

Slight swellings of their inner edges may or may not indicate a disposition to form pali. They may or may not be distinguishable into two cycles. Forms with such septa, of which the best known example is *P. astræoides*, Lamarck, were grouped into a separate genus† *Neoporites* by Duchassaing and Michelotti. But the disposition to form pali and also to pass into the condition shown in fig. 2 renders it impossible to admit any such distinction.

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* Ann. Sci. Nat. 3rd ser., xvi. 1851, p. 25.

† Or 'subgenus,' Pourtalès, Bull. Mus. Comp. Zool. iv. 1871, p. 85.

2. The septa meet and fuse, and *always in the way shown*, two pairs on each side of a line passing through two opposite septa, the significance of which will be seen presently.

3. The fusion of septa goes still further, and, in addition to the two pairs, a triplet is formed (fig. 3). Pl. **35.** figs. 5 and 6 show these fusions fairly clearly, and probably careful study might make them out on some of the other figures, but they can naturally be best seen in forms in which the upper edges of the septa are nearly on a level with the walls. I have never found any other fusions of septa but these. And here we may note that we obviously have the directive plane in the line passing through this triplet and the columellar tubercle. The calicle is divided into two symmetrical halves; and whether the two cycles of septa are distinguishable or not in size and development, we can always now ascertain which are the primaries and which the secondaries.

4 & 5. The septa which are best developed in fig. 1 become usually poorly developed in figs. 4 and 5 (diagr.), and their upper edges are interrupted. A portion, frequently only a granule, shows near the wall, and another portion appears as a palus at the tip of each septum. I propose to call the peripheral portions of the septal edges, the septal granules. Their variations are found to supply new and valuable taxonomic characters.

In these figures, the spaces between the septal granules and the pali are exaggerated, the figures not being intended to be more than diagrams.

We now come to the pali, which are so very characteristic of the genus, but on the arrangements of which no light has hitherto been shed.

The Pali.—These structures, though well shown in one of the earliest figures of *Porites* *, attracted no attention till Dana described them in his 'Zoophytes' †. He speaks of an inner and an outer ring of points, and adds that sometimes one of the inner unites with two of the outer to form a V-shaped palus. Since that time, the pali have always been treated as features of taxonomic importance, but nothing could be said about them than that their numbers were 5, 6 or more, and that they were large and prominent or the opposite, and occasionally V-shaped.

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* Ellis & Solander, 'Zoophytes,' 1786, pl. 47. fig. 2.

† P. 550.

Reference to the digrams shows that they occur in a definite order, and that, in their development, they are closely associated with the fusions of the septa.

Passing over the cases of those *Porites* with septa arranged as in fig. 1 (p. 492), and each with a slight paliform swelling, and therefore with traces of 12 pali, the number is limited to eight as shown in fig. 4. Of these eight, the four which arise at the points where the septa meet in pairs are usually much larger than the rest (Pl. **35.** fig. 1). They may be very large indeed as compared with those arising from single septa. When the large palus is formed by the fusion of the three septa, as shown in fig. 5 (diagr.), we have, with the four large ones at the points of fusion of the pairs, five large pali. Whenever we have a ring of five large pali, we know where and how they arise, viz., at the five points in which the septa fuse (see many of the rings of pali, Plate **35.** figs. 3 & 6). Among these will be seen many in which there is a small extra palus, making five principal pali and one minute palus. The last is that on the directive septum, which remains single as shown in fig. 5 (diagram).

In Plate **35.** fig. 6, it is easy to see the large pali arising from the points of fusion of the septa, and here and there having the **V**-shape described by Dana. But this arises not from the fusion of granules, as the great American naturalist believed, but from the fact that the fusing septa are slightly exsert *.

As the pali will have to figure in all future specific descriptions, it is necessary to name them. I propose therefore to call those which arise at the points of fusion of the four pairs, the four '*Principals*.' The directive palus which often takes part in the triple fusion may be called the '*Directive principal*.' The rest may be called *Supplementaries*, and we have a directive supplementary and two lateral supplementaries; one or both of these last-named may fuse with the directive principal.

It should be noted that no palic formula seems to be constant throughout all the calices of a stock. When describing the formula of any species of *Porites*, all that is meant is that there is apparent in the colony a tendency to produce that particular formula.

Having now described the septa and the pali, we may return

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* This prominence of the pali and septa in many of the *Porites* with developed cœnenchymas was thought to be another generic distinction of *Synaræa*, but the point is an unimportant one.

to the finer texture of the walls which are built out of these septa, with their synapticular junctions.

It is quite correct to say of *Porites* that the stiff radial and concentric symmetry of septa and synapticulæ which characterizes the typical Madrepore is here melted down into a reticulum; a reticulum more loose because of the perforate and incomplete character of the septa.

We find, however, interesting variations in this respect. Not a few *Porites* still show traces of the stiff radial septa radiating outwards on the top of the walls as so many short ridges, *e. g.*, slightly seen in fig. 4, Pl. 35. These sometimes run from calicle to calicle, but are always slight and never approach the fine systems of parallel striæ which are so well developed over the whole cœnenchyma in *Madrepora* and *Turbinaria*, as unmistakable evidence of the part which the laminate septa (or costæ) play in the construction of the walls.

The first stage of dissolution is probably that in which the vertical elements persist as trabeculæ or upright threads which end above the surface as granules. This is the most common condition of the surface of *Porites*. The connection between the walls can then be seen from the fact that the wall granules are only a repetition of those seen within the calicle—septal granules and pali.

Not infrequently the horizontal elements become flattened flakes, so that the vertical section shows tiers of floors supported by short pillars.

The last stage is that in which both vertical and horizontal elements melt down entirely into either a sponge-work, or into a system of flakes mostly lying horizontally. In these cases we do not usually find the surface covered with granules, they are present only so far as the vertical elements, the tips of which constitute these surface-granules, continue to be developed as pillars.

The Columellar Tangle and Tubercle.—The base of the calicle in *Porites* always fills up sooner or later with a mass of reticular tissue, as emphasized by Dana*. This tissue may be conveniently called the Columellar Tangle. The most symmetrical manner in which this can develop is as a regular ring joining the septa and pali. It rises to various heights. It may be very simple and

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* Zoophytes, 1848, p. 117.

open, or else, especially in cases where the horizontal elements are flaky, it may appear solid. I have never seen the columellar tangle as such protuberant or convex in *Porites*.

And here it is worth noting that there appears to be some trace of dimorphism in the calicles of a stock, while in some the centre of the columellar tangle fills up with cross bars, in others the latter remains a deep open pit. These two forms on one and the same stock are so frequent, that they suggest some definite physiological significance (*cf. infra*).

The tubercle which rises from the columellar tangle but is absent when the centre is hollow, is, as above noted, often found flattened in the directive plane and here and there joined to one of the directive pali. It is the equivalent of the directive keel seen bisecting the columellar tangles in many *Turbinaria*. It appears as if, in the earliest stages of budding, the directive septa met straight across the calicle, and that this columellar tubercle is the remains of the connecting link. This conclusion commends itself from the fact that a close study of columellar tangles, as in *Turbinaria*, where they are specially well developed, shows that they are primitively built up of the usually curled lower edges of the septa.

These comparisons help to confirm my view of the relationship of *Porites* to the Madreporids. In the case of *Madrepora*, the directive plane in the buds falls in with the radial symmetry of the parent, and might almost be regarded as coincident with that of one of its costæ. In *Turbinaria* although, in large stocks, the directive keels point almost all ways, yet, near the margins, they are often seen all pointing towards the growing edge. I have been fortunate enough to see this phenomenon in a thin explanate *Porites* (fig. 4, Pl. 35). In this figure the great majority of the directives point nearly uniformly up and down, that is, in the line of growth. If we refer to the diagrams, the direction of growth runs out between the four principal pali as indicated by the arrow (diag. 4 & 5, p. 492).

Whether these directive planes, when found twisted all ways on a stock, indicate special relationships between adjacent individuals of the colony it is impossible to say. I should be inclined to think that the individual as such is submerged except in *Madrepora*, and that the buds come from the common cœnosarc.

Before leaving this columellar tubercle, I would draw attention to the fact that I have inserted it in all the diagrams as a permanent feature of the skeleton. While I believe it to have been a primitive element of importance, it is not now universally developed. I have already mentioned those scattered calicles which occur on most stocks in which the fossa is a deep pit, but, apart from these, we find in very deep calicles that the pali and the columellar tubercle are sometimes wanting. There can be little doubt that there is some correlation between the depth of the calicle and the development of pali. The same phenomenon occurs also in *Goniopora*. Stocks occur in which great variation exists in the depths of the calicles; for instance fig. 2, Pl. 35, is taken from one side of a stock in which the calicles on the opposite side are much deeper and show only the faintest traces of pali.

It is not surprising, then, that it is just in the deeper calicles with all septa free, as is shown in diagram 1, that the columellar tubercle is most frequently absent, and the pali often only slightly traceable as faint swellings. But cases are not wanting in which, while the septa are free and the pali hardly traceable, the columellar tubercle is well developed: I have found this in some West Indian species. The combination is interesting, because a *Porites* without pali but with a columellar tubercle exists in the Berlin Museum, and was named by Ehrenberg *P. punctata*. Milne-Edwards & Haime first suggested a new generic name for it, and called it *Stylaræa Mülleri*. But these authors suppressed this name the same year and reverted to Ehrenberg's *P. punctata*. In recent years, however, Dr. Klunzinger* has again revived the genus, re-naming the original specimen *Stylaræa punctata*, and placing it next to *Porites*. I find it necessary to add this genus *Stylaræa* to the list of apparently needless genera given in my previous paper. For, not only is there nothing specially startling in the absence of pali and the presence of the columellar tubercle, but, among the many other variations presented by *Porites*, we actually have specimens in which the columellar tubercle is well developed while the pali are here and there only faintly traceable. As against the advisability of making a new genus on the original specimen of Ehrenberg, I should like to point out that it is so small that, as Ehrenberg suggested, it might easily be a young form in which adult conditions are not yet fully developed. I have frequently observed that young, and perhaps very rapidly

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* Corallenthiere, ii. 1879, which see for other references.

growing stocks have characters very unlike those of the larger stocks close to which they are growing, and from which it is probable, though not always certain, that they have been derived.

Growth-forms.—Very young colonies consisting of a small mass of reticulum filling up an epithecal saucer are frequently met with. I have, however, never met with one in which the parent calicle was still recognizable. Such, however, must of course be postulated. The appearance, in cases in which the wall is reticular, is almost indistinguishable from that shown by young Montipores (see figs. 1 & 2, Ann. & Mag. N. H. (6) xx. pl. ii.). I have not found any young colonies of forms with membranous walls. A knowledge of the early colonies would be very desirable: considering the ease with which, in a large stock, one type of calicle passes into a very different type, we might expect them to vary considerably from the adult.

The budding of shallow, saucer-like calicles from the sides of other shallow calicles is not likely to be very plastic. But among other causes of form-variation, we may note the local thickening of the walls. When this is very irregular and confined to small groups of calicles, it leads to the formation of bosses and knobs from which branches are easily developed. In this way purely branching forms many have been evolved, but the branches are for the most part thick and coarse; elegantly branching forms are rare.

Considerable variation occurs as to the depth to which the colony descends in branching forms. We find all extremes: merely the tips for a centimetre or two may be alive, or the living layer may extend right down to the base of the stock, twenty centimetres or more.

As reef-builders, this genus of Stony Corals has long been famous. It is a conspicuous component of the outermost edge of the reef where the surf is most violent. The unfavourable conditions of existence at such spots may supply us with a clue to the dwarfing of the polyps, this having resulted in the building-up of almost solid coral-masses. Hence again, though branching forms are fairly numerous, they are insignificant as compared with the rounded masses of almost solid coral-rock (often many feet in diameter) which are most frequently met with. In the West Indies, we read of thick tangles of branching Porites spreading over the surface, but the branches are coarse, thick and matted together.

Dana thought that there were no foliate forms, the nearest being the sublamellate growths due to the fusion of the branches. There are, however, a few thin explanate forms which approach the foliate condition. But there is certainly no rich foliation such as we find in the foliate group of the *Turbinariæ* and, only in lesser degree, in the Montipores.

The various growth-forms pass so gradually into each other that it is only possible to group them in series. I place the explanate forms, which admit of being described separately, as the first division. The second consists of those explanate and encrusting forms which throw up lobes and columns; these vary imperceptibly in two directions: (*a*) into columns, and (*b*) into branching forms, both without encrusting bases. The third group consists of glomerate forms beginning (*a*) with those with edges expanding while the centre thickens, and may either, by continuous growth or by fresh relays, form great hemispherical masses, and ending (*b*) with those in which the stock develops at once as a rounded mass. These again are often difficult to distinguish from one another: and hard and fast distinctions are impossible.

Some Preliminary Notes on the Soft Parts.

In the diagram of *Porites* which I sketched in my former paper*, in order to compare the structure of the skeleton upon its flattened epitheca with that of a Madreporid, the porous septa were purposely drawn very low. The diagram represents only an ideal parent calicle of a *Porites*. As a matter of fact, while, in very many forms, the calicle-depression is like that there shown, the underlying reticular skeleton occupied by the soft tissues is very much deeper.

In sections of dried *Porites*, the staining of the living tissues penetrates some 3–4 mm. beneath the surface, and, if a piece be decalcified, the soft parts are left as a fleshy reticulum of nearly even thickness (3–4 mm.), from the surface of which the polyps project. The enteric cavities of the compound stock are simply a network of fine canals.

On decalcifying a fragment of *P. recta* (?) from Jamaica, beneath the fleshy rind was found a cloudy mass of hyphæ, threads of which had run up through the skeletal reticulum into

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* This vol., p. 135, fig. 1.

the septa and pali. These threads kept the hyphal mass attached to the rind after the skeleton was dissolved away. Several different kinds of fungoid growths can be distinguished, many presenting appearances so interesting that the whole will be submitted to specialists in that branch of study, in the hope that some new biological facts will be forthcoming.

Further, in the clear spaces left by the decalcified skeleton, are sections of an organism which is almost certainly a ciliate Infusorian. These are essentially like those figured by Moore of *Spirostomum* (Journ. Linn. Soc., Zool. xxiv. pl. 27),—an open angular network with staining granules at the nodes, the cilia not staining and passing out through a thin, deeply staining membrane which, in sections, is broken up by the cilia into a row of dots. How Infusoria live in the apparently solid coral I do not know. It is, however, worth recording that one not infrequently finds the thinnest skeletal framework completely hollowed out by a system of thin-walled tubes, so that it is in reality not solid. I have never hitherto found any clue to this phenomenon. The discovery of a large Infusorian in the spaces of a Porites-section which are, in life, occupied by skeletal bars, adds another to the organisms, Sponges, and Fungi, to whose agency the excavations above mentioned might possibly be due.

There seems to be great variation in the shapes of the polyps, both contracted and protruded, judging from the published figures. But it is very doubtful how far any value can be attached to these variations.

Nevertheless some of these differences should be noted. Lesueur [*], who first figured the polyps of *Porites*, shows three different kinds in a species called by him "*P. astræoides*," possessing a large disc, and short round tentacles each with a distal black point. Duchassaing [†] also figures a *Porites* without name, with large convex disc and short, slightly knobbed tentacles each with a black distal point. This so far agrees with the above-mentioned figure of Lesueur. Agassiz [‡], on the other hand, gives five figures of polyps of "*P. astræoides*," viz., a young one, in which no tentacles are yet seen, and four adults in which the arrangement of the parts are not at all clear. The ring of lobes drawn round the mouth can hardly be the tentacles, while

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[*] Mém. Mus. Paris, vi., 1820.

[†] Coraliaires des Antilles, Suppl. 1864, pl. viii. fig. 2.

[‡] Florida Reef, 1880, pl. xvi.

the peripheral fringe looks very like the mesenterial furrows which run down the sides of most *Porites*. The escape of a planula is shown.

The other two polyps figured by Lesueur, *P. recta* and "*P. clavaria*" (non Lamarck), have much smaller discs and short tentacles inclined to be pointed. Dana figures the polyps of *P. levis* as contracted down flush with the surface, the external mesenterial furrows radiating like spokes round the ring of knobs representing the contracted tentacles. The disc is fairly large and only furrowed by six mesenteries, whereas in most of the figures referred to, at least in which any furrowing of the disc is at all marked, the disc is furrowed by the full number of mesenteries. This is the case also in the figures of the long polyps of "*P. furcata*" given by Agassiz, in which the tentacles are thin, fusiform, and pointed. Saville Kent, in his 'Great Barrier Reef,' figures the polyps of three Australian species, with thin, cylindrical tentacles about as long as the diameter of the disc, each tentacle ending in a distinct spherical knob. The only specimen examined by myself which I would provisionally classify with *P. recta*, Lesueur, has rather a narrow column which suddenly enlarges to carry the twelve tentacles, which stand erect and short, stout and round-topped; the disc was rather small.

Agassiz (*l. c.*) first figured the nematocysts, or rather the coiled threads of the nematocysts. On my sections these occur chiefly in small groups raised into hemispherical batteries. One large battery occurs at the tip of each tentacle, and a row of smaller batteries runs down its inner face. The stinging-threads were all I could see, and they were mostly coiled in more or less conical spirals, the cones pointing inwards, and each beneath what appears to be a small round aperture on the covering membrane of the battery. Between these batteries the ectoderm was largely composed of slime-cells.

In addition to these small ectodermal stinging-threads, the cavity of the polyp contains great numbers of long, membranous sacs some 40 μ in length, each with a long coiled thread; the coil is never a regular spiral, and the membranous sac is often collapsed upon the thread. No nucleus or communication with the exterior could be found, the bodies being loosely attached to the endoderm in great numbers in the tentacles, but also, though in smaller numbers, on the mesenteries. Examined with a very high power, the thread, which was as thick as the whole coil of the ordinary nematocyst (*i. e.* about 2 μ), appeared to have spiral lines running round it, and, when cut across, I saw it on more than one occasion hexagonal with the sides inwardly curved. While it is fairly safe to assume that these are defensive weapons *, more extended researches with better preserved material would be necessary to throw light on their structure and to discover their origin and the nature of their contents and method of discharge.

