XXVI A NOTE ON THE MARINE INVERTEBRATE FAUNA OF CHANDIPORE, ORISSA.

By F. H. GRAVELY, *D.Sc., Assistant Superintendent, Zoological Survey of India.*

With

NOTES ON ECHIUROIDS

By B. PRASHAD, *D.Sc., Officiating Director of Fisheries, Bengal, Bihar and Orissa.*

The following notes are based on visits to Chandipore in or about May of the years 1915, 1916, 1917 and 1919. I have to thank Dr. N. Annandale and Mr. S. W Kemp for many of the identifications.

Chandipore is situated on the Orissa coast, about ten miles from Balasore. A stretch of jungle interspersed with muddy pools and creeks of brackish water, where Calling Crabs (*Gelasimus*) of various colours abound, is separated from the shore by a narrow belt of sand-dunes. The shore slopes very gradually, and a mile or more of wet sand or mud is uncovered at low tide. The Burhabalang River empties itself into the sea two or three miles to the north-east, and a smaller stream at a somewhat greater distance to the south-west. The nature of the shore between tide-marks varies considerably in different places and there are patches of sparse low grass or sedge towards the latter estuary, where the ground is particularly muddy. The fauna includes estuarine species, such as *Bimeria fluminalis* and *Meretrix meretrix* as well as species which are essentially marine; but the greater part probably belongs to the latter category.

At the mouth of the Burhabalang River the open sea has evidently encroached on an old mangrove swamp, and the tide comes up over banks of stiff clay, where roots and stumps of bushes are still to be seen, and Calling Crabs and other species characteristic of the jungle swamps behind the sandhills are still abundant. This clay was examined in 1917 and 1919 only. Where the mangrove roots had been washed away and the fauna was more of a marine type the following invertebrates were found:—

COELENTERATA.

Burrowing Actinians. A few small specimens.

LAMELLIBRANCHIATA.

Solen sp. Very minute; siphons normal, *i.e.* not as in the Chilka Lake species (*Mem. Ind. Mus.*, pp. 354-355, fig. 5). Few specimens found.

Fragile burrowing Lamellibranch with very long siphons. Abundant.

GEPHYREA.

Thalassema branchiorhychus, Annandale and Kemp. Abundant in 1917. One doubtful specimen (without proboscis) found in 1919.

Thalassema microrhynchus, Prashad. With very small proboscis. One specimen only of this interesting new species found in 1919.

CRUSTACEA.

Isopod (? *Sphaeroma*) living in burrows and rolling into a ball like a woodlouse when disturbed. Common in 1919.

Upogebia sp. One specimen only (1919).

Alphaeus sp. The snapping of its claws could be heard in all directions as one's weight pressed on its burrows.

The invertebrates found between tide-marks on the shore generally were as follows:—

COELENERATA.

Clavactinia gallensis, Thornely (*Report on the Pearl Oyster Fisheries of the Gulf of Manaar*, II, pp. 110-111, pl. i, fig. 3). Abundant on *Nassa* and other shells, both living and inhabited by hermit crabs.

Clavactinia sp. Much denser and more luxuriant than the former, and of a deeper pink colour, but possibly the same species. Found only on the exposed ends of Chaetopterid tubes in 1919.

Bimeria fluminalis, Annandale. (*Mem. Ind. Mus.*, V, pp. 111-114, text-fig. 10, pl. ix, figs. 3-3*a*). On post driven into sand between tide-marks. This species has not hitherto been found in the open sea.

Obelia spinulosa, Bale—(see Annandale, *Mem. Ind. Mus.*, V, p. 106, fig. 9.) On exposed ends of Chaetopterid tubes.

Cavernularia sp. Common every year except 1919, when no specimens were seen.

Virgularia sp. Apparently fairly common, especially in 1919, near low-tide mark. Occasionally specimens are found lying on the sand when they can readily be collected; more often they are embedded in mud or sand to within an inch or two of the top. When touched or disturbed by pressure they shoot down out of sight and out of reach with extraordinary rapidity.

Actinians are sometimes found attached to shells inhabited by hermit crabs. One species attaches itself to Chaetopterid tubes below the surface of the ground, rising up to spread its tentacles at the surface. The largest form (? *Cerianthus* sp.), common every year, except 1919 when none were found, lives with its elongate column deeply embedded in the sand, and its tentacles expanded, usually at the bottom of a slight depression in the ground.

POLYCHAETA.

Syllidae. Small worms, some of them strobilizing, found among *Obelia* on Chaetopterid tubes.

Polynoidae. Sometimes found in large shells inhabited by hermit crabs.

Spionidae. Small worms living among debris at base of *Obelia* on Chaetopterid tubes.

Chaetopteridae (? n. gen.). A small Chaetopterid with a single pair of tentacles, 7 short chaetigerous segments (including the specialized fourth segment), 2 longer ones, 2 very long ones and then a number of short ones, forms slender and strongly anulated hyaline tubes (diameter about 1 mm.) in the sand near low-tide mark. About 60 mm. of the tube project above the ground and are often covered with hydroids on which small nudibranchs feed and among which small Syllids and Spionids live. Actinians sometimes attach themselves to these tubes below the surface of the ground, stretching up to spread their tentacles in the water.

Other worm tubes, including tubes of *Pectinaria* washed up by the tide, are common.

MOLLUSCA.

Nassa. A large species is the commonest gastropod between tide-marks. Its shell is often covered with *Clavactinia gallensis* which is found on living individuals as well as on shells inhabited by hermit crabs.

Nudibranchs, probably minute Aeolids, were found eating and laying eggs among hydroids on Chaetopterid tubes. A larger nudibranch without cerata was washed up by the tide in considerable numbers in 1916.

Lamellibranch shells washed up by the tide are both varied and numerous. *Meretrix meretrix* is sometimes found alive on the surface of the ground between tide-marks.

ECHINODERMATA.

Small Echinoid shells are sometimes washed up by the tide, and were specially abundant in 1919, when a few living specimens were found between tide-marks. Their tube-feet were very small, and appeared to be useless for walking, this function having been taken over by the somewhat long purplish spines.

CRUSTACEA.

Ocypoda macrocera, Milne-Edwards (see Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, II, p. 347) is by far the most striking crab on the beach on account of its bright red colour, large numbers and considerable size.

Scopimera investigatoris, Alcock (see Kemp, *Rec. Ind. Mus.*, XVI, pp. 316, 317) burrows in the sand at about high tide-mark, arranging its moderately large pellets beside a broad and very definite straight pathway from its hole.

Dotilla intermedia, de Man (see Kemp, *Rec. Ind. Mus.*, XVI, pp. 331–333, fig. 10) occurs to some extent with *Scopimera* but also extends a great deal further out. Where it burrows in sand that is not too wet it brings up pellets, somewhat smaller than those of *Scopimera*, and arranges them in concentric arcs which may be completed to form either a spiral or a series of concentric circles, with less definite paths across them from the burrow to the outside. When burrowing in wet mud it builds a sort of rampart round its hole, which often closes over it as a small dome. Two forms of male occur at Chandipore in this species (see Kemp, *loc. cit.*, pp. 331–333, fig. 10).

Macrophthalmus transversus, Latreille (see Kemp, *Rec. Ind. Mus.*, XVI, p. 386) lives further out towards low water than does *Dotilla*. It is usually common, but was very scarce in 1916. Its burrows are markedly oblique, not vertical as are those of *Ocypoda*, *Scopimera* and *Dotilla*.

ARACHNIDA.

Limulus molluccanus, Latreille (see Pocock, *Ann. Mag. Nat. Hist.*, 7, IX, pp. 260-266, pl. v-vi; and Annandale, *Rec. Ind. Mus*, III, pp. 294-295), is moderately abundant.

INSECTA.