The internal tissues were much disorganized (1) by the symbiotic algæ and (2) by the great quantities of slime. The former were large, very numerous, and often found dividing. They occurred in greatest numbers in the extensible or projecting parts of the polyp, that is, doubtless, where the light can reach them, although they also occur scattered among the cœnosarcal canals.

The slime seemed to have filled the internal cavity with a network of darkly staining strands, quite different from the bright carmine of the ectoderm-cells of the gullet.

Among the fragments of the cœnosarc which appear in the sections separated by the clear spaces left by the decalcified skeleton, the interseptal loculi can be made out by their radial arrangement, and by the presence of the mesenteries, which are here correspondingly narrowed. Different conditions would doubtless be found in other forms in which the intrathecal skeleton did not rise to the level of the walls.

Small as this contribution to the subject is, my work on the sections having been unexpectedly interrupted, it is enough to show the desirability of an extended study of the soft parts of different species of the genus.

EXPLANATION OF PLATE 35.

The six photographs here reproduced are from negatives kindly lent, for the illustration of this paper only, by the Trustees of the Natural History Museum. All are enlarged five times.

Fig. 1. *Porites* with full number of pali typically arranged; the directives point in all directions.

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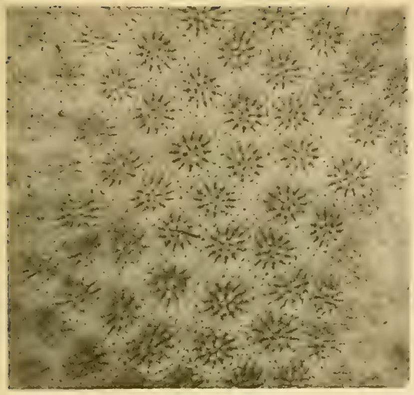
* At the suggestion of my friend Prof. Howes, I have compared these organs with figures of large cells with thick, coiled threads given by Weymouth Reid (Phil. Trans. 1894, B) for the skin of the Eel, and Goodrich (Q. J. M. Sci. xxxix.) for the cœlomic corpuscle of the Oligochæte *Enchytræus*. As Prof. Howes points out, these latter seem to be curious modifications of ordinary slime secretions. While I can trace only slight structural resemblance between these cells and those described above and *Porites*, the fact that here again they are associated with immense numbers of slime-cells suggests a line of enquiry which might be followed up.



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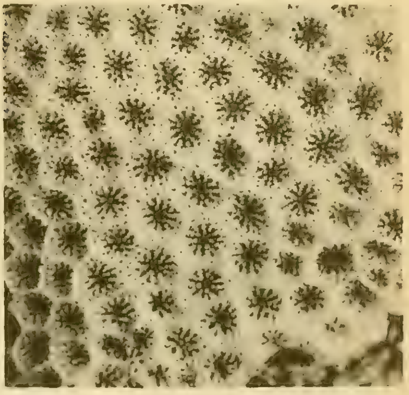

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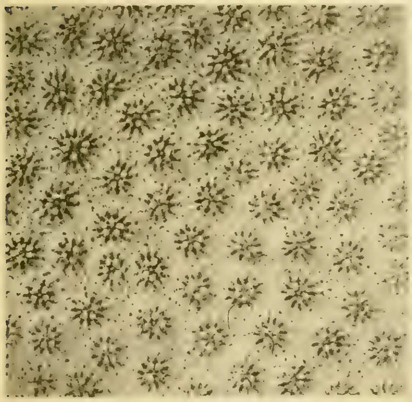

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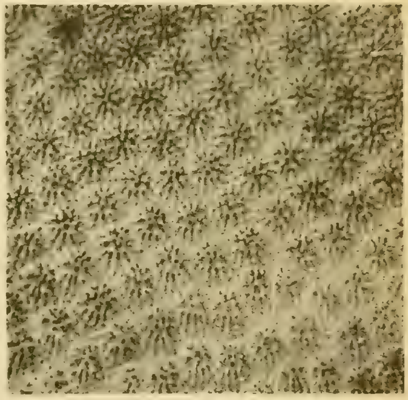

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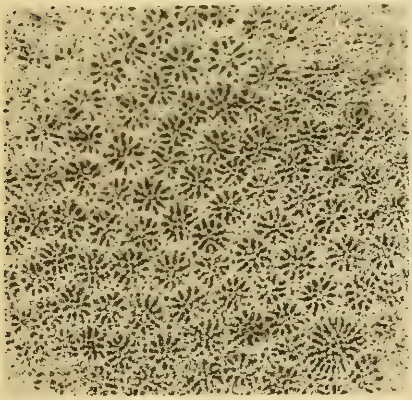

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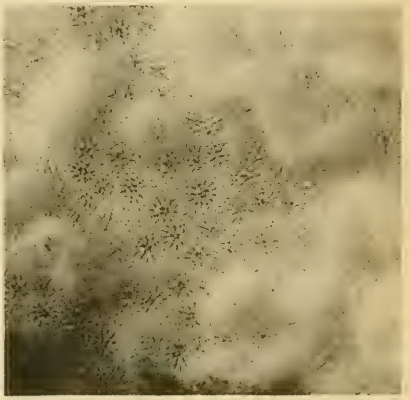


6

THE STRUCTURE OF PORITES.

Fig. 2. The form referred to on p. 488; on one side of the specimen the pali are developed, and on the other the calicles are deep and the pali quite obscured as a definite system.

Fig. 3. A form with the more usual ring of five pali. Traces of the others and of the columellar tubercle can be seen.

Fig. 4. A leaf-like specimen of *P. exilis*, Gardiner, showing the directives all pointing in the direction of growth (towards the top edge of the figure).

Fig. 5. A form with thin wavy walls and showing a double calicle; the columellar tangle rises to the surface, and here and there unites the pali in a ring.

Fig. 6. A cœnenchymatous form, the cœnenchyma rising into rounded ridges and papillæ; the pali are slightly exsert and are often slightly V-shaped. In a few cases the directive principal and its adjacent lateral supplementaries can be seen forming a very blunt broad arrow (the triple fusion mentioned on p. 490).

The Air-bladder and its Connection with the Auditory Organ in *Notopterus borneensis*. By Prof. T. W. Bridge, Sc.D., F.L.S., Mason University College, Birmingham.

[Read 21st December, 1899.]

(Plates 36 & 37.)

Contents.

I. Introduction.

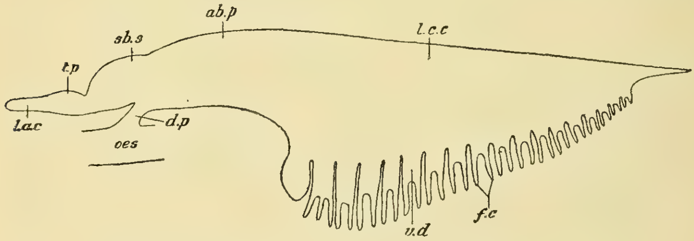
While recently dissecting the air-bladder and associated structures in a specimen of *Notopterus borneensis*, Bleeker, certain features were noticed in which this species differed from *Notopterus Pallasii*, C. & V., as described by Cuvier and Valenciennes (4. pp. 139–141). How far the differences observed are due to imperfections in the account given by the two distinguished French zoologists whose names have been mentioned, or to the existence of genuine variations in which *N. borneensis* deviates from *N. Pallasii*, I am not in a position to decide. Nevertheless, and apart from the question of specific variations in the structure of a particular organ, there are other features in the air-bladder of *N. borneensis*, and more especially its connection with the auditory organ, which, perhaps, are not without importance to those interested in the study of the obscure but fascinating problem of subaqueous audition. For these reasons I venture to give a brief account of the air-bladder of *N. borneensis*, and, as the organ has not hitherto been figured in any species of the family, to supplement the description by suitable figures.

I desire to express my grateful thanks to the Council of the Royal Society for a grant from the Research Fund in aid of this and other kindred investigations.

II. THE GENERAL STRUCTURE AND RELATIONS OF THE AIR-BLADDER.

The specimen examined was 38 cm. long, and to this length the postanal portion of the body or tail contributed 28 cm.

For convenience in description, the air-bladder may be said to consist of three well-defined portions, which, from their regional disposition, may be termed (1) the anterior or pre-cœlomic, (2) the abdominal or cœlomic, and (3) the caudal or post-cœlomic.



Lateral view of the air-bladder of *Notopterus borneensis.* About two-thirds nat. size. *ab.p*, abdominal portion; *l.c.c*, left caudal cæcum; *d.p*, ductus pneumaticus; *f.c*, filiform cæca; *l.a.c*, left auditory cæcum; *œs*, œsophagus; *sb.s*, subspherical sac; *t.p*, its tubular prolongation; *v.d*, ventral diverticulum.

The abdominal portion (see fig., *ab.p.*) is more or less cylindrical in shape, but much deeper behind than in front, and occupies the usual position beneath the vertebral column, being separated from the latter by the kidney. The ventral surface only is invested by the peritoneum, the line of reflection of this membrane on to the inner surface of the abdominal wall being coincident with the junction of the lateral with the ventral wall of the organ. Posteriorly, the peritoneum is reflected downwards on to the hæmal arch and spine of the first caudal vertebra and the first radial element ("interspinous bone" or "pterygiophore") of the anal fin, and therefore does not accompany the caudal prolongations of the air-bladder.

At its hinder extremity, immediately anterior to the first radial element of the anal fin, the abdominal portion of the bladder divides into two caudal cæca (*l.c.c.*), each of which at its commencement, if not so wide, is nearly twice the vertical dimension of the former. The two cæca extend backwards on opposite sides of the tail, and, gradually contracting, finally terminate in pointed and almost filiform extremities about 13 cm. behind the anus, or, approximately, about the middle of the length of the tail. In its course along the tail each cæcum is situated wholly internal to the caudal musculature of its side, and in immediate contact with the hæmal spines of the caudal vertebræ and the supporting radial elements of the extensive anal fin. The dorsal and external walls of each cæcum are invested by a strong aponeurotic membrane, the outer surface of which receives the insertions of the inner margins of the fibrous septa separating the caudal myotomes.

Along nearly the whole length of each of the caudal prolongations of the air-bladder, the ventral margin gives off a fringe of numerous short but relatively wide diverticula (*v.d.*), which form pairs with their fellows of the opposite side of the tail. With the exception of the first two of the series, each diverticulum eventually terminates by subdividing into an anterior and a posterior slender, filiform cæcum (*f.c.*), which extend ventrally towards the base of the anal fin, and are intercalated between, and partially covered by, the superficial flexor muscles of the contiguous dermal fin-rays, but are external to the corresponding deep flexors. The second diverticulum has three filiform cæca, while the first remains simple and undivided. The series of ventral diverticula and their filiform prolongations gradually diminish in size from before backwards, and eventually cease at some little distance anterior to the tapering terminal portions of the caudal extensions of the bladder.

The anterior or pre-cœlomic section of the air-bladder consists posteriorly of a somewhat subspherical sac (*sb.s.*), separated externally from the abdominal portion of the organ by a shallow transverse or obliquely disposed groove. In this groove the subvertebral portion of the mesonephros curves downwards on each side to fuse with the large anterior and unpaired portion of that organ, or "head-kidney," which is situated dorsad to the heart and gills, but ventrad to the subspherical sac. Anteriorly, the sac abruptly contracts to form a somewhat tubular or slightly inflated, median prolongation (*t.p.*), which extends forwards immediately above the dorsal extremities of the hinder branchial arches, in contact with the ventral surfaces of the centrum of the first vertebra and the basioccipital, and by each of its lateral surfaces is in relation with the branchial branches of the corresponding pneumogastric nerve. A constriction separates the subspherical sac from its tubular prolongation, and at the same time transmits on the left side the cœliac branch of the dorsal aorta. Eventually the tubular prolongation divides into two somewhat narrower, cæcal, auditory cornua, each of which (*l.a.c.*) diverges somewhat from its fellow and passes upwards and outwards, as well as forwards, in order to reach the outer surface of the auditory capsule of its side, where, as Cuvier and Valenciennes (*op. cit.* p. 140) have described in the case of *Notopterus Pallasii*, it becomes intimately associated with the enclosed membranous labyrinth of the organ of hearing. Between the origins of the two auditory cæca, and on the dorsal side, the dorsal aorta may be seen passing backwards to reach the bony aortic groove, to which further reference will subsequently be made.

The whole of the anterior section of the air-bladder is situated in front of the abdominal cavity, and consequently none of its various divisions or chambers are invested externally by the peritoneum.

It is perhaps worthy of note that anteriorly and dorsally the branchial cavity is prolonged forwards on each side of the skull for some distance, parallel to the lateral surface of the auditory capsule, and directly external to the corresponding auditory cornua of the air-bladder. This singular extension of the branchial cavity practically takes the form of a cæcal diverticulum (Pl. 36. fig. 1, *a.b.c.*), ending blindly in front by reason of the gradual contraction of its walls, but communicating behind with the general branchial cavity. Into each cæcal diverticulum the dorsal portions of the first and second branchial arches ($br.^1$, $br.^2$), with their branchial lamellæ, extend for some distance; the remaining arches, however, lying posterior to the opening of the diverticulum into the dorsal portion of the branchial cavity. The relatively thin inner wall of the branchial diverticulum is coextensive with, and directly and closely invests the outer wall of, the corresponding auditory cæcum (*l.a.c.*), and hence in this region the air-bladder and its gaseous contents are more intimately related to the external medium in which the Fish lives than is the case at any other point.

For a Teleost the ductus pneumaticus (text-fig., and Pl. 36. fig. 3, *d.p.*) is remarkably short and unusually wide, its length not exceeding 3 mm., while its lumen, even in a spirit-preserved specimen, is approximately the same in diameter. The œsophageal opening of the ductus is in the mid-dorsal line, and about 8 mm. behind the last branchial cleft. The aperture by which the ductus communicates with the air-bladder is situated a little to the left of the median ventral line, and directly posterior to the oblique groove (*o.g.*) separating the subspherical sac from the abdominal portion of the organ. The ductus is surrounded at its œsophageal extremity by a strong sphincter muscle, but no valvular mechanism in connection with either of its apertures could be detected.

No gas-secreting or gas-absorbing "red-glands" or "red-bodies" were to be found in the air-bladder.

III. THE INTERNAL STRUCTURE, AND THE RELATIONS AND ATTACHMENTS OF THE AIR-BLADDER TO THE SKELETON.

In the condition of their inner or mesial walls, and in the relation of these structures to the skeletal elements of the tail, the caudal prolongations of the air-bladder present several interesting features.

With regard to the character and disposition of the caudal skeletal elements, it may be mentioned that the hæmal spines of the suprajacent vertebræ are relatively short (Pl. 36. fig. 2, *h.s.*). The radial elements of the anal fin (*r.e.*), on the contrary, are of considerable length in the anterior part of the tail, although they gradually become much shorter as they are traced backwards towards the caudal fin; and as two of them, forming a pair, are associated dorsally with each hæmal spine, it follows that the radial elements are twice as numerous as the caudal vertebræ, at any rate in the region of the air-bladder. At the commencement of the tail only the ventral third of the radial elements serve for the origin of the flexor muscles of the anal fin-rays, the dorsal two-thirds, and the short hæmal spines with which the former interdigitate, being quite free from muscular attachment. With the gradual shortening of the radial elements towards the middle portion of the tail, where the air-bladder terminates, nearly the whole length of each radial element becomes invaded by the origin of the flexor muscles. The area over which the various radial elements are wholly devoid of muscular attachment is coextensive with that of the inner wall of each of the two closely-related caudal cæca. The series of radial elements and hæmal spines are connected together by a thin, but tough, sheet of fibrous tissue, which extends from one to the other and fills up the intervals between them, and, with the caudal skeletal elements above mentioned, form the only separation between the caudal cæca of opposite sides of the tail. It may be added, that the series of ventral diverticula occupy the intervals between the successive pairs of radial elements.

The dorsal and outer walls of each caudal cæcum are of moderate thickness, as also are the external walls of the ventral diverticula, while the filiform cæca have much thinner walls. In each case, nevertheless, a relatively thick outer fibrous stratum or tunica externa, and an extremely thin lining or tunica interna, consisting of an internal epithelial stratum, supported externally by a thin layer of connective tissue, can readily be recognized. The inner wall of each caudal cæcum, including also that of each of its primary ventral diverticula, on the contrary, is of extreme tenuity, consisting only of the tunica interna, and, moreover, is closely adherent to the outer surfaces of the radial elements and hæmal spines, and also to the fibrous sheet which stretches between them. In fact, in the intervals between these skeletal elements, the median fibrous sheet and the attenuated inner walls of the caudal cæca are all that separate the cavities of the cæca of opposite sides of the tail; and so thin are the inner walls of these that, when the cavity of either of them is exposed by the removal of its outer wall, the various skeletal elements (*h.s.*, *r.e.*) appear as if completely bare of any investing tissue and to project freely into the lumen of the bladder.

In addition to the investment of the outer surfaces of the caudal skeletal elements by the tunica interna of the inner wall, the dorsal and ventral walls are also firmly attached to the skeleton. Along its inner or mesial dorso-lateral margin, where the relatively thick dorsal wall becomes continuous with the attenuated inner wall, the tunica externa becomes somewhat thickened and terminates by becoming firmly attached to the bases of the hæmal spines and also to the dorsal extremities of the two radial elements with which each spine is associated. Ventrally also the tunica externa thickens and forms a series of strong transversely disposed ridges projecting from the floor of the cæcum, and separating the orifices leading into the ventral diverticula. Traced towards the inner wall of the cæcum, the ridges cease by becoming inserted into the adjacent sides of two contiguous radial elements and to the connecting fibrous membrane which extends between them. On the other hand, if traced ventrally, the fibres of each ridge split to form the posterior wall of one diverticulum and the anterior wall of the next succeeding diverticulum, both walls nevertheless retaining their mesial attachments to the contiguous radial elements between which the diverticulum is situated.