Cicindela biramosa, Fabricius, is very abundant.

Cicindela quadrilineata, Fabricius, is sometimes to be found where the ground is muddy. In 1919 it was comparatively abundant on muddy sand at the mouth of the Burhabalang River. Both species are common seashore insects, living near high-tide mark, but I am not aware that they have been found so closely associated before. In Annandale and Horn's Annotated List of Indian Museum Cicindelinae (Calcutta, 1909) *C. biramosa* is recorded from various places from N. Canara on the Malabar coast to Java, and *C. quadrilineata* from Burma and Bengal to south of Madras; and the known range of the latter species is extended in the "Fauna of British India" to Sind and Baluchistan. More recent observations both by Dr. Annandale and myself suggest that *C. biramosa* is the common seashore species of the east and south-west coasts of the Indian Peninsula, that *C. quadrilineata* holds this position on the

northern parts of the west coast. Mr. Kemp found both on the coast of Portuguese India.

NOTES ON ECHIUROIDS FROM CHANDIPORE, ORISSA.

By B. PRASHAD, *D.Sc.*

In May 1919, Dr. F. H. Gravely obtained two specimens of Echiuroids from the mud-flats at Chandipore on the coast of the Bay of Bengal. The two specimens belong to the genus *Thalassema*, Gaertner, and are referable to two distinct species. One of the specimens is without the proboscis and so it is impossible to assign it to its species with any great certainty, but it bears in general shape and anatomy a very close resemblance to *T branchiorhynchus*, Annandale and Kemp,[1] which was collected previously by Dr. Gravely at the same locality in fairly large numbers. The other specimen cannot be assigned to any previously known species and is described as a new one. This species is very important from a biological point of view, and affords an interesting example of the occurrence under essentially similar biological conditions of animals with exactly opposite types of apparently adaptive characters.

Thalassema branchiorhynchus, Annandale and Kemp.

1915. *Thalassema branchiorhynchus*, Annandale and Kemp, *Mem. Ind. Mus.*, V, p. 61, figs, 2, 3.
1919. *Thalassema branchiorhynchus*, Prashad, *Mem. As. Soc. Bengal*, VI, p. 324.

I assign the specimen without the proboscis to this species with some hesitation, because the most characteristic feature of the species—the proboscis—is absent. In the position of the proboscis a semicircular scar is to be seen, and from this it appears that the proboscis must have been cast off long ago, for the scar is quite healed up, and there is no trace of the openings of the vascular sinuses.

The specimen is preserved in an expanded condition, and is an elongated sickle-shaped organism much more pointed at the posterior than at the anterior end. The length is 31 mm. and the maximum breadth only 5 mm. The arrangement of the integumentary papillae is very similar to that described for the type-specimen. The general anatomy also is identical.

Thalassema microrhynchus, sp. nov.

There is a single specimen of this species from the same locality as the preceding one. Preserved in an expanded condition,

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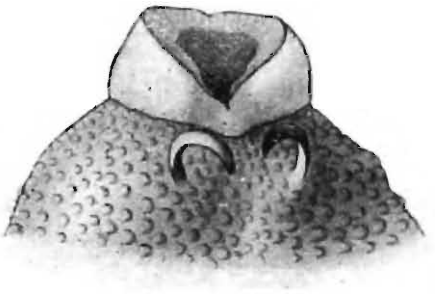
[1] *Mem. Ind. Mus.*, V, p. 61 (1915).

it measures 26·5 mm. in total length, of which 1·4 mm. is formed by the proboscis. The greatest breadth at a point just behind the middle is 7 mm., but this measurement is very unreliable as it varies greatly with the state of expansion or otherwise at the time of preservation. In general shape the animal is elongate, slightly curved near the middle and pointed at both ends.

The proboscis, the length of which is only one nineteenth of the entire length of the body, is a rudimentary structure. Its cross section a little behind the tip would be more or less of a semi-circle, while near the base where the two margins are united the structure becomes quite tubular. In appearance it resembles the proboscis of *T sabinum* described by me in another paper,[1] except that the structure is at a much lower grade of development. The two species agree in the lateral margins of the proboscis being united ventrally at the base, but in other respects such as the absence of finger-shaped outgrowths in the Indian form they are



Thalassema microrhynchus, sp. nov.
Ventral view of the proboscis and setal region, × 8.

quite different from one another. The distal free end of the proboscis is truncated. No ciliated groove is to be made out on the ventral surface but the inner surface anteriorly shows longitudinal furrows. The dorsal surface is practically smooth.

The body wall is covered with papillae, which near the two ends of the body are arranged in definite rings; between the rings of large papillae rows of much smaller ones are also visible. On the ventral surface of the body about the middle there is a crescentic area on which the adjacent papillae are united together to form small elongated ridges, but the individuality of the papillae can still be distinguished. The circum-anal region also shows distinct papillae covering it.

The ventral hooks are situated very near the anterior end; they are, as shown in the figure, very well developed and have the free projecting portion of the hooks very broad and curved.

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[1] *Mem. As. Soc. Bengal*, VI, p. 325 (1919).

The longitudinal muscles form a continuous sheath and are not divided into bundles.

There are two pairs of segmental organs with their external openings behind the level of the ventral hooks. The vesicle is an elongated bag-like structure with the free closed end pointing backwards, and has the mouth of the internal funnel drawn out into very long spiral lobes.

The anal vesicles are of a simple type, about half the length of the body, and each provided with two rows of ciliated funnels on their anterior half. There is nothing special to note with regard to the rest of the anatomy.

The animal preserved in spirit after fixation in formalin is of a pale yellow colour; the proboscis, however, is very much lighter in tint, being creamy white.

Type specimen:—W $^{2}\frac{10}{1}$ in the collection of the Zoological Survey of India (Indian Museum).

The species under consideration belongs to the group of *Thalassema* treated of in my paper referred to above. The general anatomy and form are very similar; the most important feature, however, in which it differs from the forms discussed in that paper is the low grade of development of the proboscis. In discussing the different grades of development of this structure in the various species I stated, that in *T sabinum* we have a form which shows the origin of small processes from the ventral margins of the proboscis, that in the second species *T dendrorhynchus* the processes are much better developed even becoming dendritic by division, while in *T branchiorhynchus* the processes are still better developed forming regular gills. The condition in the present form is even more primitive than in *T sabinum*, for there is only a proboscis of a rudimentary type without any processes. *T microrhynchus* in this respect represents probably the most primitive member of this group of the genus *Thalassema*.

A point of great biological interest arises from the occurrence under similar conditions of two such diverse forms as *T branchiorhynchus* and *T microrhynchus*, which stand at two extremes as to the development of the proboscis and the branchial processes. Specimens of the two species have been collected from the same locality, living under apparently similar biological conditions. The lines of evolution of respiratory structures in the two forms, however, are as divergent as possible. Whereas in *T branchiorhynchus* the respiratory surface has been very greatly increased by the development of a large proboscis and very long, branched branchial processes, in the other (*T microrhynchus*) the proboscis is quite rudimentary. Similar cases of adaptive characters of exactly opposite type developed by two species living in similar biological surroundings are not unknown elsewhere, and reference may be made to the various examples amongst sponges cited by Annandale.[1] In all these cases the two species have developed or at

[1] *Journ. As. Soc. Bengal* (n. s.), IX, p. 75 (1913), *Mem. Ind. Mus.*, V, p. 54 (1915) and *Mem. As. Soc. Bengal*, VI, pp. 196-197 (1918).

any rate possess special characters adapting them to a peculiar habitat, but the structural peculiarities are of an exactly opposite nature. In the present case it is impossible to say whether the special structures have a particular physiological function, or whether they are merely highly developed in the one case and rudimentary in the other. We do not know what are the effects of this type of diverse evolution on the two species.

XXVII ON THE GENERIC POSITION OF SOME ASIATIC UNIONIDAE

By B. PRASHAD, *D.Sc., Officiating Director of Fisheries, Bengal, Bihar and Orissa, Calcutta.*

This paper deals with the anatomy, etc. of Unionids from countries as far apart as the Malay Archipelago and Burma on the one hand and Palestine on the other.

I. ON THE GENUS *MONODONTINA*, Conrad.

In a recent paper,[1] while describing the soft parts of an Indian form of the genus *Pseudodon*, Gould, I questioned the propriety of Simpson's grouping[2] of the various species of that genus. This observation was based on a study of the soft parts of the species *P. salvenianus*, Gould—the type-species of the genus. I felt myself justified in making the remark referred to, because my description of *P. salvenianus* differed very materially from that of the genus *Pseudodon* as compiled by Simpson (*loc. cit.*) from Deshayes and Jullien's figure of *P. moreleti*.[3] It was, however, impossible for me to go into the question in any greater detail as I had no material of the other species. Through the courtesy of Mr. Van der Doop of Sumatra, Dr. N. Annandale recently received a large consignment of molluscs from Sumatra for identification, and he very kindly passed on the entire collection of Unionids to me. This collection, though consisting of a single form, has proved very valuable in enabling me to clear up a number of doubtful points regarding the synonymy of some of the species as also of the various groups assigned by Simpson to the genus *Pseudodon*. According to that author, the species to which the specimens must be assigned is *P. chaperi* (de Morgan). The question of the validity of this species is, however, discussed at length further on.

To understand properly the situation regarding the generic name of the group to which the species under consideration belongs, it is necessary to go into the history of the type-species of *Monodontina*, namely *M. vondembuschiana* (Lea). This species was originally described by Lea as *Margaritana vondembuschiana*,[4] though in a later work [5] he changed the name to *Margaron* (*Mono-*

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[1] *Rec. Ind. Mus.*, XVI, pp. 289-297 (1919).
[2] *Proc. U.S. Nat. Mus.*, XXII, pp. 501-1075 (1900).
[3] *Nouv. Arch. du Mus.*, X, pl. v, figs. 1-3 (1874).
[4] *Proc. Amer. Phil. Soc.*, I, p. 288 (1840). [5] Lea, *Synopsis*, p. 45 (1852).

condylea) *vondembuschiana*. H. & A. Adams,[1] recognizing the validity of d'Orbigny's genus *Monocondylea*, assigned the species to that genus. Later Conrad[2] established a new genus *Monodontina* for the same species,[3] abbreviating the specific name also; but subsequently, considering his new genus to be a synonym of Gould's *Pseudodon*, he again described the species as *P. vondembuschiana*. Simpson (*loc. cit.*), following Conrad, has included the form in the genus *Pseudodon*, making it however the type of a distinct group, which included a number of other species. This grouping on the whole is artificial, since widely different species such as *P. salvenianus* have been included in the group of *P. vondembuschiana*. A few other unimportant changes affecting the name of this species are given by Simpson.

The material from Sumatra has made it possible for me to examine the animal of a form of *P. vondemhuschiana*, and as a result of this examination I have found it necessary to revive Conrad's genus *Monodontina*—because the animal of the Sumatran species—a form of the type-species of *Monodontina*—is very different from that of the type-species of *Pseudodon*, namely *P. salvenianus*. I have also added a few notes on the synonymy of the other species, based on an examination of the collection of the Zoological Survey of India (Indian Museum) and a critical study of the excellent figures in Haas' incomplete monograph[4] and other available literature.

Of the species included by Simpson in this group *P. ellipticum*, *P. zollingeri*, *P. cumingii*, *P. aeneolus* and *P. tumidus* seem to be related to *M vondembuschiana*, and will probably have to be assigned to Conrad's genus *Monodontina*. It is, however, impossible for me to go further into this question as no specimens of these forms are available. It is also impossible to express any opinion as to *P. thomsoni*, *P. cambodjensis* and *P. nicobaricus* owing to incomplete information, while *P. moreleti* cannot be included in the genus, for, as is shown in the rather poor figure of the soft parts by Deshayes and Julien (*loc. cit.*), the animal appears to be very different from that of *M. vondembuschiana*. Specimens of *P. inoscularis* identified as such by Mr. H. B. Preston, and now in the collection of the Zoological Survey of India, are undoubtedly no more than a variety of *M vondembuschiana*, while specimens of *P. chaperi* also merge very gradually into this species. *P. zollingeri*, as stated above, is undoubtedly a distinct species, but I do not think that Mousson[5] was right in including in it shells which he described as var. *angulosa*, for this latter is probably nothing more than what I describe below as var. *chaperi*

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[1] *Gen. Rec. Moll.*, p. 501 (1858).

[2] *Proc. Acad. Nat. Sci. Philadelphia*, VI, pp. 266-449 (1853).

[3] *Amer. Journ. Conchology*, I, p. 233 (1865).

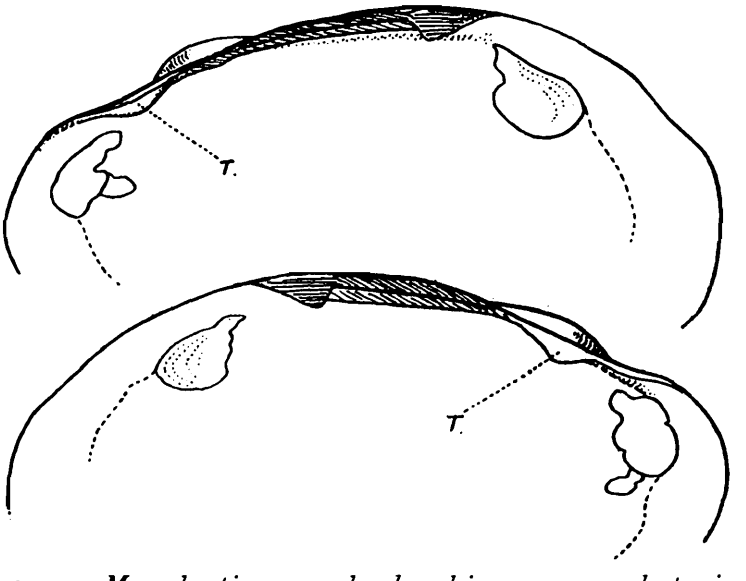
[4] Martini und Chemnitz, *Conch. Cab.* (*ed.* Kuster), *Unio*. Owing to the war no further instalments of this work were received in the Calcutta libraries after page 256 and plate 59 (1910).

[5] *Moll. Java*, Zurich, p. 96, pl. xvii (1849).

of *M. vondembuschiana.* Simpson considers Mousson's species *Alasimodonta crispata* synonymous with *M. vondembuschiana,* but in my opinion it is a distinct species, as it was also considered to be by von Martens.[1]

Monodontina, Conrad.