Near the dorsal wall of each caudal cæcum, the fibrous sheet between the radial elements presented a series of oval vacuities (*d.v.*), which were disposed in regular order between the successive pairs of radial elements which are attached to the vertebral hæmal spines. Over most of these vacuities the thin inner wall of the caudal cæcum appears wanting, and hence the cavity of each cæcum seems to communicate with that of its fellow at these points. In one or two instances, however, it is clear that no such communication exists, for, notwithstanding the vacuity in the fibrous sheet, the opposed inner walls of the two cæca remain intact over the area of the vacuity. It is difficult, therefore, to be quite certain that these vacuities are associated with normal perforations in the opposed walls of the cæca, or that the cavities of the latter really intercommunicate during life, or in perfectly fresh specimens, more especially as, owing to its thinness and fragile character, the tunica interna is extremely likely to break down and disintegrate where unsupported by the much stronger and more resistant fibrous sheet, unless more than ordinary care is taken with the preservation of the Fish.

A similar series of small, oval, or rounded vacuities (*v.v.*) in the interradial fibrous membrane was also present towards the ventral side of each caudal cæcum, where the membrane in question separates the closely related inner walls of the two series of ventral diverticula, and, as regards their relations to the caudal skeleton elements, these correspond in position with the dorsal series. Wherever these ventral vacuities existed, corresponding perforations in the opposed inner walls of the diverticula were also present, and each of the latter seemed to communicate with its fellow of the opposite side of the tail. In some instances it was possible to determine the continuity of the inner wall of a diverticulum with the corresponding wall of its fellow at the edges of the vacuity; and for this reason I am inclined to believe that the caudal cæca are really in communication with each other ventrally, through the fusion and subsequent perforation of the inner walls of their ventral diverticula. Nevertheless, it is perhaps desirable that the caution needful in the case of the apparent dorsal perforations should also be observed here, at all events until fresh or well-preserved specimens of *Notopterus* have been submitted to examination.

A somewhat interesting numerical and regional correspondence is to be observed in the anterior half of the tail between the various caudal skeletal elements and the arrangement of the cæcal outgrowths from the caudal divisions of the air-bladder.

Thus, the ventral diverticula are situated exactly opposite the intervals between the series of hæmal spines, and, at the same time, occupy the interspaces between successive pairs of radial elements; that is, each diverticulum fills up the interval between two contiguous pairs of radial elements which, dorsally, are attached to the hæmal spines of two successive caudal vertebræ. Hence, therefore, the diverticula closely agree in number with the pairs of radial elements, and in position may be said to be intervertebral. Again, each of the series of fibrous ridges which separate the orifices of communication between the ventral diverticula and the caudal cæca, is attached to the opposed surfaces of a pair of radial elements as well as to the fibrous membrane between them; and as each ridge coincides dorsally with the hæmal spine to which the two radial elements belong, it is vertebral in its relations to the axial skeleton. Lastly, the filiform cæca agree in number with the radial elements, the posterior cæcum of one diverticulum, and the anterior cæcum of the next succeeding diverticulum, being situated immediately external to the corresponding factors of two contiguous pairs of radial elements.

The dorso-lateral margins of the abdominal portion of the air-bladder (Pl. 36. fig. 3) are firmly attached to the transverse processes of certain of the trunk vertebræ and to the proximal portions of their costal elements, the latter being so intimately related to the bladder as to produce a series of faint transversely-disposed grooves in the lateral walls of that organ. As previously stated, the peritoneum invests the ventral surface of this portion of the air-bladder; and it may be added, that in this region it assumes the condition of an exceptionally tough fibrous membrane which is firmly adherent to the ventral wall of the bladder. Posteriorly, the peritoneum is reflected downwards on to the hæmal arch and spine of the first caudal vertebra and the first radial element of the anal fin, and is, moreover, firmly attached to these skeletal structures. Hence it follows, that the ventral wall of the abdominal section of the air-bladder is firmly attached posteriorly to the anterior caudal skeletal elements. The walls of this portion of the bladder are of moderate and equal thickness throughout. Internally, the cavity of the bladder is subdivided into two lateral compartments by a vertical longitudinal septum, which is continuous dorsally and ventrally with the corresponding walls of the bladder (fig. 3, *l.s.*). Posteriorly, the septum increases in height with the increasing vertical dimension of the bladder, and, at the point where the latter subdivides into the two caudal cæca, the hinder margin of the septum is inserted into the anterior face of the hæmal arch and spine of the first caudal vertebra and the proximal portion of the first radial element of the anal fin. Anteriorly, the longitudinal septum deviates from the median plane towards the left side, and, so far as its ventral portion is concerned, the septum ceases immediately behind and a little to the right side of the internal aperture of the ductus pneumaticus (*l.s.*, *d.p.*). At this point the dorsal portion of the septum, which, it may be mentioned, extends forwards into the subspherical sac, is connected by a narrow obliquely-transverse septum (*t.s.*) with the left lateral wall of the bladder along the line of the external oblique groove (*o.g.*) separating the sac from the abdominal portion of the bladder*. The effect of this singular unsymmetrical disposition of the longitudinal septum, and the presence of an oblique transverse septum on the left side only, combined with the

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* In fig. 3 that portion of the left lateral wall of the bladder which is traversed by the oblique groove is indicated as a slender strip.

position of the aperture of the ductus pneumaticus slightly to the left of the median line, is (1) that the left lateral compartment is smaller than the right; (2) that the orifice of communication between the subspherical sac and the left lateral chamber is reduced to the condition of a relatively small aperture, which is in striking contrast to the widely open, direct communication between the sac and the lateral compartment of the right side; and (3) that while the ductus pneumaticus opens directly into the left compartment, its connection with the right chamber is somewhat indirect and takes place through the cavity of the subspherical sac, round the free anterior margin of the ventral portion of the longitudinal septum (fig. 3).

Like the abdominal portion of the bladder, the subspherical sac (Pl. **36**. fig. 3, *sb.s.*) is firmly attached along its dorso-lateral margins to the transverse costiferous processes of certain of the trunk vertebræ, viz., the second to the fifth, inclusive. Its dorsal wall is extremely thin, and, in fact, is represented by the tunica interna alone; the latter stratum, in the absence of the mesonephros in this region, being closely adherent to the lateral and ventral surfaces of the anterior vertebral centra. Internally, the sac is partially subdivided by an extremely thin median longitudinal septum (*l.s.*'), which projects downwards from its dorsal wall, and is a direct continuation of the dorsal half of the longitudinal septum previously mentioned as unsymmetrically dividing the cavity of the abdominal portion of the air-bladder. The septum is best developed behind, and gradually diminishes in height towards the anterior limit of the sac. Its free ventral margin is remarkably thick and forms a strong, arch-like band, the fibres of which diverge behind to strengthen and stiffen the inner and outer lips of the orifice by which the sac communicates with the left lateral compartment of the preceding portion of the bladder. Anteriorly also the band divides, but into three fibrous bundles, the more laterally-situated of which diverge downwards into the lateral walls of the sac and strengthen the outer lips of the aperture through which the sac communicates with its anterior tubular prolongation, while the mesial fibres continue their forward course.

IV. Relations of the Air-bladder to the Skull and Auditory Organs.

The structure of the tubular prolongation of the subspherical sac and of the auditory cæca, and the relations of both to the skull and the auditory organ, will be better understood after a brief description of certain structural features in connection with the hinder part of the skull (Pl. 37. fig. 4).

The basioccipital (*b.o.*) is somewhat hourglass-shaped, being slightly constricted at the junction of the hinder third with the anterior two-thirds of its length, and expanded towards either extremity, but much more so in front than behind. The hinder half of the bone is produced ventrally into a laterally-compressed bony keel, which is traversed by a moderately deep, median, longitudinal groove, bounded by prominent lateral ridges, and transmitting the initial section of the dorsal aorta.

Traversing the lateral surface of the basioccipital, immediately ventrad to the sutural articulation of this bone with the exoccipital and opisthotic, is a well-marked oblique ridge, which, on each side, extends backward and downward and finally terminates in a free projecting process (*a.p.*), closely applied to the ventro-lateral surface of the centrum of the first vertebra after the fashion of an accessory articular process. Between the aortic groove ventrally and the oblique ridge dorsally, the lateral surface of the basioccipital is traversed by a fairly deep groove (*b.g.*), the direction of which is obliquely upward and forward towards the outer surface of the auditory capsule of the same side. Anteriorly to the commencement of the aortic groove the basioccipital ceases to be laterally compressed, and, instead, becomes greatly swollen laterally, assuming in fact a distinctly bullate appearance. The lateral surface of this portion of the bone is also traversed by a well-defined groove, which, however, is merely an extension forwards of that mentioned above. Ventrally, the anterior half of the basioccipital is in relation with the hinder portion of the parasphenoid (*ps.*), and in front the bone articulates by means of an irregular squamous suture with the hinder margin of the prootic (*pro.*).

There is a complete series of periotic bones, which, in the main, exhibit the usual relations one to another and to the adjacent cranial bones. The opisthotic (*op.*) forms the postero-lateral portion of the auditory capsule, articulating with the exoccipital (*eo.*) behind, the pterotic (*pt.*) above, with the supero-lateral margin of the basioccipital (*bo.*) below, and in front with the prootic (*pro.*). The relatively large prootic (*pro.*) forms the anterior portion of the periotic capsule, and articulates above with the sphenotic (*spo.*) and pterotic (*pt.*), below with the parasphenoid (*ps.*), and posteriorly and dorsally with the opisthotic (*op.*), while the posterior portion of the bone forms a thin squamous lamina which extends backwards, overlapping the lateral surface of the basioccipital (*bo.*), and at the same time closing in the anterior portion of the basioccipital groove. In addition, the ventral portion of each prootic sends inwards a strong horizontal process (Pl. 37. fig. 5, *pro.*), which unites with its fellow in the floor of the cranial cavity behind the pituitary fossa. The pterotic (Pl. 37. fig. 4, *pt.*) constitutes the superior lateral margin of the auditory capsule, and also contributes the usual articular surface for the proximal extremity of the hyomandibular; anteriorly, the bone is in articular relation with the upper surface of the prootic and with the sphenotic, and behind overlaps the dorsal margin of the opisthotic. The sphenotic (*spo.*) is a small nodular ossicle, wedged in between the upper margin of the prootic and the overlapping anterior extremity of the pterotic.

As already indicated, the anterior termination of each lateral basioccipital groove is overlapped by the squamous posterior extension of the prootic, and thus becomes converted into a short, but relatively spacious, bony cul-de-sac (*c.s.*), continuous behind with the open portion of the groove, but terminating blindly in front. The inner or cranial wall of the cul-de-sac is coincident with a somewhat considerable fontanelle (Pl. 37. fig. 5, *a.f.*), which is encircled above, below, and in front by the prootic (*pro.*), and behind is limited by the anterior margin of the opisthotic (*op.*) and by the antero-superior border of the basioccipital (*bo.*), and in the dried skull places the cul-de-sac in free communication with the cavity of the auditory capsule. The formation of this auditory fontanelle is apparently due to the widening of the normal sutures which separate the surrounding periotic elements one from another and from the basioccipital. An extremely thin fibrous membrane, which in texture, colour, and appearance closely resembles the membrane closing the supero-lateral cranial fontanelle, extends between the margins of the auditory fontanelle, and constitutes the only separation between the lumen of the bony cul-de-sac and the perilymph-containing cavity of the auditory capsule.

Returning now to the air-bladder (Pl. 36. fig. 3), it may be stated that the dorsal surface of the tubular prolongation (*t.p.*) of the subspherical sac is closely moulded to the ventral surface of the centrum of the first vertebra, and also to the ventral and lateral surfaces of the hinder part of the basioccipital. From its laterally-compressed shape, the ventral portion of the latter bone forms a median keel projecting downwards and pushing before it the dorsal wall of the subjacent part of the air-bladder, which, consequently, appears as if partially subdivided internally by an incomplete, but very thick, longitudinal partition (*l.p.*), while dorso-laterally the bladder fills up the grooves on the lateral surfaces of the basioccipital. Laterally and ventrally, this portion of the air-bladder is free from any special relations or attachments to the skeleton, and hence its moderately thick walls consist of both tunica externa and tunica interna: elsewhere, however, the walls are intimately related to the skeleton, and then are either firmly attached thereto or become greatly reduced in thickness. Thus, dorso-laterally, on each side, the tunica externa ceases by becoming inserted into the oblique bony ridge on the lateral surface of the basioccipital. In the mid-dorsal line, the tunica externa is not only considerably thickened by mesial fibres derived from the arch-like band which forms the free ventral margin of the longitudinal septum of the subspherical sac, but is also attached to the lips of the bony aortic groove in such a way as to convert the groove into a canal. Between the mid-dorsal and the dorso-lateral skeletal attachments, however, the tunica externa is wanting, and all that represents the proper wall of this part of the bladder is the thin tunica interna investing and lining the hinder portion of the grooves on the lateral surfaces of the basioccipital, into which the lateral portions of the bladder are received. The diameter of the tubular portion of the bladder is about 6 mm.

The two auditory cæca (*l.a.c.*, *r.a.c.*) communicate with the preceding part of the bladder by relatively wide orifices; and at this point the simple non-septate lumen of each cæcum is about 3·5 mm. in diameter. From their origins the two cæca diverge obliquely upward and forward towards the outer surfaces of their respective auditory capsules. In its forward extension, each auditory cæcum traverses the anterior portion of the oblique groove on the lateral surface of the basioccipital, and, with only a slight reduction in calibre, appears to terminate at the sutural junction of the latter bone with the prootic. The outer lateral wall of each cæcum is complete, but both dorsally and ventrally its tunica externa ceases by becoming firmly inserted into the corresponding lips of the basioccipital groove in which the cæcum is lodged. Towards the anterior termination of the cæcum even the tunica externa of the outer wall disappears through its continuity with the hinder margin of the prootic bony lamina, which, anteriorly, converts the groove into a cul-de-sac. The inner wall, on the contrary, is throughout formed by the tunica interna alone, and, moreover, is closely adherent to the sides of the basioccipital groove.

Reduced to a simple wall of tunica interna of extreme tenuity, the terminal portion of the auditory cæcum now enters the bony cul-de-sac (Pl. 37. fig. 4, *c.s.*), and, on its inner or cranial side, becomes closely applied to the outer surface of the membrane closing the auditory fontanelle (fig. 5, *a.f.*).

V. The Cranial Fontanelles and their Relation to the Auditory Organ.

In their account of the bones of the skull in *Notopterus Pallasii*, Cuvier and Valenciennes (4. p. 143) describe two interesting vacuities in the postero-superior aspect of the cranial roof. "Ces mastoïdiens ont en avant une très-profonde échancrure, qui cerne près des deux tiers du grand trou pariéto-mastoïdien, dont les côtés du crâne sont percés, une échancrure du frontal postérieur contribue aussi à former le cercle de ce trou. Ce grand trou, analogue à celui que nous avons observé dans l'Alose et dans plusieurs autres Clupées, mais beaucoup plus semblable encore à ce que existe dans le Mormyre, est bouché par une couche peu épaisse de cette mucosité graisseuse, qui remplit les cavernes du crâne et sur laquelle passe la peau mince, nue et sans écailles de la tête. Par ce trou on pénètre largement dans l'intérieur de la cavité du crâne, et l'on voit presque sans dissection, après avoir toutefois enlevé toutes ses parties externes, les canaux semicirculaires supérieurs, leur ampoule commune et une portion du sac qui contient l'otolithe."

This description is in the main an accurate one, but may nevertheless be supplemented in certain details.

Two longitudinal grooves traverse the lateral portions of the cranial roof, and are bounded for the anterior part of their extent by prominent bony ridges on the external surface of the frontals, and more posteriorly by similar parallel ridges on the upper surface of the pterotic (Pl. **37**. figs. 4 & 6, *g*). Externally, the grooves are closed in and converted into complete canals by the thin, scaleless, superficial skin of the dorsal surface of the head. In these grooves or canals are lodged the main lateral sensory canals of the head and their respective supra-orbital prolongations. At its hinder extremity each groove suddenly deepens into a shallow basin-shaped, or funnel-like, oval depression, at the bottom of which is the somewhat smaller, but also oval, cranial fontanelle (Pl. **37**. fig. 6, *c.f.*), which in the dried skull communicates internally with the cavity of the auditory capsule, precisely as described by Cuvier and Valenciennes. The margins and sides of the funnel are smooth and rounded, and are formed anteriorly, and also to a large extent on each side, by the deeply concave posterior border of the pterotic (*pt.*), and completed laterally and behind by the epiotic (*ep.*), the opisthotic (*op.*), and the exoccipital (*eo.*). The long axis of the mouth of the funnel measured 10 mm., and its transverse dimension 6 mm. The fontanelle is smaller, the corresponding dimensions being 6 mm. and 4 mm. respectively. Across the fontanelle, and firmly attached to its margins, is stretched a thin, fibrous, drum-head-like membrane, which is in relation internally with the somewhat fatty perilymphatic tissue of the interior of the auditory capsule.

There is, however, one point to which Cuvier and Valenciennes make no reference, viz.—the relations of the main sensory canal of the head to the cranial fontanelle and the membrane closing it. As it passes directly dorsad to the proximal or supra-clavicular element of the pectoral girdle, the sensory canal traverses the axis of a somewhat cylindrical bone, and then enters the lateral longitudinal groove or canal to which reference has just been made. At this point the sensory canal expands considerably, and assumes a singular cavernous or sinus-like appearance, practically filling the bony groove in which it is lodged. The lateral and inner walls of the sensory canal are here strengthened by two longitudinally-arranged, thin, demi-cylindrical bones, or sensory canal ossicles, the convex inner surfaces of which are in close relation with the cranial fontanelle and the whole extent of the outer surface of its drum-head membrane, while the outer wall of the sensory canal is in contact with the external scaleless skin of this part of the head.