As already stated, the genus was established by Conrad for Lea's species *Margaritana vondembuschiana,* with the following description : "Hinge with an obtuse rounded tooth immediately below the beak." It may be redescribed as follows :—Shell rather thin, rhomboid ovate, rounded in front, truncated posteriorly, with the result that the posterior margin is nearly straight; with a narrow wing and a feebly developed posterior ridge; in young specimens a second ridge also visible above the posterior ridge ;



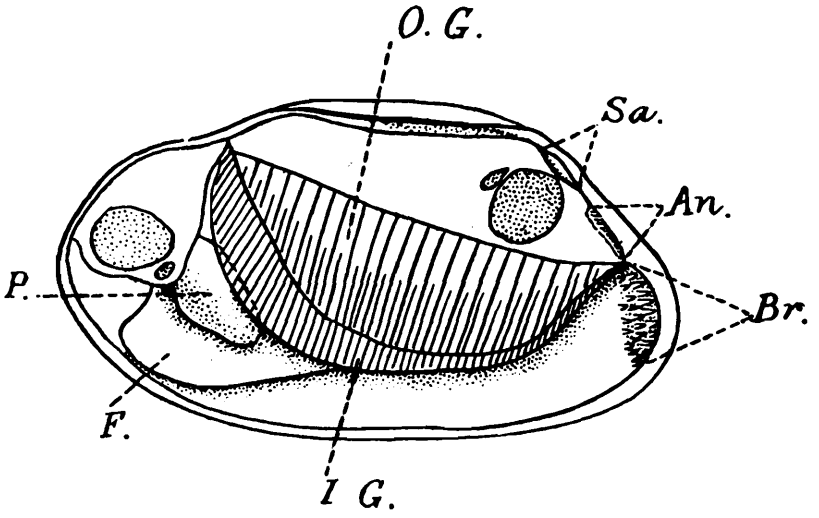
TEXT-FIG. 1.—*Monodontina vondembuschiana,* var. *chaperi,* hinge and muscle-scars.

umbo compressed, beak sculpture consisting of concentric zig-zag lines ; shell practically smooth except for lines of growth ; hinge-line straight (fig. 1); a single smooth cardinal tooth (T) in each valve, that of the right valve situated just in front of the umbo and fitting in front of that of the left valve ; lateral tooth represented by a feebly developed ridge in each valve, its posterior limit having a triangular brownish scar containing a prolongation of the hinge-ligament; the two anterior muscle-scars prominent, uniting with one another and having very irregular outlines; posterior muscle-scars very faint and separate; nacre bluish, somewhat iridescent with a brownish marginal line running parallel to the border at a little distance from the edge.

The animal of the Sumatran form (fig. 2) has the inner pair of gills very much wider than the outer throughout their entire length.

[1] *Malakol. Blätter,* XIV, p. 13 (1867).

The inner lamellae of the inner pair of gills are attached to the abdominal sac only along one-third of their anterior length, while the posterior two-thirds is quite free until the lamellae of the opposite sides meet each other a little behind the posterior margin of the abdominal sac and unite to form the diaphragm. The outer lamellae of the outer pair of gills are united with the mantle all along. The diaphragm is complete and is formed only by the gills, there being no mantle connection between the branchial and the anal apertures, though the mantle-wall of the opposite sides is slightly drawn in. The palpi are well developed, rather ellipsoid in outline, with a narrow base of attachment to the abdominal mass and further attached along one half of their posterior margin to the mantle. The anterior margin of the gills is separated from the palps by a small gap. The branchial aperture is large with two to three rows of elongated papillae , the anal is a little more



TEXT-FIG. 2.—Animal of *M. vondembuschiana*, var. *chaperi*. *An.*=anal aperture; *Br.*= branchial aperture; *F.*=foot; *I.G.*= inner gill; *O.G.* outer gill; *P.* palp; *Sa.* supra-anal.

than two-thirds the size of the branchial and is quite smooth ; the supra-anal is much smaller than either and is separated from the anal by a small mantle connection. The foot is fairly large.

A comparison of the above description of a form of the genus *Monodontina* with that of *Pseudodon* described in my former paper (*loc. cit.*, p. 295) shows that the two genera differ from each other in the following respects :—

1. The inner lamellae of the inner pair of gills of *Monodontina* are free from the abdominal sac along two-thirds of their length, while in *Pseudodon* they are attached all along.

2. There is a distinct supra-anal in *Monodontina*, but owing to the absence of a mantle connection in the position between the anal and supra-anal of other genera there is no distinction between the anal and the supra-anal in *Pseudodon*.

3. The anal is quite smooth in *Monodontina*, whereas its lower part is papillose in *Pseudodon*.

4. The foot in the genus *Monodontina* is a much better developed structure than in *Pseudodon*.

Relationships.—Frierson [1] in discussing the relationship of *Pseudodon resuspinatus*, von Martens, says that the outline and sculpture are very like that of the genus *Virgus*, while specimens of *Nodularia* (probably *brandtii* from Japan) show a very close kinship to *Pseudodon* in the teeth and general facies. I do not, however, think that the comparison is quite correct for the sculpture of *Virgus* (vide Simpson, *loc. cit.*, p. 852) is quite different from that of any of the species of *Pseudodon* that I have seen, and also from that of the species that I now assign to the genus *Monodontina*. The hinge also is quite different in the two genera. The above remarks apply with equal force to the comparison made by the same author between *Nodularia* (probably *brandtii*) and *Pseudodon*, for the hinge and teeth in the group of *Nodularia japanensis*, to which *N brandtii* belongs, are very different from those of *Pseudodon* and *Monodontina*. *Monodontina*, on the other hand, seems to have a rather close relationship with the group of *Nodularia contradens*, which Haas (*loc. cit.*, p. 173) has recently separated into a distinct genus *Contradens*.

Monodontina vondembuschiana (Lea).

1900. *Pseudodon vondembuschiana*, Simpson, *op. cit.*, p. 836.
1910. *Pseudodon vondembuschiana*, Haas, *op. cit.*, pl. xliv, figs. 4, 5.

A number of specimens of the typical form are present in the collection of the Zoological Survey, from Sarawak, and one specimen from the Philippine Islands (presented by the late Mr. W. Theobald). Mr. H. B. Preston also identified some shells (No. $M\frac{5031}{1}$) from Pegu as *P. vondembuschiana*, although he does not mention this species in his volume in the 'Fauna of British India.' These last-mentioned specimens, however, do not even belong to the genus *Monodontina*; they are rather specimens of *Pseudodon crebristriatus* and *P. peguensis*.

Var. chaperi (de Morgan).

1885. *Pseudodons chaperi*, de Morgan, *Bull. Soc. Zool. France*, X, p. 423, pl. ix, fig. 1.
1900. *Pseudodon chaperi*, Simpson, *Proc. U.S. Nat. Mus.*, XXII, p. 838.

Both de Morgan and Simpson considered this a distinct species. The large number of specimens of different ages received from Sumatra, however, show beyond doubt that it is no more than a variety of *M. vondembuschiana*. *P. zollingeri*, var. *angulosa* of Mousson (*loc. cit.*) also seems to me to be no more than a variety of that species. Indeed, it is probably identical with the var. *chaperi*, but it is impossible to express a definite opinion on this point without further material.

The record of the occurrence of this variety in Sumatra greatly extends its range, for it was previously known from

[1] *Nautilus*, XXIV, p. 97 (1911).

Cambodia and Siam only. It probably occurs also in the Malay Peninsula, the freshwater molluscs of which are little known.

Var. **inoscularis** (Gould).

1844. *Anodon inoscularis*, Gould, *Proc. Boston Nat. Hist. Soc.*, I, p. 160.
1900. *Pseudodon inoscularis*, Simpson, *Proc. U.S. Nat. Mus.*, XXII, p. 837.

There are two specimens of this form in the collection, one labelled "Tenasserim" and another "Tenasserim river."

It differs from the typical form in the shell being much smaller and more depressed, the posterior wing rather broader, the surface smoother and the cardinal tooth better developed.

Monodontina cumingii (Lea).

1850. *Anodonta cumingii*, Lea, *Proc. Zool. Soc. London*, p. 199.
1900. *Pseudodon cumingii*, Simpson, *op. cit.*, XXII, p. 837.

A single specimen from Cambodia in the collection belongs to this species.

A point worth noting about *M. cumingii* is that the origin of the cardinal tooth is exactly in line with the upper margin of the shell.

II. SUB-GENERA OF *UNIO* FROM THE NEAR EAST.

The specimens on which this part of the paper is based were collected by Dr. Annandale in 1912 in the Lake of Tiberias.[1] The entire collection of molluscs from this area was reported on by Preston,[2] but nothing was said by him about the anatomy of the various forms; further, the identifications of the two forms treated of in this paper are not correct in view of later work. One of the species belongs to Germain's recently proposed subgenus *Rhombunio*,[3] while I have found it necessary to give a new subgeneric name to the other species. Annandale[4] also has pointed out the great confusion that exists regarding the nomenclature of the various species of the genus *Unio* from Palestine, but I am unable to go into the question further owing to insufficient material of the related forms. I have, however, adopted Germain's plan of dividing the genus *Unio* into subgenera instead of groups as Simpson[5] had done, because Germain's idea conduces to a clearer understanding of the relationships.

Rhombunio, Germain.

Germain proposed this subgenus in 1911 (*loc. cit.*) for a group superficially resembling that of *Unio littoralis* group. According

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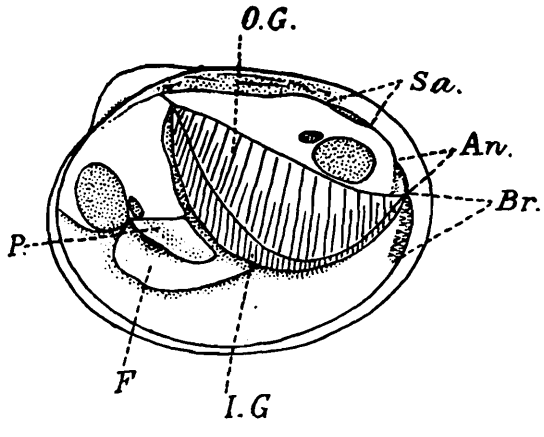
[1] For further details about locality, etc., reference may be made to *Journ. As. Soc. Bengal*, IX, p. 17 onwards (1913).
[2] *Ibid.*, pp. 465-476, pl. xxvii (1913).
[3] *Bull. Mus. D'Hist. Nat. Paris*, XVII, p. 67 (1911).
[4] *Journ. As. Soc. Bengal*, XI, p. 459 (1915).
[5] *Proc. U.S. Nat. Mus.* XXII, p. 679 onwards (1900).

to him this subgenus differs from *Unio*, *s.s.* in both shell characters and the soft parts. He stated in his paper that the account of the subgenus would be published later, but so far no such account has appeared.

In Dr. Annandale's collection there are three specimens of *Unio* (*Rhombunio*) *semirugatus* preserved in spirit; these were identified as *Unio simonis* by Preston. One of the three specimens is a gravid female. The following description of the soft parts of the sub-genus is based on this material.

Corresponding to the shape of the shell the gills (fig. 3) are fairly broad but rather short; the inner pair being much broader than the outer, particularly in the anterior half. There is only a very small gap between the anterior margin of the gills and the posterior margin of the palpi. The outer lamellae of the outer pair of the outer gills are attached to the mantle all along their length. The inner lamellae of the inner pair of gills are free from the abdom-

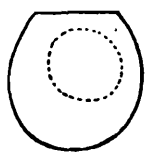


TEXT-FIG. 3.—Animal of *Unio* (*Rhombunio*) *semirugatus*, reference lettering same as in fig. 2.

inal sac except for a very short distance near the extreme anterior end; posteriorly the lamellae of opposite sides unite to form the diaphragm. The diaphragm is formed entirely by the gills, the mantle taking no part in its formation. The outer pair of gills alone are marsupial, but in these also a very small anterior and a much smaller posterior portion of each is not modified for a marsupial function. The margins of the marsupial gills are quite sharp even when the gills are charged with glochidia. The water-tubes in the gills are simple but well developed. The septa in the outer pair of gills are very crowded in the female, but in the male the arrangement is practically the same as in the inner pair of gills. The palpi are ellipsoid, attached to the abdominal sac along their base, and along nearly half of their posterior margin to the mantle. The branchial, anal and supra-anal openings are as is usual; the mantle connection between the anal and the supra-anal being nearly equal in length to the supra-anal and slightly larger than the anal, while the branchial is much larger. The branchial bears

three to four rows of elongated papillae at its edge, while the mantle covering also in this region is crenulate. The anal is smooth and so is the margin of the mantle below the branchial.

The glochidia (fig. 4) are very like those of *Physunio ferrugineus* [1] in outline, but have the hooks much better developed. They measure ·23 mm. × ·19 mm.



TEXT-FIG. 4.—Glochidium of *Unio* (*Rhombunio*) *semirugatus*, × 75.

The animal of this sub-genus differs from that of *Unio, s.s.*, as described by Ortmann,[2] in having the whole organism of a much more compact type, the gills much shorter and broader, in the different shape of the palpi, the extent of the marsupial region and the very different shape of the glochidium.

Eolymnium, sub-gen. nov.

This new sub-genus is proposed for the species *Unio terminalis*, Bourguignat, and its allies. A large number of specimens of this species were collected by Dr. Annandale from the Lake of Tiberias in October, 1912.

Simpson (*loc. cit.*, p. 689) includes this species in his group of *Unio pictorum* (Linn.), the type of the section *Lymnium*, and Germain has followed him in calling the species *Unio* (*Lymnium*) *terminalis*. The soft parts of *Unio terminalis*, however, are very different from those of *U. pictorum* as described by Ortmann (*loc. cit.*, pp. 274-275). I have, therefore, found it necessary to separate *U. terminalis* into a distinct sub-genus. Reference here might also be made to the interesting controversy started by Thiele [3] regarding the validity of the generic name *Unio*. Haas [4] took objection to his statement and expressed the opinion that the name *Unio* could not be replaced by *Lymnium*, because Bruguière's name had priority over that of Oken. Ortmann,[5] who has recently summed up the whole situation very well, has come to the conclusion that *Lymnium* is nothing more than a synonym of *Unio* as restricted by Bruguière.

The animal (fig. 5) of the sub-genus *Eolymnium* may be described as follows :—The gills are elongate but relatively shorter than in *Unio pictorum*. The inner pair of gills is much broader than the outer throughout their length and the free region of the inner lamellae of the inner pair of gills is also much larger than in *U. pictorum*; the other attachments of the gills are similar to those described for *Rhombunio*. The outer pair of gills, except at the extreme anterior end, is marsupial, as was ascertained by cutting sections. The palpi are similar to those of *U. pictorum* except that they are more pointed

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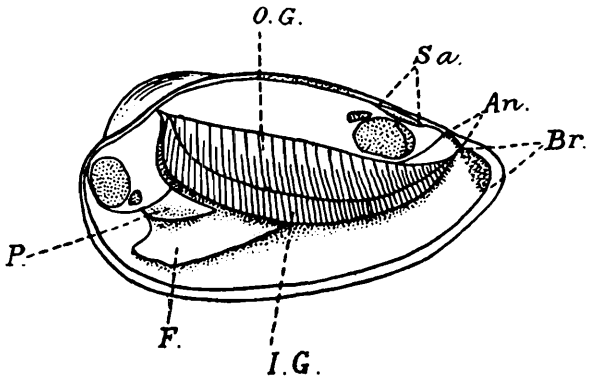
[1] *Rec. Ind. Mus.*, XIV, p. 184, pl. xxii, fig. 10 (1918).
[2] *Ann. Carnegie Mus.*, VIII, pp. 273-275 (1911-12).
[3] *Nachr. Bl. deutsch. Malakozool.*, XLII, p. 29 (1909).
[4] *Ibid.* pp. 68-72 (1909).
[5] *Nautilus*, XXV, pp. 88-91 (1911).

at the tip. The branchial aperture occupies nearly the whole of the curved posterior end of the shell and hence the anal is placed higher above; it is separated from the anal by a distinct notch and has three rows of elongated papillae on its margin. The anal is about half the size of the branchial and is smooth; it is separated from the supra-anal by a mantle connection a little more than half



TEXT-FIG. 5.—Animal of *Unio* (*Eolymnium*) *terminalis*, reference lettering same as in fig. 2.

the size of the anal and very much smaller than the supra-anal. The foot is rather poorly developed.