Practically, therefore, the cavernous sensory canal and its investing ossicles completely separate the cranial fontanelle and its membrane from the superficial skin. Anteriorly to the fontanelle the sensory canal is still of considerable width, but, as it passes dorsad to the orbital cavity, gradually contracts to more normal dimensions.

VI. The Auditory Organ.

The utriculus and the sacculus of each side occupy a spacious common recess excavated in the substance of the corresponding lateral half of the large basioccipital (Pl. 37. fig. 5, *u.s.r.*). So large is the recess, that the outer portion of nearly the anterior two-thirds of the bone is reduced to the condition of a thin partially transparent shell, and corresponds to the externally bullate portion to which reference has already been made; while a thin, vertical, bony partition in the axis of the basioccipital is all that separates each recess from its fellow of the opposite side of the skull. The two recesses are partially roofed in by the mesial union of horizontal ingrowths from the two opisthotic bones (*op.*), in a fashion which recalls the method by which the similarly-situated saccular recesses are roofed by the exoccipitals in the Siluroid Fishes. The utriculus occupies the anterior two-thirds of the utriculo-saccular recess, and is relatively of large size. The much smaller sacculus fills up the hinder third of the recess, and is connected with the utriculus by a very short but obvious ductus sacculo-utricularis. Anteriorly and dorsally, the utriculus gives off a conical, forwardly-directed diverticulum, which occupies a recess of corresponding shape excavated in the prootic *. Near the origin of the diverticulum, the ampullary extremities of the horizontal and the anterior vertical semicircular canals communicate with the utriculus by opening into a small recessus utriculi. The great utricular otolith, or "sagitta," is nearly as large as the cavity of the utriculus itself; and it is interesting to note that, anteriorly and dorsally, the otolith is produced into a conspicuous, tapering, conical process, which extends into the

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* *Cf.* Ridewood's account of the auditory organ in the Clupeidæ (9).

utricular diverticulum in the prootic. The membrane which closes each auditory fontanelle (*a.f.*), and is invested externally by the tunica interna of the auditory cæcum of the air-bladder, is almost in contact internally with the outer wall of the utricular diverticulum. The semicircular canals have the normal arrangement, both as regards their relations to the utriculus and to the various periotic bones. It may be mentioned, however, that each supero-lateral cranial fontanelle (*c.f.*) is almost completely encircled by the three semicircular canals—the horizontal canal in the pterotic (*pt.*) curving round the lower or outer border, the posterior vertical canal in the epiotic (*ep.*) and opisthotic (*op.*), and the anterior vertical canal in relation with the inner surface of the prootic (*pro.*), being similarly situated with regard to the anterior and hinder margins respectively; while the vertically-disposed common stem, or sinus utriculi superior, by which the two latter canals join the utriculus, crosses the fontanelle at a short distance internal to the membrane which closes it.

Careful examination failed to reveal the existence of any connection between the sacculi of opposite sides by means of the supra-cerebral or sub-cerebral union of their endolymphatic ducts, such as has been described by Weber (12) for *Silurus glanis*, and in the case of other Siluroids by Bridge and Haddon (2) and Ramsay Wright (13), and by Hasse (6) for the Herring (*Clupea harengus*); or of any communication between the two utriculi, similar to the sub-cerebral connection which has been described in the last-mentioned Teleost by Weber (12), and in the Shad (*Clupea alosa*) by Breschet (1). It must be admitted, however, that the single specimen of *Notopterus* examined by me was not sufficiently well-preserved to quite justify purely negative conclusions on these points.

VII. COMPARISON WITH *NOTOPTERUS PALLASII*.

As regards the general structure and relations of the various divisions of the air-bladder, the account above given agrees generally with that of *N. Pallasii* by Cuvier and Valenciennes. In certain details, however, there are important discrepancies, which may be due either to the existence of structural variations in the two species, or possibly to errors in the description of the air-bladder of *N. Pallasii*. The more important of these differences will now be considered.

In their account of the air-bladder of *N. Pallasii,* Cuvier and Valenciennes (4. pp. 139–141) make no mention of the existence of a series of branched diverticula similar to those which fringe the ventral margins of the caudal prolongations of the air-bladder in *N. borneensis*; neither do these authors refer to the extreme tenuity of the inner walls of these portions of the bladder, or to their attachments and relations to the caudal skeletal elements, nor to the existence of vacuities in the closely related inner walls of the caudal cæca, by which the cavities of the two cæca freely intercommunicate.

In their description of the caudal portion of the bladder in *N. Pallasii,* Cuvier and Valenciennes (*op. cit.* p. 139) remark :—"Il existe sur la surface externe des cornes un organe singulier, comme glanduleux, divisé par un nombre considérable de filets blanchâtres, anastomosés entre eux en petits lobules, que l'on ne pourrait séparer par la dissection qu'avec beaucoup de peine. Cet organe, qui couvre presque tout le bas de la corne, ne dépasse guère la moitié de sa longueur."

No trace of any such gland-like structure could be detected in *N. borneensis* ; and as no organ of a similar character is known to be associated with the external surface of the air-bladder in any other Fishes, it is impossible to hazard even a conjecture as to its nature in *N. Pallasii.*

In their description of the abdominal and anterior portions of the air-bladder, Cuvier and Valenciennes apparently failed to note the skeletal attachments of the organ, or the general tendency of the bladder to lose its external fibrous coat wherever its walls enter into intimate relations with the cranial or vertebral elements of the skeleton. The unsymmetrical subdivision of the abdominal section of the bladder seems also to have escaped their notice.

The account given by Cuvier and Valenciennes of the mode of termination of the auditory cæca and their relations to the membranous labyrinth in *Notopterus Pallasii* is so different from my own observations on *Notopterus borneensis,* that I venture to quote their remarks *in extenso.*

After describing the extension of the air-bladder towards the cranium, it is stated : "De là elle donne deux cornes qui s'engagent dans l'intérieur de la boîte cérébrale sous les mastoïdiens, en passant entre l'os et le sac de l'oreille. Ces cornes s'avancent dans l'intérieur de la boîte cérébrale jusque sur la grande aile du sphénoïd, et atteignent la hauteur de la scissure qui sépare le second tubercule, ou le tubercule optique du cerveau, du troisième, derrière lequel existe le cervelet. En pénétrant dans la boîte cérébrale la vessie perd ses tuniques fibreuses, ou plutôt c'est la seule tunique propre ou membraneuse de la vessie qui s'avance ainsi dans la cavité du crâne. On voit en dedans de la corne le sac qui contient la pierre de l'oreille. Il y a donc ici communication médiate entre la vessie et l'organe de l'ouïe; c'est le seul exemple que je connaisse d'une communication aussi intime entre la vessie et l'organe de l'ouïe" (*op. cit.* p. 140).

It is quite certain that the auditory cornua or cæca do not enter the cranial cavity in *N. borneensis*, but, on the contrary, are wholly extra-cranial. The statement quoted above that " en pénétrant dans la boîte cérébrale la vessie perd ses tuniques fibreuses, ou plutôt c'est la seule tunique propre ou membraneuse de la vessie qui s'avance ainsi dans la cavité du crâne," correctly describes the behaviour of the auditory cæca on entering the bony culs-de-sac in which their terminal extremities are lodged; and it is therefore possible that Cuvier and Valenciennes have mistaken this canal for a portion of the cranial cavity. It has been shown, however, that this canal has no communication with the cranial cavity, inasmuch as it remains separated therefrom either by the thin membrane which closes the auditory fontanelle, or by the various periotic bones surrounding it. Hence it follows that the subsequent statement, " Il y a donc ici communication médiate entre la vessie et l'organe de l'ouïe," is obviously erroneous as regards *Notopterus borneensis*, whether it implies an open communication between the two organs, or the existence of a direct connection by the simple apposition of their limiting walls; and I entertain little doubt that the statement is equally inapplicable to *Notopterus Pallasii.*

It is also stated by Cuvier and Valenciennes that *Notopterus* affords the only instance known to them " d'une communication aussi intime entre la vessie et l'organe de l'ouïe; car je n'hésite pas à répéter ici que celle qui avait été annoncée dans l'Alose ou dans le Hareng, et dans plusieurs autres poissons, n'existe réellement pas " (*op. cit.* p. 140).

The reference to the Allis Shad (*Clupea alosa*) and the Herring (*C. harengus*), as Ridewood (**9.** p. 40) has pointed out, is evidently based on the misconception that previous writers had described an open communication between the air-bladder and the auditory organ, such as Valenciennes apparently believed to exist only in *Notopterus*. It is now scarcely necessary to add that no such open communication exists, or has even been affirmed to exist, in any Fish except *Notopterus Pallasii*; and, for the reasons given above, it is extremely improbable that the latter species offers any exception to the general rule, or, so far as this point is concerned, differs in any way from its congener, *Notopterus borneensis*.

VIII. COMPARISON WITH OTHER TELEOSTS.

Perhaps the most interesting point in the air-bladder of *Notopterus* is the combination which it exhibits of structural features, some of which are unique, while others are individually characteristic of widely different genera or species of Teleosts.

The extension of the air-bladder from its normal position in the abdominal region into the tail is by no means of infrequent occurrence in Teleosts, although it may take place in various ways. In some species (*e. g.*, species of *Exocœtus*) the organ is prolonged backwards without undergoing subdivision into the expanded hæmal canal of the anterior part of the tail (**11**. p. 222). In others the caudal extension takes the form of an unsymmetrical prolongation of the entire organ along the left side of the tail, as in *Ophiocephalus*, or along the right side, as in the Characinoid *Alestes Hasselquistii*, C. & V. (*A. dentex*, Müll. & Trosch.) [**11**. p. 222] *, and in the Siluroids *Cryptopterus micronema*, Blkr., and *C. micropogon*, Blkr. (**2**. pp. 202–3). More frequently, perhaps, the air-bladder subdivides anteriorly to the first caudal hæmal arch, and in the form of two bilaterally-arranged cæcal prolongations extends for a variable distance on either side of the tail and internal to the lateral caudal musculature, as in some Sparidæ, Scombridæ, and Carangidæ (**11**. pp. 221–2), and also as in *Notopterus*. But in none of the Teleosts above mentioned, except *Notopterus*, or in any others with which I am acquainted, do the caudal prolongations of the air-bladder exhibit the slightest tendency to branch, or to develop structures in any way comparable to the singular fringe of bifurcate ventral diverticula which are so characteristic of *Notopterus borneensis*; and very rarely in any Teleost are the

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* On the authority of Cuv. & Val.

inner walls of the caudal cæca reduced to so attenuated a condition through the intimacy of their relations and attachments to the caudal skeleton, as is the case in the last-mentioned species. Even in the two species of *Cryptopterus*, where the caudal portion of the air-bladder is in contact with the subvertebral hæmal arches and spines, the walls of the organ are of uniform thickness and are quite free from any special connection or attachment to the skeleton.

Perhaps, on the whole, the air-bladder of certain species of Sparidæ (*e. g.*, species of *Box*) approaches more nearly to that of *Noptopterus* than does the bladder of any other Teleosts. In *Box vulgaris*, C. & V., not only are caudal cæca present, but the inner or mesial walls of these structures are devoid of an outer fibrous coat, or tunica externa, and the tunica interna, which alone remains, closely invests the opposite sides of the hæmal arches and spines of the caudal vertebræ. The resemblance is further heightened by the fact that in *Sparus salpa*, L. (*Box salpa*, C. & V.), as Weber (12. p. 71 *et seq.*) pointed out, auditory cæca are also present, although in the location of their connection with the auditory fontanelles and in some minor details the latter Sparoid does not precisely agree with *Notopterus*. On the other hand, *Box* has no bifurcate ventral diverticula in connection with the caudal cæca, and the air-bladder is wholly destitute of internal septa, and of a ductus pneumaticus in the adult.

The extension of the air-bladder into the tail in *Notopterus*, as no doubt is also the case in many other Teleosts, is to be associated with the extreme shortness and laterally-compressed shape of the abdominal portion of the body, which, if the bladder is to acquire its normal degree of development as a hydrostatic organ, necessitates its prolongation into the caudal region *.

In the disposition of the internal septa, and especially in the development of a principal longitudinal septum which, anteriorly, meets an incomplete transverse septum, the cœlomic or abdominal portion of the air-bladder of *Notopterus* presents some approximation to the characteristic T-shaped arrangement of the primary septa in the bladder of a considerable number of Siluroids; and the resemblance is rendered still more marked by the fact that in both the carinate shape of the suprajacent axial skeleton involves a partial subdivision of the anterior portion of the bladder through the inpushing of its dorsal wall in the

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* See reference to remarks by Günther (7. footnote to p. 491).

median line. On the other hand, however, *Notopterus* differs from the more typical Siluroids in the absence of the transverse septum on the right side, the unsymmetrical division of the air-bladder by the longitudinal septum, and also in the fact that it is the basioccipital which is carinate ventrally and not, as in Siluroids, the confluent centra of the "complex" vertebra.

An additional resemblance to many Siluroids is also apparent in the tendency of the outer fibrous coat of the air-bladder to become invaded by ossific deposit whenever it becomes attached to, or inserted into, adjacent portions of the axial skeleton. The bony ridges which bound the basioccipital grooves for the reception of the auditory cæca, and the squamous hinder portions of the prootics which form the outer walls of the bony culs-de-sac wherein these cæca terminate, almost certainly owe their existence to the ossification of the tunica externa at the points where it is attached to these cranial bones.

By no means the least noteworthy of the many interesting structural features in connection with the air-bladder of *Notopterus borneensis* is the extreme shortness and relatively wide calibre of the ductus pneumaticus, and the position of its œsophageal aperture in close proximity to the last pair of branchial clefts. Such a combination of features is eminently characteristic of the Acipenseroid, Crossopterygian, Amioid and Lepidosteoid Teleostomi and of the Dipnoi, but is rarely to be found in Teleosts, although an approximation thereto may be noted in such genera as *Arapaima*, *Heterotis*, and *Gymnarchus*, at any rate to the extent that in these Teleostei the ductus is both short and wide.

In the absence of gas-secreting or gas-absorbing "red glands" and "red bodies," *Notopterus* agrees with the generality of those Teleosts in which an open ductus pneumaticus is retained throughout life.

From a physiological point of view, the most noteworthy feature in the air-bladder of *Notopterus* is its intimate relation with the auditory organ.

The presence of antero-lateral cæcal outgrowths from the air-bladder is by no means uncommon in Teleostean Fishes, especially in the Sparidæ, Sciænidæ, Cottidæ, and Gadidæ; and such outgrowths may even extend so far forwards as to become more or less closely related to the skull, but it is only in a comparatively limited number of genera that the air-bladder acquires any special connection or physiological relationship with the auditory organ. As regards the precise nature of the connection between the two organs in different Fishes, three principal methods may be distinguished:—

A. Auditory cæca are present, and the anterior extremity of each is closely applied to a fontanelle in the outer wall of the auditory capsule, the utricular portion of the membranous labyrinth and the surrounding perilymph being in relation with the inner surface of the fibrous membrane by which the fontanelle is closed. In no part of their course are the auditory cæca enclosed within bony canals or grooves, and no connection between the auditory organs of opposite sides of the head has so far been described.

According to Stannius (**11.** p. 171) this method of connection is characteristic of *Priacanthus* * *macrophthalmus*, C. & V. (*P. arenatus*, C. & V., or *P. cruentatus*, C. & V. †), among the Serranidæ; of certain species of Berycidæ pertaining to the genera *Myripristis* and *Holocentrum*; and possibly of *Hyodon claudulus* (*H. tergisus*, Les.), the solitary representative of the North-American freshwater family of the Hyodontidæ. Jeffery Parker (**8**) has recorded an essentially similar arrangement in the New Zealand Gadoid, *Lotella* (*Pseudophycis*) *bacchus*; and Weber (**12.** pp. 71–72) for such Sparidæ as *Sparus salpa*, Linn. (*Box salpa*, C. & V.), and *S. sargus*, Linn. (*Sargus Rondeletii*, C. & V.).

B. Instead of being closed by a fibrous membrane, the auditory fontanelles are open, and through each of them passes a cæcal diverticulum from the corresponding utriculus, which thus becomes directly and closely applied to the anterior extremity of an auditory cæcum.

Those Teleosts which afford examples of this method of connection by direct apposition are also characterized by certain other noteworthy modifications. Thus, for the greater part of its forward course each slender auditory cæcum is enclosed in bone, first traversing a groove and subsequently a canal in the exoccipital bone, and finally terminates by dividing into two distinct vesicular enlargements, of which one lies in a chamber excavated

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* The generic name "*Triacanthus*" given by Stannius (*loc. cit.*) is apparently a misprint for *Priacanthus*.

† For synonyms of *P. macrophthalmus*, *vide* Brit. Mus. Cat. Fishes, 2nd ed. vol. i. p. 353 & p. 356.

in the pterotic bone and has no special relations with the auditory organ. The other vesicle occupies a globose chamber in the prootic, and there becomes closely applied to the wall of the corresponding utricular diverticulum, which enters the chamber through an auditory fontanelle in the prootic. In some instances there appears also to exist a connection between the two utriculi in the form of a transverse sub-cerebral canal, which, however, is not to be regarded as homologous with the similarly situated ductus endolymphaticus of the Cyprinoid and Siluroid Teleosts. Such a utricular connection was first discovered in *Clupea harengus* by Weber (**12**. p. 77), and subsequently by Breschet (**1**) in *C. alosa*. On the other hand, the evidence as to the existence of a supra-cerebral connection between the two sacculi, as affirmed by Hasse (**6**), or between the two utriculi, as stated by Breschet (**1**. p. 17), is too conflicting to admit of any definite conclusion being drawn *.

The preceding arrangement, which appears to be restricted to the physostome family of the Clupeidæ, was first described by Weber in the Herring (*Clupea harengus*). Recently, Ridewood (**9**. p. 26) has contributed an excellent revision of the anatomical relationships of the two organs in the six British species of Clupeidæ, viz.:—*Clupea harengus*, Linn., the Pilchard (*C. pilchardus*, Walb.), the Sprat (*C. sprattus*, L.), the Allis Shad (*C. alosa*, L.), the Thwaite (*C. finta*, Cuv.), and the Anchovy (*Engraulis enchrasicholus*, Cuv.). These species apparently include all the Clupeidæ in which a connection between the auditory organ and the air-bladder has so far been described.