The glochidia are unknown, as none of the specimens are gravid.

This sub-genus comes near the group of *U. pictorum*, but differs in the general shape of the animal, the shape and size of the gills, the relations of the branchial, anal and supra-anal apertures, and in the poorer development of the foot.

XXVIII CONTRIBUTIONS TO THE FAUNA OF YUNNAN BASED ON COLLECTIONS MADE BY J COGGIN BROWN, B Sc , 1909–1910 [1]

PART IX. TWO REMARKABLE GENERA OF FRESHWATER GASTROPOD MOLLUSCS FROM THE LAKE ERH-HAI.

By N. ANNANDALE, *D.Sc., F.A.S.B., Director, Zoological Survey of India, and* B. PRASHAD, *D.Sc., Offg. Director of Fisheries, Bengal, Bihar and Orissa.*

Numerous fossil shells from the Miocene beds of Eastern Europe have been assigned (somewhat doubtfully we agree with Fischer [2]) to the family Pleuroceratidae or Pleuroceridae, but this family is usually believed to be confined in a living condition to North America. In the collection of molluscs made by Mr. J. Coggin Brown of the Geological Survery of India in Yunnan some years ago, we find numerous specimens of two species which we think may find a place at least provisionally among the Pleuroceratidae more conveniently than elsewhere. One of these species has already been described more than once, and has been placed by three different authors in three different genera of Hydrobiidae. Its proper name is *Fenouilia kreitneri* (Neumayr). The other species has not, so far as we can discover, been as yet described. It is impossible to separate it generically from the living and fossil Burmese and Chinese genus recently described by one of us under the name *Paraprososthenia*. It has, however, such marked conchological differences that we propose for its reception a new subgenus. We have named it *Paraprososthenia* (*Parapyrgula*) *coggini* in allusion to the name of its discoverer and to the *Pyrgula*-like appearance of the shell.

The precise locality at which both species were found is Shankuan at the north end of Erh-Hai. They were living on stones at the edge of the lake at a spot liable to strong wave-action.

The shells of *Paraprososthenia coggini* and *Fenouilia kreitneri* are very different in shape, that of the former being elongate and strictly conical, while that of the latter is trochiform. They resemble one another, however, in the structure of the mouth, which is pyriform with a continuous peristome and a thin, slightly everted outer lip, and is slightly produced posteriorly but broadly rounded anteriorly. Neumayr in 1880 placed *F. kreitneri*, on

[1] Former papers in this series were published in Vols. V-VII of the *Records of the Indian Museum* (1910–1912).

[2] *Man. Conchyl.*, p. 705 (1887).

shell-characters, in the genus *Lithoglyphus*. He was acquainted with the peculiarities of the radula to which we will refer later, but did not consider them of generic importance. In 1889 Heude erected a new genus (*Fenouilia*) for what we believe to be the same species. He was apparently ignorant of Neumayr's description and called the form *F. bicingulata*. This species was described for the third time in 1904 by Fulton under the name *Jullienia carinata*. The shell is very like that of *Lithoglyphus* but differs in the shape of the mouth (which is not shown quite correctly in Neumayr's figures); from *Jullienia* it differs in its thin outer lip.

The genus *Paraprososthenia*, or rather the only known recent species, was identified by Neumayr with the fossil genus *Prososthenia*. The latter is only known from the Miocene beds of Eastern Europe, while the living species inhabits Lake Tali Fu, in which *P. coggini* was also found. The fossil shells differ, however, in their thick outer lip and the resemblance is probably convergent. The subgenus *Parapyrgula* resembles the recent and fossil genus *Pyrgula* of Central Europe and the eastern Mediterranean basin in shell-characters, but has not quite the same type of sculpture and again differs in the distinctly pyriform shape of the mouth. Except in its very small size and delicacy of structure it closely resembles the shell of the N. American *Goniobasis*, the most prolific in species of the Pleuroceratid genera and the only one of which the geographical range extends to the Pacific coast of North America.

This resemblance in the outward form of the shell between *Parapyrgula* and *Goniobasis* would not be sufficient in itself to establish family identity, and in *Fenouilia* evidence of the kind is weak, depending as it does on a much less marked resemblance between the shell and that of *Anculosa*. The operculum of the two Chinese genera might equally well belong to the Hydrobiidae, to the Melaniidae or to the Pleuroceratidae. It is only when we examine the radulae that definite affinities begin to manifest themselves. According to Troschel's[1] figures the radulae of the Pleuroceratidae resemble those of the Melaniidae rather than those of the Hydrobiidae. The central tooth is small and transverse and its disc is without latero-basal denticulations or other projections. The tooth on either side of the central tooth differs greatly from the two outermost teeth and the dental formula would seem to be 2. 1. 1. 1. 2. The lateral tooth is characterized by the large size of the central denticulation. According to Stimpson[2] this feature is characteristic of the family as a whole, but Walker[3] in his recent synopsis of the N. American freshwater molluscs lays stress on the absence of basal denticulations on the central tooth.

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[1] *Das Gebiss der Schnecken* I, p. 109, pl. viii, figs. 7-9 (Berlin: 1856-63).

[2] For an account of certain features of the anatomy of the Pleuroceratidae see Stimpson, *Amer. Journ. Sci.* (1) XXXIII, pp. 41-63 (1864).

[3] In Ward and Whipple's *Fresh-water Biology*, p. 991 (New York: 1918).

The radulae of *Fenouilia* and *Parapyrgula* are very similar in general structure. They differ from those of all Melaniidae, Pleuroceratidae, Rissoidae or Hydrobiidae we have examined or seen figured (except the (?) Hydrobiid *Delavaya*, Heude [1]) in that the cusp of the central tooth is a simple elongate plate. This tooth is otherwise like that of the Hydrobiidae and Rissoidae, with latero-basal denticulations as in many genera of these families. The lateral and marginal teeth, however, resemble those of the American Pleuroceratidae, especially in the great enlargement of one of the denticulations of the laterals. As a whole the radula of these two Chinese genera is, therefore, intermediate in structure between that of the Hydrobiidae or Rissoidae and that of the American Pleuroceratidae, but it is no more different from the latter than the radulae of some genera of Hydrobiidae are from one another. Fischer [2] regards the presence or absence of latero-basal denticulations on the central tooth as a subfamily character, but this distinction is not accepted by all malacologists.

When the soft parts of *Fenouilia* are examined its real divergence from the Hydrobiid type becomes apparent. From this type it differs in the shape of its head, in the position of its eyes and above all in the complete absence of a copulatory organ in the male. The distal part of the genital system, especially in the male, is also simpler, the intestine is more capacious and the gill-filaments are longer, extending almost completely across the dorsal wall of the branchial chamber. Unfortunately the anatomy of the Pleuroceratidae is imperfectly known, but the absence of a copulatory organ is well established in all the genera that have been examined. We have satisfied ourselves that this organ is also absent in males of *Fenouilia* diagnosed by a microscopic examination of the gonad. Stimpson's figure of the living *Anculosa dissimilis* shows clearly that the eyes are situated just behind the cleft between the tentacles and the head, and this is precisely their position in *Fenouilia*. The latter also differs from all the Hydrobiidae of which we have particulars in that the head is spindle-shaped, with a distinct neck. Whether this is the case in the Pleuroceratidae we have no information. Stimpson states that the only visible difference between the sexes in *Anculosa* (= *Mudalia*) is the presence of a groove on the right side of the body of the female between the tentacle and the base of the operculiferous lobe of the foot. We think that we have detected a similar groove in female specimens of *Fenouilia*, but they are too much contracted to permit a dogmatic statement.

Of *Paraprososthenia* we have examined only dried specimens of *P.* (*Parapyrgula*) *coggini*. So far as we can say, they resemble those of *Fenouilia* preserved in spirit, but we rely in placing the

[1] Heude, *Mém. Hist. Nat. Emp. Chinois*, I, p. 172, pl. xxxiii, figs. 8, 9, 10, 10*a*. See also Bavay and Dautzenberg (*Journ. de Conchyl.*, L.X, p. 37 : 1912), who regard *Delavaya* as a subgenus of *Pachydrobia* and ascribe to it several species from the Mekong.

[2] *Man. Conchyl.*, p. 724 (1887).

two genera together rather on the resemblance between the radulae than on other anatomical grounds.

The conclusion we derive from the above observations is that the genera *Fenouilia* and *Paraprososthenia* are not Hydrobiidae but resemble the Pleuroceratidae, within the limits of which they may be included provisionally, rather than any other family.

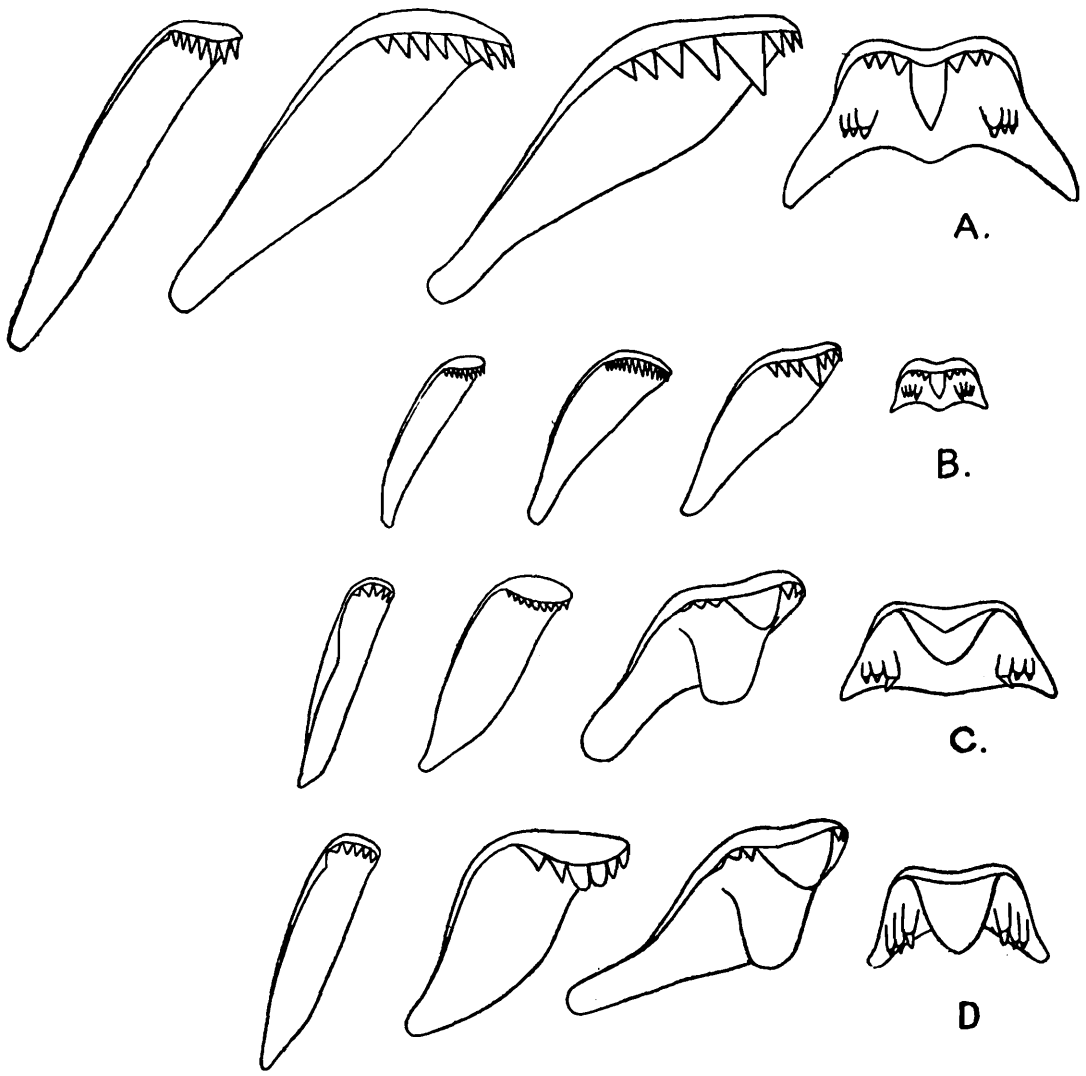

FIG. 1.—Radulae of Hydrobiidae and (?) Pleuroceratidae from China and Europe.

A. *Lithoglyphus fuscus*, Zieg. from E. Europe.
B. *Lithoglyphus liliputanus*, Gredler, from the Tong-Ting Lake, China.
C. *Fenouilia kreitneri* (Neumayr) from Erh-Hai Lake, China.
D. *Paraprososthenia coggini*, sp. nov. from the same lake.

Their possible relationship to the Rissoidae cannot be discussed in a satisfactory manner owing to lack of anatomical information about that family. Some relationship to forms like those included in the genus *Iravadia*, Blanford, is not impossible, but the position of that genus is also doubtful. It is found in brackish water, chiefly in the estuaries of the Ganges and Irrawaddi and also in the backwaters of the West Coast of India.

Neumayr[1] in describing *F. kreitneri* alluded, as we have already stated, to the peculiar form of the central tooth, but did not regard this character as of generic importance and placed the species in the genus *Lithoglyphus*. This genus is made the type of a subfamily by Fischer,[2] who describes the Lithoglyphinae thus: "Pied simple; plusieurs denticulations basales; verge simple ou fourchue; opercule corné, spiral ou subspiral." The only other species from China ascribed to *Lithoglyphus* is *L. liliputanus*, Gredler, of which there are specimens (apparently cotypes or paratypes) in the Museum collection. We have extracted the radula from one of these and find it differs little from that of the European *L. fuscus*. The radular teeth of *L. fuscus* have been figured by Troschel.[3] Our preparation differs from his figure only in having the chief denticulation of the lateral tooth relatively larger. We figure the teeth of *L. liliputanus* and *L. fuscus* for comparison with those of *F. kreitneri*.

Genus **Fenouilia**, Heude.

1880. *Lithoglyphus*, Neumayr, *Wiss. Ergebn. Reise B. Szechenyi* II, p. 655.
1889. *Fenouilia*, Heude, *Journ. de Conchyl.* XXXVIII, p. 46.
1890. *Fenouilia, id., Mém. Hist. Nat. Emp. Chinois* I, p. 172.

The only known species has experienced some vicissitude of nomenclature at the hands of three authors who have described it under as many generic and specific names. Heude described it as *Fenouilia bicingulata*, gen. et sp. nov., while Fulton called it *Jullienia carinata*. We have been able to compare specimens named by Fulton with topotypes of Neumayr's species.

Heude's original description of the genus (1889) ran as follows:—*Testâ trochoideâ, imperforatâ; operculo corneo, paucispirali, nucleo basali. Animali probabiliter rissoino.* Later (1890) he added, *radulâ 3. 1. 3., laminâ mediâ integrâ, laterali paucidentatâ.* So far as it goes, this is a correct description of the shell, operculum and radula, except that we read the dental formula 2. 1. 1. 1. 2. Heude, moreover, published in 1890 some good figures of the soft parts drawn by Rathouis, and most of these we have been able to substantiate by dissecting specimens from Mr. Coggin Brown's collection. Our examination of specimens diagnosed as male by a microscopic examination of the gonad shows that the vas deferens ends in a simple pore the margin of which is not even invaginated. The peculiarities of the head and branchial chamber to which we have alluded are also clear.