C. In a third and last series of Teleostean fishes, viz., the physostome families of the Cyprinidæ, Characinidæ, Siluridæ, and Gymnotidæ, the connection between the air-bladder and the auditory organ attains its maximum complexity and physiological importance, and is effected, not by auditory cæca, but by means of a chain of movable Weberian ossicles. The auditory organs of opposite sides of the head are connected together by the mesial union of the two endolymphatic ducts, one from each sacculus, and the consequent formation of a transverse sub-cerebral connection between the two sacculi. From the point of union of the two ducts a median sinus endolymphaticus, enclosed in a similar median extension of the perilymphatic spaces of the

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* For a discussion of this point, *vide* Ridewood (**9**. pp. 38–39).

two auditory capsules (sinus impar), is prolonged backwards to its physiological connection with the most anterior of the series of Weberian ossicles *.

Whether *Hyodon claudulus* is rightly to be regarded as an example of the first method, as stated above, or not, is by no means quite clear. The description of the connection between the auditory organ and air-bladder in this Teleost, as given by Stannius (*op. cit.* p. 171), is as follows:—

"Bei *Hyodon claudulus*—und ganz analog verhält sich *Notopterus*—communicirt das vordere Ende des Schwimmblasenkörpers durch enge Oeffnungen mit zwei sphärischen dickwandigen Blasen. Jede derselben legt sich in eine Vertiefung der Knochen der Hinterhauptsgegend ihrer Seite und haftet eng an den letzteren. Dem vordersten Theile jeder dieser Blasen entspricht eine Oeffnung in den Knochen, die inwendig von einem Theile des Vestibulum, auswendig aber von der innersten Haut dieser Blase bekleidet ist, indem die weisse Faserhaut derselben im Umkreise der äusseren Gehörsöffnung aufhört und nicht über letztere selbst sich fortsetzt."

From this account it would seem that, as in the Clupeidæ, the auditory fontanelles in *Hyodon* are not closed by fibrous membranes, and, consequently, the auditory cæca, after losing their outer fibrous coat, are either closely related to the vestibular walls, or in actual contact therewith, or, at all events, are not separated by any intervening fibrous membrane. If, however, the description given by Stannius is correct, then the statement "und ganz analog verhält sich *Notopterus*" is scarcely applicable to that Teleost, inasmuch as there is no doubt as to the existence of a separating membrane in *Notopterus*.

It would be interesting to ascertain if any tubular communication between the two vestibuli, similar to that present in the Clupeidæ, exists also in *Hyodon*. So far as I am aware, no observations on this point have yet been made.

Comparison of *Notopterus* with the various Teleosts mentioned above, proves that it furnishes an additional example of the first of the three methods by which the air-bladder and auditory organ are brought into physiological relationship, although in one or two minor features an approach to the second type is indicated.

Thus in *Notopterus* there is no direct contact between the

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* For references *vide* Bridge & Haddon (**2**. p. 65 *et seq.*).

walls of the utriculi and those of the auditory cæca, the two structures being separated by the membranes which close the auditory fontanelles; neither is there any open tubular communication between the utricular and saccular portions of the auditory organs of opposite sides of the head by means either of sub-cerebral or supra-cerebral connections. In these features *Notopterus* closely agrees with those Teleosts in which the first method has been adopted. On the other hand, it is equally evident that to some extent *Notopterus* approaches the second type and resembles the Clupeidæ in the fact that, for a part of their course, the auditory cæca are enclosed in bony grooves and for the terminal portion of their extent occupy the interior of bony culs-de-sac, and also in the origin of the cæca from an anterior tubular portion of the air-bladder.

It is perhaps worth remarking that some little variation in minor details exists amongst those Teleosts which offer examples of the first and second methods, more especially with regard to the precise position of the auditory fontanelles and the nature of the cranial or periotic bones which form their boundaries, and also in the degree of tenuity of the closely related walls of the auditory prolongations of the air-bladder.

For example, in *Sparus* (*Box*) the fontanelle is represented by Weber (**12**. tab. vii. fig. 62) as being situated posteriorly to the foramen for the exit of the Vagus nerve. In *Pseudophycis bacchus* the auditory fontanelle is described by Parker (*loc. cit.*) as situated between the basioccipital and the opisthotic, and immediately beneath the Vagus foramen. In *Holocentrum spiniferum*, Gthr., the fontanelle is bounded by the exoccipital, opisthotic, and prootic bones, and is anterior to the Vagus foramen; and in *Notopterus*, as we have seen, the prootic, opisthotic, and basioccipital encircle the fontanelle. Finally, in the Clupeidæ the fontanelle is a simple perforation in the prootic alone, and hence is more anteriorly placed than in any other Teleosts. There can be no doubt, I imagine, that the precise location of the fontanelle and the nature of its limiting bones, are due to the varying extent to which the auditory cæca are prolonged forward, and perhaps also to variations in the size of the fontanelle itself.

Of much more importance is the degree of tenuity of the walls of the auditory cæca at their point of contact or closest relationship with the auditory organs; for upon this will depend the degree of intimacy and perfection of the physiological connection between the two organs.

On this point it may be mentioned that in *Pseudophycis bacchus,* as described by Parker (*op. cit.*), the anterior extremity of each auditory cæcum forms a thickened pad which is closely applied to the membranous sheet closing the corresponding auditory fontanelle. From this account it may be legitimately inferred that both the outer fibrous coat of the cæcum and the tunica interna are applied to the fontanelle and its membrane. In *Sparus* (Weber, *op. cit.*), on the contrary, the tunica externa of the auditory cæcum ceases at the margins of the fontanelle, and only the extremely thin tunica interna is applied to the membrane which closes the aperture. So far as this point is concerned *Notopterus* closely resembles *Sparus*; but in the Clupeidæ, and possibly in *Hyodon*, the connection of the two organs becomes even more intimate, inasmuch as it is effected by the actual apposition of the limiting walls of auditory cæca and utricular outgrowths.

The derivation of the second and more intimate type of connection between the air-bladder and the auditory organ from the first method is easy to imagine, as the process simply involves the atrophy of the fibrous membranes closing the auditory fontanelles, so as to admit of the actual contact of the two organs by the direct apposition of outgrowths from each. A much more difficult problem is the genesis of the third method by means of Weberian ossicles, and so far no satisfactory solution has yet been offered. There is every probability, however, that the Weberian mechanism has been independently evolved, but that the initial stages of its evolution have not yet been discovered, if they exist, in any Fishes at present living.

In his account of the connection between the air-bladder and auditory organ in *Pseudophycis bacchus*, Parker (*op. cit.*) remarks: “The anterior end of the air-bladder fits closely against the hinder end of the skull and is produced outwards into paired pouches which are in contact with the thin skin beneath the operculum and in front of the shoulder-girdle.” To this arrangement *Notopterus* offers a parallel in the close relation of the auditory cæca to the cæcal diverticula of the branchial cavity, and, therefore, to the external medium in which the fish lives. The Siluroids (2) also afford examples of a somewhat similar modification. In the majority of these Teleosts the lateral walls of the anterior chamber of the air-bladder are in contact, often over a considerable area, with the superficial skin behind the pectoral girdle.

Notopterus is by no means the only Teleost in which the existence of cranial fontanelles, more or less closely associated with the auditory organ, has been recorded. Nevertheless, the position of these vacuities, and their precise relation to the membranous labyrinth, exhibit a wide range of variation in different Teleosts.

In *Notopterus*, as we have seen, the fontanelles are situated on the upper surface of the hinder part of the skull and immediately dorsad to the auditory capsules.

According to Stannius (**11.** p. 170) cranial fontanelles essentially similar to those of *Notopterus* exist also in *Hyodon claudulus*.

In the Herring (*Clupea harengus*, L.) "the ventro-external surface of the sacculus lies over a membranous fenestra of the skull-wall, situated between the exoccipital, basioccipital, and prootic bones, and described by several authors as a foramen ovale; the sacculus-wall is here separated from the mucous membrane of the mouth by this membrane only" (Ridewood, *op. cit.* p. 38).

In referring to certain of the Macruridæ, Stannius (*op. cit.* p. 170)* states:—"Bei *Lepidoleprus trachyrhynchus* † findet sich seitlich am Hinterkopfe über dem oberen Ende der Kiemenspalte eine trichterförmige von dünner Haut gesschlossene Grube, welche in den zur Aufnahme des Gehörorganes bestimmten Theil der Schedelhöhle hineinragt. Zwischen der Innenfläche ihrer Haut und dem Labyrinthe liegt eine faserig-gallertartige Substanz." Similar fontanelles are said to be present in *L. cœlorhynchus*, but not in *L. norvegicus*.

The skin-covered fontanelles on the postero-superior surface of the skull of *Mormyrus* somewhat resemble those of *Lepidoleprus*, except that immediately beneath the external skin there is a perfectly free and very thin lamina of bone which partially covers each fontanelle (Stannius, *op. cit.* p. 170 ‡). Fontanelles,

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* On the authority of Otto, Tiedemann u. Treviranus' Zeitschrift f. Physiol., Bd. ii. S. 86

† =*Macrurus trachyrhynchus*, Risso.

‡ Apparently on the authority of S. Heusinger, Meckel's Archiv f. Anat. u. Physiol. 1827, Bd. i. S. 324.

similar to those of *Mormyrus*, are also said to be present in *Gymnarchus niloticus* (Stannius, *l. c.* *).

Mention may also be made of the prevalence of median fontanelles in the cranial roof in many Siluroids, although in these Fishes the structures in question have no special relation to the auditory capsules †.

It is certainly worthy of remark that the existence of cranial fontanelles, as a possible avenue for the transmission of sound vibrations from the water to the auditory apparatus, has been recorded not only for those Fishes in which the air-bladder has no connection with the membranous labyrinth (e. g., *Mormyrus*, *Macrurus*), but also, and apparently quite as frequently, even in those Teleosts in which such a connection is known to exist (e. g., *Clupea*, *Hyodon*, and *Notopterus*).

IX. REMARKS ON THE SUPPOSED AUDITORY FUNCTION OF THE AIR-BLADDER.

The physiological value of the connection between the air-bladder and the auditory organ is still one of the unsolved problems of comparative physiology, and this statement seems to be equally applicable to any of the three principal methods by which such a connection is established. The reason for this is, no doubt, that practically nearly all attempts to solve the problem have been based upon anatomical evidence alone; and, as must be admitted, morphological data are often unreliable, and even misleading, when employed as the sole basis for physiological deductions, and not infrequently appear to support with remarkable impartiality conclusions of a widely different character. When the problem has received the attention of the experimental physiologist, then, and then only, may a final and satisfactory solution be expected.

The question has been most frequently discussed in connection with the Ostariophyseæ ‡, and, so far, comparatively little attention has been devoted to those Teleosts (e. g., *Sparus*, *Notopterus*, *Hyodon*, *Clupea*, &c.) in which the connection of the air-bladder and auditory organ is effected by other means than the presence of Weberian ossicles. In venturing to discuss certain physio-

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* According to Erdl, see Stannius, *l. c.*, footnote to p. 170.

† Professor Howes has reminded me of the large lateral occipital fontanelles in the Cyprinidæ (*c.f.* Sagemehl, Morph. Jhb. Bd. xvii. p. 495).

‡ The physostomous families of the Cyprinidæ, Siluridæ, Characinidæ, and Gymnotidæ, in which a Weberian mechanism is present.

logical points in connection with the latter Fishes, I must again emphasize my conviction that physiological conclusions drawn solely from anatomical data must be regarded as little more than tentative and provisional suggestions.

At the conclusion of his account of the mode of connection between the air-bladder and the auditory organ in certain species of *Sparus*, Weber (*op. cit.* p. 72) states his views as to the physiological value of the connection in the following words:—

"Prima utilitas hæc est, ut tremoros soniferi aquæ toti piscium corpori communicati, a vesica natatoria elastica recipianter, in se colliquantur, et in membranam, fenestram vestibuli ossei obducentem, transferantur, cuius tremoros liquorem, cavum cranii replentem, movent itaque vestibulem membranaceum ipsum, ab aqua cranii circumdatum, afficiunt ad quam quidem utilitatem vesica natatoria, quippe quæ singulis costis affixa est, aptissima videtur."

On this theory the air-bladder, by reason of its connection with the auditory organ, becomes a physiological accessory to audition, in addition to its usual and normal function as a hydrostatic organ.

In discussing Weber's view of the auditory function of the air-bladder and Weberian ossicles in the Ostariophyseæ, it was pointed out by Bridge and Haddon (**2.** p. 276) that, assuming sound-waves to be transmitted from the air-bladder to the auditory organ by these ossicles, the fact that such stimuli would, in the first instance, affect certain median and unpaired structures common to both auditory organs (sinus impar and sinus endolymphaticus) involved the difficulty that the membranous labyrinths of opposite sides of the head would be affected with equal intensity and simultaneously, and, consequently, as no differential stimulation took place, the Fish would be incapable of appreciating the direction of the sound.

Sörensen (**10.** pp. 185–186), in attempting to mitigate the force of this criticism, remarks:—"As far as I can see this is the only real objection that can be made against the theory of Weber. But I do not judge it to be of great importance. If this objection were absolutely valuable, no human being would be able to decide if a sound arises before or behind him when the direction of the sound coincides with the symmetrical plane of the body; and this, however, we are able to decide. And, would not this objection be just as valuable if you presume the sound not to be transmitted to the ear through the air-bladder? Are not the Fishes deprived of the means by which the higher Vertebrata are able to judge the direction of the sound, viz., by turning the head (or external ears) to the right or to the left? It must also be kept in mind that it is always very difficult thoroughly to understand that beings differently conditioned know how to use the powers with which they are endowed, especially when these powers are inferior to those bestowed upon us."

Sörenson's attempt to lessen the importance of what he terms the only "real objection" to Weber's theory does not impress one as being very successful. The capacity for appreciating the direction of sounds, whether employed as a means of securing prey, or escaping from enemies, or, as in the case of gregarious Fishes, as a means of keeping together in shoals for breeding or other purposes, must be of primary importance in any modification of the auditory organ in the direction of giving to its possessor exceptional powers of hearing. Fishes may have no power of rotating or inclining the head, but it must not be forgotten that a slight deflection of the long axis of the body to the right or left will at once enable the differential action of the two auditory organs to come into play, and the Fish would be in a position to appreciate the direction from which the sound is travelling. An Ostariophysean, in so far as those parts of the auditory apparatus which it possesses in common with all other Fishes are concerned, is in much the same position as regards the sense of direction. It is quite true that the two auditory organs are in open communication by means of a sub-cerebral transverse ductus endolymphaticus; but it is also obvious, I think, that the auditory organ, right or left, turned towards the direction of the sound, will be stimulated appreciably sooner, or it may be more forcibly, than its fellow, and hence the cognizance of direction. Again, is it not possible, or even probable, that sound-waves reaching the auditory organs simultaneously by two distinct channels will have their effect nullified, and the sense of direction seriously interfered with? In fact it seems extremely probable that sound stimuli which, according to Weber's hypothesis, are received by the auditory organs through the air-bladder and Weberian ossicles, would have the effect of confusing any sense of direction based upon similar stimuli, generated by the same cause and at the same moment, but pursuing, as in the generality of Fishes, the usual direct path through the bones and other structures of the head to the membranous labyrinths. It may be also urged that this objection loses none of its force when it is considered that the cranial bones are far more pervious to sound-waves travelling in water than, as is the case with terrestrial animals, in air.

If this argument has any force, does it not suggest that the Weberian mechanism, considered as an accessory to audition, may prove a positive disadvantage to the Fish in so far as the sense of direction is concerned? Finally, if the Weberian mechanism is a means of increasing the acuteness of the sense of hearing, is it not a little remarkable that sounds heard through this agency convey no idea of direction, especially when the latter is of so much importance to the animal, and that the sense of direction should depend upon the perception of sounds of an obviously more limited range of intensity which reach the auditory organs directly through the head?

Other objections which may be urged against Weber's theory as applied to the Ostariophyseæ are scarcely pertinent to the present discussion, which is designedly restricted to those Fishes in which there is no Weberian apparatus and the auditory organ and air-bladder are connected by other methods.

It may at once be affirmed that the same "real objection" is equally applicable to such Fishes as *Notopterus*, *Sargus*, *Sparus*, *Hyodon*, *Clupea*.

In some of these Fishes (e. g., *Sparus*, *Sargus*, and *Clupea*) there is no longitudinal bipartition of the air-bladder, which, therefore, for the greater part of its extent encloses a simple undivided cavity. Sound-waves in the gases of the air-bladder travelling along the auditory cæca will ultimately affect the auditory organs to an equal extent and simultaneously. Hence, these Fishes will derive no sense of direction from auditory stimuli reaching the membranous labyrinths by such channels. Whatever sense of direction they possess will be derived from those stimuli which reach the auditory organs by the usual path through the skull; but here, as in the Ostariophyseæ, we are confronted with the probability that such sense of direction will be interfered with by the stimuli received through the air-bladder.

From this point of view the condition of the air-bladder in *Notopterus* is especially significant. For more than three-fourths of its extent the organ consists of two lateral chambers; and if, by an anterior extension of the longitudinal septum, these compartments had become entirely separated from each other, and each had remained continuous with the auditory cæcum of its side, it is at least conjecturable that each chamber would be somewhat differently affected by sound-waves impinging on its own side of the body and eventually propagated to the auditory organ of the same side. In this way, it seems possible that stimuli received by the auditory organ through the intervention of the air-bladder might be competent to give rise to a sense of direction. So far, however, from this being the case, the longitudinal septum ceases at the very point where its forward prolongation seems to be most desirable; and, in consequence, the auditory cæca arise from an anterior, median, tubular portion of the bladder, which is only slightly divided longitudinally by the carinate growth of the suprajacent axial skeleton. Hence, as in non-septate air-bladders, sound-waves are propagated to the auditory organs simultaneously and with equal intensity.

There is also another point which deserves consideration in discussing the possible auditory function of the air-bladder in these Fishes.

Well-marked cranial fontanelles are present in several of them, and these structures are not only paired but each is in immediate relation with the auditory organ of its side of the head. Do not these skin-closed fontanelles afford a better channel for the transmission of sound-vibrations to the membranous labyrinths than the air-bladder?, and is not one of these structures somewhat superfluous if we regard both of them as sound-transmitting organs? Moreover, so far from interfering with the sense of direction, cranial fontanelles would probably facilitate the differential action of the two auditory organs.

If the connection of the air-bladder with the auditory organ is not subservient to the sense of hearing, can any other function be assigned to it?

In the case of the Ostariophyseæ, Ramsay Wright (13) and Bridge and Haddon (2) have supported the view that the connection of the two organs was possibly for the purpose of enabling these Fishes to appreciate the varying degrees of tension of the gases in the air-bladder, resulting from corresponding variations of hydrostatic pressure produced by locomotor movements involving differences of depth. Subsequent reflex or voluntary impulses, it was suggested, might find expression in the exercise of some form of regulatory control over the liberation of gas through the ductus pneumaticus, so that only so much gas will be eliminated as will suffice to maintain the Fish in a plane of least effort.

In attempting to extend this theory to such Teleosts as *Sargus*, *Hyodon*, *Priacanthus*, *Notopterus*, and *Clupea*, it must be at once admitted that there are grave difficulties in the way. It is easy to conceive how distension or contraction of the air-bladder, produced by variations in the superincumbent column of water, would be competent to give rise to stimuli affecting the auditory organ. A tendency to over-distension may be conceived to produce such a bulging of the anterior extremities of the auditory cæca as would modify the condition of the perilymph surrounding the auditory organs, and impart a stimulus to the sensory epithelium of those organs. The objection to this view is, however, that it is very difficult to see in what way the contingent efferent impulses will find expression. In Fishes like *Notopterus* and *Clupea*, where a ductus pneumaticus is present, the existence of some kind of regulatory control over the liberation of gas from the air-bladder is possible; but this suggestion is obviously inapplicable to such Fishes as, for example, the species of *Sparus* and *Sargus* in which the ductus atrophies in the adult. In the latter genera, variations in the amount of gas present in the air-bladder must depend upon the relatively slow processes of gaseous secretion or absorption; and it is at least within the bounds of conjecture that the connection of the air-bladder and auditory organ forms part of a reflex mechanism by which the varying tensions of the gases of the air-bladder constitute a stimulus to the auditory organ and central nervous system, and, ultimately, by reflex action lead to such a modification of the rate of secretion or absorption as will vary the amount of gas in the bladder in accordance with the requirements of the Fish. The special advantage to the Fish may be that secretion and absorption will take place more rapidly than is the case where pressure-stimuli have no special means of affecting a sensory organ, and adjustment to varying hydrostatic pressures effected with greater promptitude. Nevertheless, it must be acknowledged that there is at present but very little evidence, either physiological or anatomical, which can be adduced in support of these suggestions.

Admitting, however, the want, or rather the paucity, of evidence for such tentative suggestions, is it not possible that the connection of the auditory organ and the air-bladder may have to do with a simpler physiological rôle? The danger which a Fish incurs from over-distension of the air-bladder as the result of a too rapid rise in the water to the reduced pressure of a higher level has been emphasized elsewhere (2); and, without involving any alteration in the rate of gaseous absorption, the afferent impulses communicated to the auditory organ may, through appropriate efferent channels, lead to such modifications of the locomotor movements as will enable the Fish to guard against over-distension, and return to its normal plane of equilibrium or "least effort" at a greater depth.

It is a significant illustration of the difficulties of the problem that even Weber, who was primarily responsible for the theory of the auditory function of the air-bladder in those Fishes in which that organ is connected with the membranous labyrinth, was sufficiently far-seeing to admit the possibility of a second function. Immediately following the quotation with reference to *Sparus*, which has been previously given, Weber proceeds (12. pp. 72–73):—

"Altera vesicæ natatoriæ utilitas hæc est, ut aëre vesicæ compressione alvi in appendices superiores impulso, membranaque fenestram utramque vestibuli ossei obducente tensa et introrsum pressa, aqua cranii cavum replens adeoque vestibulum membranaceum, ad hac aqua circumdatum ipsum prematus.

"Quam ob rem, si cranio aperto et labyrintho membranaceo conspicuo vesica natatoria manu comprimatur, facile hic vesicæ natatoriæ contractæ effectus oculis percipitur. Per vesicam enim manu compressam liquor cranium replens non solum propellitur, sed vestibulum membranaceum ipsum quoque motu liquoris cranii commovetur."

The two paragraphs just quoted suggest that Weber certainly entertained the idea of the air-bladder being the means of conveying to the auditory organ stimuli due to its varying degrees of distension, such as, we may presume, are naturally brought about by variations of depth and, therefore, of pressure; and, further, prompt the remark that the term "Weberian theory" may be as reasonably applied to this view as to the "auditory theory" with which the name is more generally associated.

In conclusion, it may be affirmed that there are obvious objections both to the auditory and hydrostatic views of the physiological *raison d'être* of the connection between the air-bladder and the auditory organs, which, in the present state of our knowledge of the individual functions of those organs, cannot easily be explained away in accordance with either theory. With a more precise and definite acquaintance with the physiology of the organs in question, and a more extended knowledge of the habits and mode of life of the Fishes concerned, it is possible that some definite conclusions may be arrived at; but the final solution of the problem must rest with the experimental physiologist.

Whatever the significance of the inter-relationship of the air-bladder and the auditory organ, there can be no question as to its physiological importance. Such a connection presents varying degrees of perfection and specialization in different Teleosts, and its independent evolution in widely different families seems to suggest the possibility that it is correlated with the requirements of special or local conditions of life, and, while attaining its maximum development in the dominant families of freshwater Teleosts *, is nevertheless present in simpler forms in a limited number of both freshwater and marine Fishes.

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XI. EXPLANATION OF THE PLATES.

Plate 36.

Fig. 1. Lateral view of the left branchial cavity, to show the relation of its anterior cæcal extension to the left auditory cornu of the air-bladder. The operculum and pectoral girdle have been removed. (Nat. size.)

Fig. 2. View of the interior of a portion of the left caudal prolongation of the air-bladder. The outer wall of the bladder has been partly removed and partly reflected above and below. A portion of the outer wall of a ventral diverticulum has also been cut away in order to show one of the ventral series of vacuities. (Nat. size.)

Fig. 3. Lateral view of the anterior and abdominal portions of the air-bladder. The outer wall of the left half of the bladder, except that portion of it which is traversed by the oblique transverse groove between the subspherical sac and the abdominal part of the organ, which has been left as a narrow oblique strip, has been removed, so as to show the longitudinal septum throughout its entire ength. The outer wall of the left auditory cæcum has been removed, and the œsophagus and ductus pneumaticus laid open. (× 2.)

Plate 37.

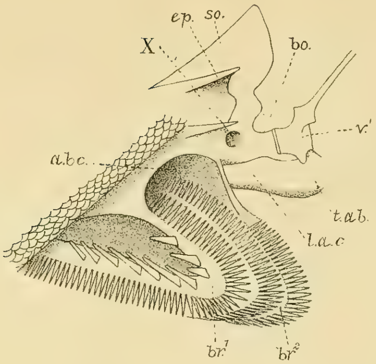
Fig. 4. Lateral view of the posterior portion of the right side of the skull. (× 2.)

Fig. 5. View of the interior of the hinder part of the right half of the cranial cavity, as seen in a vertical longitudinal section of the skull. (× 2.)

Fig. 6. Supero-lateral view of the posterior portion of the right side of the skull. (× 2.)

Reference letters.

a.b.c.	Anterior diverticulum of the left branchial cavity.
ab.p.	Abdominal portion of the air-bladder.
a.f.	Auditory fontanelle.
als.	Alisphenoid.
a.p.	Accessory articular process for the centrum of the first vertebra.
b.g.	Basioccipital groove.
bc.	Basioccipital.
br^1, br^2.	First and second branchial arches.
c.f.	Cranial fontanelle.
c.s.	Entrance to bony cul-de-sac.
d.p.	Ductus pneumaticus.
d.v.	Dorsal vacuity.
d.w.	Dorsal wall of the air-bladder.
e.o.	Exoccipital.
e.p.	Epiotic.
f.	Frontal.
f.c.	Filiform cæca.
g.	Lateral groove for the sensory canal of the head.
h.s.	Hæmal spine.
l.a.c.	Left auditory cæcum.
l.c.c.	Left caudal cæcum of the air-bladder.
l.p.	The inpushed dorsal wall of the tubular portion of the bladder.
l.s.	Longitudinal septum in the abdominal part of the bladder.
$l.s'$.	Longitudinal septum in the subspherical sac.
œs.	Œsophagus.
o.g.	Oblique groove separating the subspherical sac from the abdominal part of the bladder.
op.	Opisthotic.
p.	Parietal.
pro.	Prootic.
ps.	Parasphenoid.
pt.	Pterotic.
r.a.c.	Aperture leading to right auditory cæcum.
r.e.	Radial or interspinous element of anal fin.
sb.s.	Subspherical sac.
spo.	Sphenotic.
so.	Supraoccipital.
tp.	Tubular portion of the air-bladder.
ts.	Transverse septum.
u.s.r.	Utriculo-saccular recess in the basioccipital.
v'.	First vertebra.
v.d.	Ventral diverticulum.
v.v.	Ventral vacuity.
X.	Foramen for the exit of the Vagus nerve.



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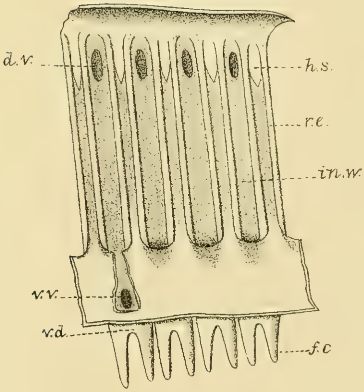

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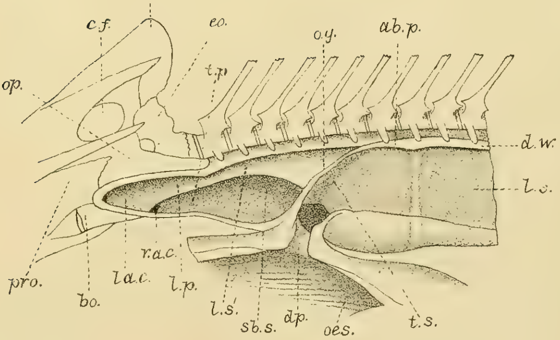

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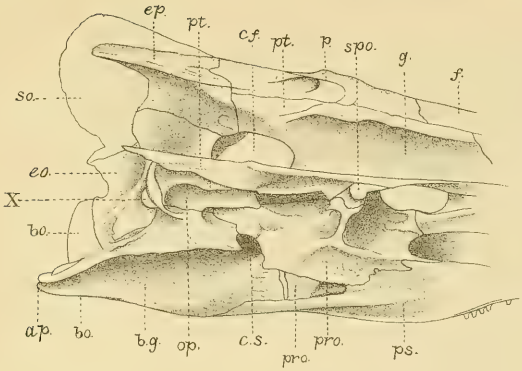
NOTOPTERUS BORNEENSIS.



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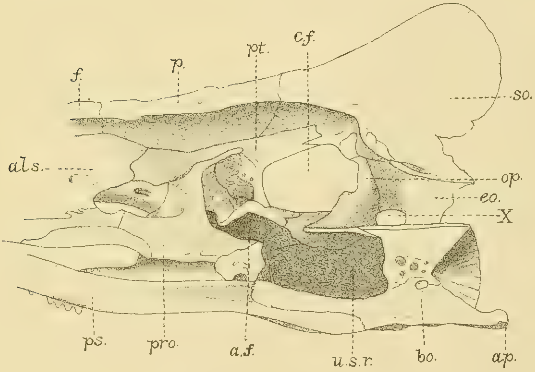

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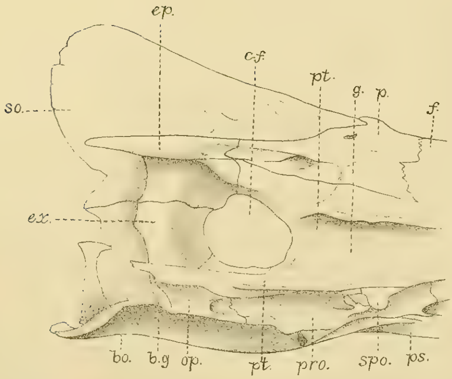

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NOTOPTERUS BORNEENSIS.

On the Presence of Nasal Secretory Sacs and a Naso-pharyngeal Communication in Teleostei, with especial reference to *Cynoglossus semilævis*, Gthr. By H. M. Kyle, M.A. (Communicated by Prof. G. B. Howes, Sec. Linn. Soc.)

[Read 18th January, 1900.]

(Plate 38.)

The observations embodied in this paper have been made during the course of a prolonged research into the anatomy of the Flat-fishes (Heterosomata). It is considered advisable to publish them separately because, though the research is far from completed, the facts to be described have a certain importance apart from the main series of results. In order to carry on my work successfully I spent some time at the British Museum of Natural History, and I desire to acknowledge my indebtedness to Mr. G. A. Boulenger, F.R.S., of the Zoological Department of that Institution. Every facility was given to me for my work, and his advice, generously offered, has aided me in many directions. I am proud to acknowledge also the friendly counsel and masterly criticism of Prof. G. B. Howes, F.R.S., to whom indeed the appearance of this paper in its present form is due.

It is generally believed and taught that Fishes possess no secretory apparatus in connection with their olfactory organs, and that in the Teleostei these organs have no direct communication with the mouth. These characters, and more especially the latter, have been considered as almost exclusively distinctive of the air-breathing Vertebrates—so much so that Huxley, in his famous paper on *Ceratodus Forsteri* *, discussing the communication present in the Dipnoi, considered it necessary to raise and answer the question—of what use are "internal nares" to purely branchiate animals? Internal nares in water-breathing vertebrates seem indeed unnecessary, because the respiratory apparatus is in immediate communication with the mouth, so that where they do occur a special explanation has to be sought. As with the Dipnoi and *Myxine*, so with the case to be herein described, the function of the naso-pharyngeal communication seems quite clear, though its presence may run counter to our preconceived notions.

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* Proc. Zool. Soc. 1876, *cf.* pp. 24 & 180.

In order to obviate a confusion of terms which might readily arise in dealing with the subject of this paper, I shall refer to the organ of smell as the *olfactory organ*; to certain accessory derivatives of that organ as *nasal sacs*; to the one or two external apertures of the olfactory organ of the Teleostei as *anterior* and *posterior nostrils*; and to the apertures and passages of communication between the nose and the mouth as the *posterior* or *internal nares*.

The existence of nasal sacs in connection with the olfactory organs of Teleostei has been noted by Owen, who in 'The Anatomy of Vertebrates' (p. 329) mentions their occurrence in the Mackerel (*Scomber scombrus* L.) and in the Wolf-fish (*Anarrhichas lupus*, L.). In the latter he states that the "reservoir passes backward (expanding) as far as the back part of the palate, where it ends blindly;" and adds, "the prolongation of the single nasal cavity in the Lamprey is analogous to this." Although Owen* mentions the Mackerel as possessing these reservoirs, they are comparatively slightly developed. Solger† has more recently discovered a similar organ in the Stickleback.

These are not the only species, however, where such "reservoirs" occur. They are met with in those forms which lead a semi-sedentary life—in the Blenniidæ, and (more largely developed) in the Labridæ and Scorpænidæ. Sometimes there are two "sacs" in connection with each olfactory organ—Scorpænidæ; sometimes only one—Blenniidæ and Labridæ.

These sacs are simple continuations of the nasal cavity and possess no secretory function. They are "reservoirs" as Owen called them, associated with the retaining, circulation, and changing of the water which passes through the nostrils. Their walls are not muscular, and their capacity is determined merely by the movements of the ascending processes of the premaxillæ and the maxillæ and palatines. Solger suggests that they may also furnish a habitat and breeding-place for Infusoria!

A further specialization of the nasal sacs is found in certain groups of flat-fishes, and here also the number present for each olfactory organ varies—in the Halibut, Plaice, and Turbot

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* Milne-Edwards also states that the nasal organ in the Mackerel possessed a 'cul-de-sac.' Leç. sur la Physiologie et l'Anat. Comp. tom. xi., 1877, p. 476.

† Solger, B.: "Notiz über die Nebenhöhle des Geruchsorgans von *Gastrosteus aculeatus*, L." Zeit. für Wiss. Zool., Bd. 57, 1894, p. 186.

there are two, in the Sole tribe only one, in the aberrant Sail-fluke (*Lepidorhombus whiff*) none at all. In the Halibut, Plaice, and Turbot tribes, when the sacs are developed they lie anterior to the ethmoid, and are closely connected with the pterygo-palatine and maxillary bones (Pl. 38. fig. 1, $n.s._1$–$n.s._4$). In the genus *Solea* that of the right or eyed side also lies anterior to the ethmoid, whilst that of the left or blind side extends posteriorly over the roof of the mouth to as far back as the posterior third of the parasphenoid (fig. 2, *l.n.s.*). In the above-mentioned groups the function of these sacs is entirely secretory, their blind ends resting on a layer of fatty tissue immediately over the integument lining the roof of the mouth (fig. 1, *f.t.*). In the genus *Solea* the larger, posteriorly directed sac acts for the most part as a reservoir just as in the cases cited. A small quantity of mucus is certainly always found in it, but mixed with a large percentage of sea-water.

In order to render fully clear the significance of these facts, it is necessary to state the correlated differences in form and structure of the several species of flat-fishes. This would lead too far away, however, from the subject at present in hand, and it need only be said that the Soles are better adapted for more sand-loving habits than are the Halibut, Plaice, and Turbot.

Leaving the physiological significance of these sacs for discussion later, we may turn now to a remarkable form first described by Dr. Günther *, a native of the China Seas, and called by him *Cynoglossus semilævis*. This species is included under a sub-family of the Sole group, but is well marked off from the true Soles, and is probably of separate origin. In European waters it has a near ally in the small *Ammopleurops* (*Plagusia* of the French ichthyologists) of the Mediterranean. The characteristics of the true Soles—the curved snout projecting in front of the mouth, the small eyes and largely developed olfactory organs, the slender and slightly developed opercular bones with contours completely hidden by the skin, the comparatively small branchial openings, and various other internal peculiarities of skull and skeleton—are accentuated in *Cynoglossus*, and indicate a greater adaption to sand-loving habits than is found even among the true Soles. The degeneration of the fins evidenced in these latter reaches its extreme. The pectoral fins have entirely

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* Ann. & Mag. Nat. Hist. ser. 4, xii. 1873, p. 379, and ser. 7, i. 1898, p. 261.

disappeared and one ventral only remains, the dorsal and anal are continuous round the tail, and the tail itself, carrying further the change begun in *Solea*, has become "pseudo-diphycercal."

These characteristics give the impression not merely of sand-loving habits, but also that the animals bury their comparatively heavy jaws and snout in the sand or gravel, whilst their long, slender, and flexible tails move freely in the water. And in this position they are more dependent upon their sense of smell than upon their powers of sight for the detection of their food.

Correlated with their mode of life in some mysterious way is the peculiar development of their lateral-line system. On the right or blind side there is only one lateral line, on the left or eyed side there are three of them—one median, the other two near the bases of the dorsal and anal fins. The median and dorsal lines are continued on to the head, over the occipital region of which a connecting branch joins the two. The median line gives off the usual branch over the preoperculum to the mandible, and continues forward almost to the anterior border of the head, where it joins the dorsal line, which has followed the contour of the head and is continued round the border to the curved snout.

Five specimens referred to this species, *Cynoglossus semilævis*, have been examined, one of them in detail, the other four only with regard to certain doubtful points *. Although these are classed by Dr. Günther as representatives of one species, the individual examined in detail differs so markedly from the other four that some systematists would not hesitate to make it the type of a separate species or even genus, and the advisability of this will be considered when the facts concerning it have been described.

The characters already enumerated are shared by all five, and in external appearance there is only one point of difference between the divergent specimen and the others. In it, an accessory branch of the lateral line passes backward from the ring round the snout towards the posterior nostril between the eyes. In the others this is absent. It is difficult to say what value can be put upon this character. In many nearly allied species, e. g. *Synaptura*, it is in exactly the same position; and in many of the North American flat-fishes (especially on the Pacific coast)

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* As these were registered specimens, I was very fortunate in having so many to examine and in being permitted to handle them so fully.

Jordan* describes an accessory branch of the lateral line as passing backward from the head along the back of the dorsal fin. It is connected with other peculiarities, and must have some relation to the mode of life of the different species; and in the case of *Cynoglossus* it is present along with certain characters which plainly show the greater adaptation of its possessor to more sand-loving habits than those which do not have it.

In the case of *Solea*, it has been said that one of the nasal sacs extends backward over the roof of the mouth, whilst the other is quite separate and lies anterior to the ethmoid. In the four specimens of *Cynoglossus*, so far as could be ascertained by means of a seeker without actual dissection, there is a single large sac lying over the roof of the mouth, resembling in position the large posteriorly directed sac of *Solea*. Into this both nasal canals open—one from each nasal cavity. The nasal organs, which are placed symmetrically on each side of the head, are thus in communication with a large "cul-de-sac" which occupies the entire area overlying the median portion of the roof of the mouth.

The step is not great from this combination to that found in the divergent specimen. The roof of the mouth in this is perforated by a large oval opening (Pl. 38. figs. 3, 4, 5, *c*), around which the mucous membrane is thrown into a broad rim or fold, projecting inward and underlying a portion of the central chamber, which in position corresponds to that enclosed by the sac of the other four specimens. When this rim is cut through anteriorly, two comparatively large openings are seen (fig. 5)—one on each side of the median line. These lead into the nasal canals which pass upwards and forwards—one on each side of the parasphenoid—internal to the palatines, until they reach positions anterior to and alongside of the ethmoid, and open at their upper extremity into the posterior portion of the nasal cavities (fig. 3, *e*). On the eyed side of the head the canal passes downward from the nasal cavity close to the membranous lining of the lower orbit (fig. 3, *n.p.c.*). These canals are tolerably large, and form an effective means of communication from the exterior, through the nasal cavities, to the mouth.

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* Jordan, D. S., & Goss, D. K.: "A Review of the Flounders and Soles (Pleuronectidæ)," Rep. U.S. Comm. of Fish and Fisheries, 1886.—Jordan, D. S., & Evermann, B. W.: 'The Fishes of North and Middle America,' 1898.

The other structures in connection with the mouth vary little in the different specimens. In all, the jaws of the upper (eyed) side are quite bare, whilst those of the lower (blind) side display strong series of chisel-shaped teeth (fig. 3, *t.m.*). The mandibular and maxillary "breathing-valves"[*] are strongly developed (fig. 4, *b.v.*), and the only appreciable difference is seen in the length of the gill-filaments. These are very long in all specimens, exceeding the usual length found in the Heterosomata, but are slightly longer in the divergent specimen than in the others. Although dissections of four of the specimens were not made, it is most probable that in other characters of the head and body all five are alike, since by analogy I find in the Plaice and Flounder, in which the internal structure differs little, that what important differences there are may be seen externally.

The question then presents itself whether the single specimen of *Cynoglossus* is entitled to be taken as the type of a new species. It is possible, indeed, that such a species really exists, because if this peculiar combination of characters occurs in one individual, there is no reason why it should not occur in many others. On the other hand, it is possible that this individual may be quite unique, and that the accessory portion of the lateral line and the increased length of the gill-filaments may have arisen after the perforation of the roof of the mouth in the life-history of it alone; but this does not seem very probable. The lateral line in other forms is developed at a very early stage, and if an accessory branch is present, we should imagine that it would arise about the same time as the main portions. Hence the perforation of the roof of the mouth must have appeared in the earlier stages of life; and, if so, is possibly inherited—that is to say, a distinct species may exist whose characters are fairly constant and reappear in the offspring. It is possible again that we have here only the beginning or the foreshadowing of a new species. If we reason from the principle of Natural Selection, we may conclude that the possession of a naso-pharyngeal communication would result in great advantage to a fish living in the sand. Or we may say, with Dohrn[†], that the change in

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[*] Owen, R.: 'Anatomy of Vertebrates,' vol. i. p. 413.—Dahlgren, W.: "The Maxillary and Mandibular Breathing-valves of Teleostean Fishes," Zool. Bull. Boston, 1898. Smitt, F. A.: 'Scandinavian Fishes,' p. 263.

[†] Dohrn, A.: 'Das Princip des Functionswechsels.' Leipzig, 1874.

function, from secretory to water-retaining, being accompanied by changes in the tissues, may have led to a great change in structure, and that Natural Selection has been thereby confronted by variations which it will convert into specific differences. Or, discarding Natural Selection and questions of "advantage" and "survival of the fittest," it seems simpler and more natural to believe that the remaining longer than usual with the head buried in the sand, *i.e.* a slight change in habit*, may have brought about the perforation of the roof of the mouth, in which case the presence of the naso-pharyngeal communication, accompanied by the change of habit and habitat, would have a "discriminative" as distinguished from a "selective" value.

Whichever way the matter be argued, we see how this important "modification" gives us the possibility of a new species, although it is better perhaps to wait for additional evidence before recording it as such in the classification of the Heterosomata.

The discovery of a naso-pharyngeal communication in only one specimen so far does not, however, lessen the interest attaching to its presence. Such facts are rare in the class Pisces, so that, when they do occur, their general importance is so great as to render the question of their specific value a somewhat secondary matter. The importance and interest do not lie in the uniqueness of this single individual, but in the occurrence in the Teleostei of on organ hitherto unknown in them and considered as almost peculiar to the air-breathing Vertebrates.

We may now turn our attention to more general considerations, and in the first place to those of function. The first stage, or most elementary condition, where "reservoirs" with water-retaining function are present among Fishes, is found in *Labrus*, *Scorpæna*, *Gastrosteus*, and *Anarrhichas*, but it is absent in the Gadidæ so far as examined, as also in the Herring. These sacs are also absent from the Sail-fluke, a highly specialized Heterosomid, which lacks the "recessus orbitalis"† and has departed from the sand-loving habits of the other flat-fish. These facts lead to the conclusion that the presence of nasal "sacs" is

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* In another species of the Sole-group, it was found that certain parasites (*Lernæa*?) had made their way into the nasal sacs and had caused a perforation of the roof of the mouth!

† *Cf.* Holt, E. W. L.: "Studies in Teleostean Morphology." Proc. Zool. Soc. 1894, p. 422.

an adaptation to semi-sedentary, as opposed to migratory, habits of life.

The function of these sacs in the first stage is moreover aptly described, as has been said, by the word "reservoir." In the tolerably quiet life these animals lead, the water containing odoriferous particles will not pass so freely over the olfactory epithelium as in the case of the free-swimming migratory forms. These sacs are, however, distended and constricted by the movements of the premaxillæ and maxillæ, and are thus able to draw in water, the odoriferous particles in this way coming into contact with the sensory epithelium without necessitating any movement on the part of the animal as a whole.

The second stage, where definite secretory sacs are present, has been found so far only in the family of the Heterosomata comprising the Halibut, Plaice, and Turbot groups. The secretion is forced from the sacs into the nasal cavity and over the sensory epithelium by the movements of the premaxillæ and maxillæ, in a fashion similar to the water in the previously described species.

The function of these secretory sacs is not very evident. They are absent in other Teleostei so far as is known, and this might mean that the olfactory organ is of little importance or that the epithelium is maintained sufficiently sensitive by water alone. In the air-breathing Vertebrates the nasal secretion is of importance in cleansing the organ, in keeping the sensory epithelium in a healthy sensitive condition, and in aiding towards bringing odoriferous materials into a state of solution favourable to their full appreciation. When the secretion is present in Fishes, therefore, it may signify that the olfactory organ is much used and of great importance. Such, indeed, would seem to be the case with the flat-fishes mentioned. In the life these animals lead as ground-feeders, searching for their food almost entirely by sense of smell, this secretion may be of as much service in cleansing the olfactory epithelium and maintaining it sensitive as the nasal secretion of the air-breathing Vertebrates.

In the Sole group the secretory has given place for the most part to a water-retaining function. This change might at first sight appear strange, as a return to a previous condition, although the animals are more sand-loving in their habits than even the Plaice, Halibut, and Turbot, and in most cases have their olfactory organs as largely developed as these forms. But the tactile sense, as shown in the development of papillæ and filamentous outgrowths * of the integument, here aids and even replaces the olfactory organ to a great extent. There is probably not the same necessity, therefore, for the epithelium to be kept in a high degree of sensitiveness as is the case with the Halibut, Plaice, and Turbot. Further, it is well known that a large quantity of mucus is secreted from the external surface in the Soles; and this, entering the nasal organ with the water-currents, may replace definite secretory sacs and effect the cleansing and preservation of the epithelium as efficiently as the needs and mode of life of the animals require.

When we come to *Cynoglossus*, we find the last stage in the structural specialization, apparently the complete return of the nasal "sacs" to the earliest function of water-retaining. The sacs are not secretory, and, further, there are no tactile filaments round the head; and it may be that the mucus from the skin enters the nasal cavity and acts as a nasal secretion, just as has been suggested for *Solea.*

In the divergent specimen of *Cynoglossus*, the perforation of the roof of the mouth brings into consideration a totally new function; but by the change that has occurred, the *raison d'être* of the former function of water-retaining is still as efficiently fulfilled. The odoriferous particles which the closed sacs induce to pass over the olfactory epithelium will be drawn through the nasal cavity during the process of respiration, by the movements of the mouth and gill-covers. The respiratory function, however, although it has arisen secondarily, probably becomes the more important.

The manner by which the Teleostean fishes respire has recently been carefully described by Dahlgren (*l. c.*), who shows what an important rôle is played by the maxillary and mandibular "breathing-valves" (fig. 4, *b.v.*). These are well-developed in the divergent specimen of *Cynoglossus*; but it is probable that in the mode of life which these animals lead, the circular fold beneath the central sac which receives the internal nares has taken the place of, or at least may act in the same manner as, the breathing-valves. Both would function when the animal's head was free in the water, but when the jaws were buried in the sand, the nasal respiratory canals and this "respiratory-fold"

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* Raffaele, F.: "Papille e organi di senso cutaneo nei Pleuronettidi del genere *Solea*: nota preliminare." Naples, 1886.

would be most in action, opening and shutting synchronously with the gill-covers. When the gill-covers rise, and so increase the cavity of the mouth, whilst the posterior edges of the branchiostegal membranes close the gill-openings, this fold will also rise, and water will enter the mouth from the nasal passages. Conversely, when the gill-covers fall, the fold will press on the internal nares and close them; whilst the water from the mouth, passing between the gill-arches, bathing the gills, will escape by the gill-openings *.

The foregoing discussion of the functions of the nasal sacs and their specialization, leads on to a consideration of Huxley's conclusions with respect to the use of the communication between the nose and mouth in the fishes with which he dealt. In his paper on *Ceratodus* (l. c.), after comparing the Dipnoi and Selachii with regard to the nasal organ, he raised the question—of what use are such nasal passages and internal nares to purely branchiate animals? In answering this, he considered that in all probability they are primarily connected with respiration when the mouth is closed; and, secondarily, that by their means a constant stream of water containing odoriferous particles would be brought into contact with the sensory epithelium of the olfactory organs.

What has been advanced in the foregoing pages is so far in complete accord with both of these conclusions, but Huxley went beyond this and, reasoning from the second, concluded that the posterior nostrils of the Teleostei, where they occur, have most probably a function similar to the internal nares, viz., to aid in ensuring the adequate passage of odoriferous particles over the sensory epithelium.

This conclusion is, however, open to doubt. When internal nares are present, the pumping action which draws the water through the nasal passages is carried on by means of the gill-covers and floor of the mouth in common with that concerned in respiration. But in those Teleostei where internal nares and nasal sacs are absent and posterior nostrils are present, this pumping action during respiration cannot involve the olfactory organ. Hence the essential conditions which would render the

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* Howes has proposed to distinguish this buccal mechanism of respiration characteristic of all the Ichthyopsida as *stomatophysous*, and that characteristic of the Amniota, and taking place only in the presence of a costal sternum, as *somatophysous*. *Cf.* Jour. Anat. & Phys. vol. xxiii. p. 272.

physiological significance of the posterior nostrils similar to that of the internal nares are absent.

The walls of the posterior nostrils, again, act as valves whose function is to let water pass from within outwards. In the free-swimming forms, therefore, when both nostrils are present, it is probable that the movements of the fish through the water suffice to induce the passage of water through the nasal cavity; and this flow is controlled by the anterior nostril, whose walls may be prolonged into a contractile tube or flap-like covering. Where only one external nostril is present, it is the anterior which must carry on the functions of the two of the other forms. And hence, if analogies are to be drawn, the anterior nostrils might be likened physiologically to the internal nares, and the posterior nostrils to the gill-openings. Similarly, when nasal sacs are present the displacement of the sacs ensures the circulation of water through the nasal cavity, just as the movements of the mouth and gill-covers cause the passage of water through the mouth, and the posterior nostrils are again only comparable to the gill-openings.

We may proceed now to a consideration of the other water-breathing Vertebrates in which the function of respiration is in part carried on by a naso-pharyngeal communication. In the Cyclostomes we find an analogy to what is seen in *Cynoglossus*. In the Petromyzontidæ there is a prolongation from the nasal cavity backward to the roof of the mouth; in the Myxinidæ the latter is pierced, and the communication thus opened is supposed to fulfil a respiratory function. The origin and development of this so-called prolongation of the nasal organ have been described by Dohrn * for *Petromyzon*, and recently somewhat briefly by Dean † for *Bdellostoma*.

Leaving aside the apparent remarkable differences alleged by Dean in the development of these two forms, it is clear that the internal nares of the Myxinidæ are formed by the communication of the hypophysis with the gut. According to Dean the hypophysis arises in *Bdellostoma* before the external openings of the

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* Dohrn, A.: "Studien zur Urgeschichte des Wirbelthierkörpers. III. Die Enstehung u. Bedeutung der Hypophysis bei *Petromyzon Planeri*." Mitt. Zool. Stat. zu Neapel, 1883. *Vide* Howes, G. B.: "On the Affinities, Inter-relationships, and Systematic Position of the Marsipobranchii." Tr. Biol. Soc. Liverpool, vol. vi., 1891, p. 122.

† Dean (Bashford): 'On the Embryology of *Petromyzon Stouti*.' Kupffer's Festschrift, Jena, 1899, p. 269.

mouth and nose appear; and if this allegation should hold good also for *Myxine*, a special importance must be ascribed to such an early communication of the hypophysis with the gut, and it would furnish an argument in favour of Dean's view that the Myxinidæ and the Petromyzontidæ stand to each other in somewhat the same relation as the recent Selachians to the recent Ganoids. But, however widely they may be separated, the hypophysis would appear to present a condition analogous in the one group to that of the closed nasal-sac state aforementioned, and in the other to that of the open nasal canals in *Cynoglossus*.

The assertion of Dean that the hypophysis in *Bdellostoma* opens into the gut before the external opening of the nasal organ is formed, if correct, further leads to the conclusion that the so-called "internal nares" of the Myxinidæ, although a primary formation, is only secondarily connected with respiration. The reverse is the case in *Cynoglossus*, and thus there arises a good example of convergency in evolution, since a similar structure possessing a similar function, but having a totally different origin, would appear to have arisen in two separate groups of the animal kingdom.

On the other hand, there is so much diversity of opinion with regard to the development of the internal nares in the higher Vertebrates, that reference to them is somewhat difficult. According to Balfour's theory *, the nares arise from a single depression lying anterior to, and one on each side of, the mouth. This depression, as the embryo develops, takes the form of a longitudinal slit, and a little later passes through a stage similar to that of the adult Selachian. By the fusion of the adjacent tissues over the depression, this slit becomes tranformed into a canal with an opening at either end—these openings represent the external and internal nares. The later development differs in the different groups. In the Amniota, Balfour believed that the maxillary region of the face so develops in relation to the canal that the two openings become widely separated, the outer passing upwards and forming the external nares, the inner passing inwards and forming the internal nares. In the Amphibia it was believed that the origin of the internal nares is distinct from that above described, being "secondary," through perforation of the roof of the mouth after the latter is developed; and the development of the nares in the Dipnoi was considered to be similar to

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* Balfour, F. M.: 'Comparative Embryology,' vol. ii. pp. 533–538.

that in the Amniota, except that the upward rotation of the external nostril does not take place. In the Teleostei, lastly, it was believed that the homology still holds good, and that both nares are rotated outward and upward. Hence the posterior nostrils of the Teleostei would be homologous to the external nostrils of the higher Vertebrates, and the anterior to their internal nares.

These generalizations have been in part confirmed and in part refuted by more recent workers. For the Teleostei, Sagemehl *, though believing that he was refuting Balfour's view, in reality corroborated it. For the Dipnoi, Semon † has shown that the nares develop as Balfour suggested; and he thus confirms Huxley's conclusions (*l. c.*), drawn from a comparison of the adult conditions, that, as concerning their nostrils, the Dipnoi and cartilaginous fishes are closely related. An important modification of Balfour's view has, however, to be noted. In the Dipnoi the communication between the nose and mouth is naso-labial, not naso-pharyngeal, the posterior aperture being morphologically disposed external to the teeth which arise on the vomer and palatine bones. Further, there is no true "palate"; and the question whether the maxillæ of fishes are truly homologous with the maxillæ of the higher Vertebrates is left open (Semon, *l. c.*, p. 45). As regards the internal nares, it is thus evident that no true homologue to that of *Cynoglossus* exists in the class Pisces.

In the higher Vertebrates, however, if the internal nares arise secondarily in the Amphibia, as suggested by Balfour, there is the possibility of such an homology. Hochstetter ‡, however, has thrown doubt upon the whole of Balfour's conclusions with regard to the origin of the internal nares in the Amniota. He shows that the "palate" is not formed by the maxillary bones, but by the fusion of the external and median primitive nasal processes, and that the internal nares then arise secondarily by the perforation of the palate. These observations were made upon certain mammalian forms; and in the same forms as well as

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* Sagemehl, M.: "Das Cranium von *Amia calva*, L." Morph. Jahrbuch, Bd. ix. p. 221.

† Semon, R.: "Die äussere Entwickelung das *Ceratodus Forsteri*." Denksch. der Med.-Naturwiss. Gesellsch., Jena, Bd. iv. 1893, pp. 44–45.

‡ Hochstetter, F.: "Ueber die Bildung der inneren Nasengänge oder primitiven Choanen." Verh. d. Anat. Gesellsch. 1891 (Anat. Anz. Bd. vi Suppl.) p. 145.

in others Keibel * has more recently, in opposition to His †, confirmed those which concern the formation of the palate, though he is doubtful about the secondary origin of the internal nares.

If the conclusions of Hochstetter had been the last word on the matter, it would have been possible to frame an homology between the internal nares of *Cynoglossus* and those of the higher Vertebrates. If the latter arise secondarily in ontogeny, then it is probable that at their first beginning they were also of secondary origin, and therefore distinct from the primitive internal nares of the Dipnoi. Hence we might have in *Cynoglossus* a glimpse of what may have occurred at a remote period of time, when the air-breathing Vertebrates were but in process of evolution.

But if Keibel's suggestions (see footnote ‡) are well-founded, then we must accept, in a modified form, Balfour's view concerning the origin of the internal nares as the true one, and upon this no comparison could be made between *Cynoglossus* and the higher Vertebrates. Morphologically, *Cynoglossus* would then be perfectly unique, possessing not only the homologues of the internal nares in the morphological sense, but additional organs also which represent the internal nares in the physiological sense. The internal nares of *Cynoglossus* should then be called "pseudo-nares" or "pseudo-choani," which would emphasize their morphological distinction from the "choani" of the higher Vertebrates, whilst implying their physiological similarity.

It is of interest to note, in conclusion, that this discovery in the Teleostei of a distinctive peculiarity of the higher Vertebrates, is not without a parallel. Warm blood has been found in the

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* Keibel, F.: "Zur Entwickelungsgeschichte und vergleichenden Anatomie der Nase u. des oberen Mundrandes (Oberlippe) bei Vertebraten." Anat. Anz., Bd. viii. 1893, p. 473.

† His, W.: "Die Entwickelung der menschlichen und tierischen Physiognomieen." Archiv f. Anat. u. Phys. (Anat. Abth.), 1892, p. 399.

‡ In his short paper Keibel concerns himself mostly with the palate and upper lip of the Vertebrates, and it is only secondarily that he throws out suggestions as to the formation of the internal nares. Hence his meaning is not very easily determinable, but it seems to be as follows:—The internal nares are homologous and primary structures wherever they appear in the Vertebrate kingdom. They arise from the inner portion of the primitive nasal groove—as described by Balfour—but instead of the maxillæ growing in between the primitive nostril and nares, it is the "palate"—formed from the median and external primary nasal processes. The Selachii represent, therefore, the most primitive condition, where the primary nasal groove persists.

Tunny, viviparity occurs in *Zoarces* and in other Teleosts; and in *Anableps* it is said that "the vascular yolk-sac is provided with villi which absorb nutriment" from the fluid secreted by the walls of the dilated ovary within which the embryo develops *. The Elasmobranchs offer numerous instances of this kind; and Professor Howes (who has aided me liberally with the literature throughout my work) has at the last moment drawn my attention to another case which compares in its "uniqueness" with the divergent specimen of *Cynoglossus*. In the Anurous Amphibia he has shown † that the epiglottis—an accessory voice-organ peculiar to Mammals—is of frequent occurrence in an elementary form, liable to great individual variation. In *Chiroleptes australis* the epiglottis was developed in one specimen, a male; in another, also a male, it was insignificant; whilst in a third, a female, the epiglottis was small and the accompanying "epilaryngeal folds" absent. He informs me that three more adults, which he has examined since his paper was written, were wholly destitute of the organs in question. So far, therefore, only one specimen of this species has been found with these organs well-developed. With the exception perhaps of this last case, the foregoing are all examples of separate specializations in the respective modes of life of the animals, and show once more how plastic is the organism in the grasp of its environment.

EXPLANATION OF PLATE 38.

Fig. 1. Semidiagrammatic transverse section across the nasal region of a Pleuronectid (Plaice or Halibut), to show the nasal secretory sacs, $n.s._1$—$n.s._4$.

The Dipnoi occupy the second stage, where a rudimentary true palate is represented by the hinder portion of the upper lip anterior to the teeth, but where no true maxillæ are developed. The palate (?) is here formed by the nasal processes (*cf.* Semon, *l. c.*), and the naso-pharyngeal communications arise from the primary nasal grooves. The Amniota show the third and last stage. The palate and the internal nares are formed as above, and the maxillæ grow round anteriorly to complete the external boundaries of the mouth.

* Haddon, A. C.: 'The Study of Embryology,' p. 98. (*Cf.* Wyman—Boston Journ. Nat. Hist. vol. vi. p. 432.) My best thanks are due to Mr. A. W. Kappel, the resourceful Librarian of the Linnean Society, for the pains with which he has determined this reference.

† Howes, G. B.: "On an unrecognized feature in the Larynx of the Anurous Amphibia." Proc. Zool. Soc. 1887, p. 497.

Fig. 2. Semidiagrammatic longitudinal section through the skull of *Solea lascaris*, to show the nasal sacs, *r.n.s.* and *l.n.s.*

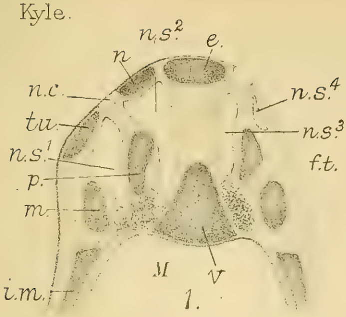
3. *Cynoglossus semilævis*: a dissection from the left side, showing the left olfactory organ (*o.l.*), the mandibular tooth-mass of the right side (*t.m.*), and indicating, diagrammatically in dotted lines, the course of the left naso-pharyngeal canal (*n.p.c.*), and the position of the aperture of the naso-pharyngeal sac (*c*).

4. The same: ventral view of the roof of the mouth, showing the aperture of the naso-pharyngeal sac (*c*), and, diagrammatically in dotted lines, the course of the naso-pharyngeal canals (*n.p.c.*). The arrows point towards the internal openings.

5. The same: a dissection to the level of the naso-pharyngeal sac, the left wall of which (*c.f.*) has been turned outwards to show the course of the left naso-pharyngeal canal (*n.p.c.*), and the slit-like expansion of the naso-pharyngeal canal of the right side (*n.c.*) as it opens into the sac (*c*).

Reference Letters.

b., basioccipital.
b.v., breathing-valves.
c., sac in roof of mouth into which the naso-pharyngeal canals open.
c.f., cut edge of fold round sac (*c*).
e., ethmoid.
e.l., left eye (displaced).
e.o., opening of naso-pharyngeal canal into nasal cavity.
f., fold round naso-pharyngeal sac (*c*).
fr., frontal.
f.t., fatty tissue.
h., hyomandibular.
i.m., premaxilla.
l.n.s., left nasal sac.
l.i.m., left premaxilla.
l.m., left maxilla.
m., maxilla.
M., mouth.
md., left mandible.
mt., metapterygoid.
n., nasal bone.
n.c., nasal cavity.
$n.s._1$—$n.s._4$, nasal sacs.
n.p.c., naso-pharyngeal canal.
o.l., left olfactory organ.
op., operculum.
p., palatine.
p.o., preoperculum.
pr., prootic.
p.s., parasphenoid.
qu., quadrate.
r.i.m., right premaxilla.
r.u., right maxilla.
r.n.c., opening of right naso-pharyngeal canal into sac (*c*).
s.o., supraoccipital.
t.m., tooth-mass of right mandible.
tu., turbinal.
v., vomer.



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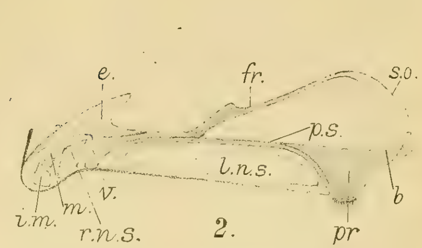

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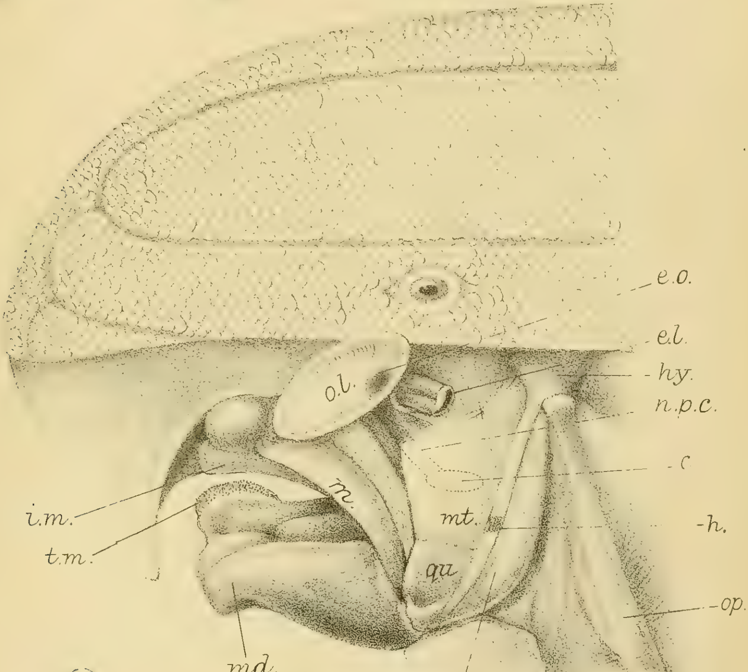

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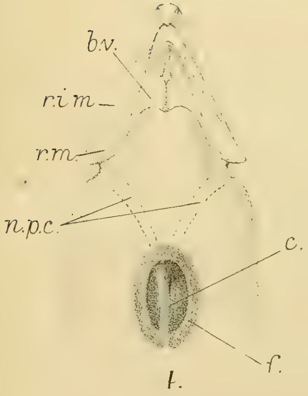

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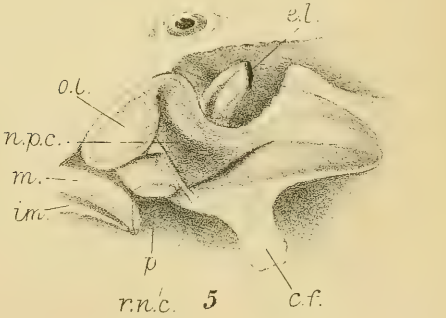

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NASAL SACS IN TELEOSTEANS.

INDEX.

[Synonyms and native names are printed in *italics*. A star is added to names which appear to be here used for the first time.]

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Treasurer's Account for the year ending April 30th, 1898. (Presented at the Anniversary Meeting, May 24th, 1898.)

Receipts and Payments of the Linnean Society, from May 1st, 1897, to April 30th, 1898.

Receipts.				£	s.	d.
Balance at Bankers' on 1st May, 1897				300	4	4
Interest on Investments				195	18	8
Admission Fees				156	0	0
Annual Contributions				1386	17	7
Compositions				396	0	0
Sales of Publications:—						
Transactions	£ 69	12	10			
Journals	100	19	9			
Proceedings and Catalogues	4	1	0			
				174	13	7
Miscellaneous Receipts				43	14	9
				£2653	8	11

Payments.				£	s.	d.
Taxes and Insurance				12	13	9
Repairs and Furniture				174	12	0
Coals and Gas				88	7	0
Salaries				730	6	8
Library:—						
Books	£155	9	1			
Binding	99	5	11			
				254	15	0
Expenses of Publications:—						
Printing	£470	14	7			
Illustrations	355	9	6			
Distribution	50	18	0			
				877	2	1
Miscellaneous Printing and Stationery				57	2	10
Petty Expenses (including Tea and Postage)				112	9	4
Investment of Compositions				100	0	0
Balance at Bankers' on 30th April, 1898				246	0	3
				£2653	8	11

Investments on April 30th, 1898.

	£	s.	d.
Consols	4486	7	11
Metropolitan Board of Works $3\frac{1}{2}$ per cent. Stock	1263	1	9
Great Indian Peninsula Railway 5 per cent. Guaranteed Stock	1055	5	0
Forth Bridge Railway Company 4 per cent. Stock (viz. Mr. Bentham's Bequest as a Library Fund)	636	15	0
Consols (Westwood Bequest)	276	18	1
FRANK CRISP, *Treasurer.*	£7718	7	9

The foregoing accounts have been examined with the vouchers and found correct.

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(Presented at the Anniversary Meeting, May 24th, 1899.)

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Receipts.				£	s.	d.
Balance at Bankers' on 1st May, 1898				246	0	3
Interest on Investments				200	19	11
Admission Fees				144	0	0
Annual Contributions				1535	4	7
Compositions				225	0	0
Sales of Publications:—						
Transactions	£109	9	7			
Journals	105	11	5			
Proceedings and Catalogues	3	11	6			
				218	12	6
Miscellaneous Receipts				245	18	6
				£2815	15	9

Payments.				£	s.	d.
Taxes and Insurance				12	13	9
Repairs and Furniture				60	7	1
Coals and Gas				95	10	5
Salaries				734	10	0
Library:—						
Books	£151	4	10			
Binding	99	17	5			
				251	2	3
Expenses of Publications:—						
Printing	£655	19	2			
Illustrations	412	0	5			
Distribution	46	8	10			
				1114	8	5
Miscellaneous Printing and Stationery				78	2	11
Petty Expenses (including Tea and Postage)				129	14	0
Investment of Compositions				100	0	0
Balance at Bankers' on 30th April, 1899				239	6	11
				£2815	15	9

Investments on April 30th, 1899.

	£	s.	d.
Consols	4545	13	9
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(Presented at the Anniversary Meeting, May 24th, 1899.)

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Balance at Bankers' on 1st May, 1898				246	0	3
Interest on Investments				200	19	11
Admission Fees				144	0	0
Annual Contributions				1535	4	7
Compositions				225	0	0
Sales of Publications:—						
Transactions	£109	9	7			
Journals	105	11	5			
Proceedings and Catalogues	3	11	6			
				218	12	6
Miscellaneous Receipts				245	18	6
				£2815	15	9

Payments.				£	s.	d.
Taxes and Insurance				12	13	9
Repairs and Furniture				60	7	1
Coals and Gas				95	10	5
Salaries				734	10	0
Library:—						
Books	£151	4	10			
Binding	99	17	5			
				251	2	3
Expenses of Publications:—						
Printing	£655	19	2			
Illustrations	412	0	5			
Distribution	46	8	10			
				1114	8	5
Miscellaneous Printing and Stationery				78	2	11
Petty Expenses (including Tea and Postage)				129	14	0
Investment of Compositions				100	0	0
Balance at Bankers' on 30th April, 1899				239	6	11
				£2815	15	9

Investments on April 30th, 1899.

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Metropolitan Board of Works 3½ per cent. Stock	1263	1	9
Great Indian Peninsula Railway 5 per cent. Guaranteed Stock	1089	18	0
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THE JOURNAL
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VOL. XXVII. **ZOOLOGY.** No. 176.

CONTENTS.

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LINNEAN SOCIETY OF LONDON.

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Vol. XXVII. ZOOLOGY. No. 177.

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