Fenouilia kreitneri (Neumayr).

1880. *Lithoglyphus kreitneri* (with varr.), Neumayr, *op. cit.*, p. 655, pl. iv, figs. 7-8.
1889. *Fenouillia bicingulata*, Heude, *op. cit.*, p. 46.

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[1] *Wiss. Ergeben. Reise B. Szechenyi* II, p. 655.
[2] *Op. cit.*, p. 724. [3] *Op. cit.*, I, p. 105, pl. vii, figs. 12, 12*a*.

1890. *Fenouillia bicingulata, id., op. cit.*, p. 172, pl. xxxiii, fig. 11.
1904. *Jullienia carinata*, Fulton, *Journ. Malac.* XI, p. 52, pl. iv.

The species has been described from three different lakes in Yunnan, as *Lithoglyphus kreitneri* from Erh-Hai (Tali Fu Lake), as *Fenouilia bicingulata* from Lake Hai Si in the same district and as *Jullienia carinata* from Yunnan Fu Lake (K'un-Yang Hai) some distance further east. The specimens we have examined are from the first and the last of these lakes. The shells from Erh-Hai are smaller and apparently thinner than the types of the species from the same lake and also than those named by Fulton *Jullienia carinata* and there is less variation among them than was the case in Neumayr's specimens. Several of them, however, possess a varix across the body-whorl as in Heude's type-specimens of *F bicingulata*. We see no reason to think that specimens from the three lakes represent more than one species. It is unnecessary for us to redescribe the shell, but for convenience's sake we give a translation of Neumayr's description.

"Shell small, blunt, conico-ovoid, stout, dextral, non-umbilicate, consisting of four whorls sharply separated by an impressed suture; upper whorls convex, but the last flattened. Shell sculptured with stout growth-lines and with 1–2 spiral keels; base flattened. Mouth shortly ovoid, pointed and strongly contracted above, strongly recurved below; peristome continuous; inner lip swollen, outer lip quite sharp. Shell covered with an olive-green epidermis."

Neumayr also describes in the same place two varieties, *carinata* and *bicarinata*, the names of which practically explain themselves. Our specimens belong to the form *carinata*.

We have examined a number of specimens in spirit. They are fairly well preserved, but brittle and contracted. The operculum is relatively large, very thin, horny, of a pale yellow colour, regularly ovoid, broadly rounded anteriorly and bluntly pointed posteriorly. It has an extremely delicate narrow colourless inner border Its sculpture is obscure, but it is possible to detect the nucleus situated near the inner anterior border and surrounded by a spiral of two or three whorls, above which curved lines radiate onwards to the base of the membranous inner margin. The external surface of the operculum is thickly covered with diatoms in all the specimens examined.

The foot appears to have been broad in proportion to its length, bluntly pointed behind and truncate in front, with a broad lobular antero-lateral process on either side. The operculiferous lobe was relatively large. There is a sharply-defined narrow transverse groove running across the sole a short distance behind the anterior margin In a contracted specimen diagnosed by microscopic examination of the gonad as female, a distinct longitudinal groove runs along the right side of the body from just behind the tentacle to the base of the operculiferous lobe. When the animal was expanded this groove may have had a vertical or nearly vertical direction.

The head is distinctly spindle-shaped, bluntly pointed in front and tapering to a short contracted neck behind. The snout is of moderate length. The mouth is a longitudinal slit, entirely ventral in position except when the head is much contracted, with tumid, corrugated lips The tentacles are rather stout but taper to their apex. They are situated rather far back on the head. The eyes are very large and prominent, though sessile. They seem to have a peculiar construction, being covered with integument except for a minute pinhole in the centre. The retinal cup is relatively large, deeply pigmented and of an oval shape. The situation of the eyes is peculiar, for they are situated one at the base of each tentacle just behind the point at which it diverges from the head.

The edge of the mantle is smooth and pale, the remainder being deeply stained with black pigment. The mantle is ample and its margin is free all along the outer end of the branchial chamber, which is relatively large. The gill consists of numerous narrow but rather deep ridges, which run almost completely across the roof of the chamber and are not differentiated at either extremity. The osphradium is well developed and ridge-like.

The mouth opens into a short conical muscular pharynx, which is rather shorter than the buccal mass. The muscles of this mass are large and powerful, forming a well developed bulb. The horny lateral jaws are situated inside these muscles, forming in contraction a thin longitudinal plate at either side of the radula. They are merely cornified and pigmented patches on the sides of the alimentary canal, with ill-defined outlines and with an obscurely squamous structure. The radula is narrow and of moderate length. The central tooth is relatively large and of transverse form. Its lower margin is sinuous and its lower lateral angles are pointed. The cusp is broadly rounded at the tip, considerably narrower and shorter than the disk. There are three latero-basal denticulations on each side, each pedunculate. The lateral tooth is hardly at all bent but consists of a relatively narrow slanting basal part and a broad upper part bearing a broad, downwardly directed lobe on its disk. The main denticulation is triangular, but rather bluntly pointed. It occupies rather less than a third of the free margin and has two or three small denticulations on either side. The inner marginal tooth is not much broader than the outer and has its denticulation, of which there are a considerable number, smaller and sharper. Neither marginal is much narrower below than above, both begin to taper a short distance above the base. The outer marginal has an elongate triangular membrane on its outer margin. The oesophagous is rather long, narrow, cylindrical and sinuate. The salivary glands, situated at the posterior end of the buccal mass, are small and their ducts short. We have not been able to trace the alimentary canal further inwards. The intestine is a relatively capacious tube which opens by a simple pore on the edge of the mantle on the right side, running along the outer edge of the branchial cavity. The faecal pellets it

contains are of large size, very compact and somewhat spindle-shaped.

The most remarkable feature of the anatomy lies in the fact that there is no intromittent organ in the male. The lower part of the oviduct and of the vas deferens is alike a simple tube opening near the anus on the right side of the body. We have satisfied ourselves of this fact by dissecting a considerable number of specimens, of which we have also examined the gonads microscopically. Unfortunately the condition of our material renders it impossible to investigate the genitalia further.

Heude (*op cit.*, 1890, pl. xxxiii, fig. 11*e*) reproduces a figure of the central nervous system drawn by Rathouis. It shows the whole structure as being compact with rather short commissures. The optic nerves are, however, long. The otocysts are situated just in front of the supraœsophageal ganglia. Each otocyst, as we have satisfied ourselves, contains a single circular otocyst.

Imperfect as is this description of the anatomy of *Fenouilia*, it is sufficient to prove its wide divergence from the Hydrobiid type.

Genus **Paraprososthenia**, Annandale.

1919. *Paraprososthenia*, Annandale, *Rec. Geol. Surv. Ind.* L (3), pp. 209-240.

This genus, although it closely resembles *Prososthenia*, Neumayr, from the Miocene beds of Eastern Europe in form of shell differs in sculpture and in the structure of the lip, which is thin and somewhat expanded instead of thickened and contracted. Nothing is known of the soft parts, radula or operculum, but the shape of the shell and the structure of its mouth are so close to those of the new species here described that we think they must be united, notwithstanding certain obvious differences, as subgenera of a single genus. For the new subgenus we propose the name *Parapyrgula* in allusion to the resemblance, probably quite superficial, between the shell and that of *Pyrgula* from central Europe and the eastern parts of the Mediterranean basin.

Parapyrgula, subgen. nov.

The shell is elongate, narrow, strictly conical, with the base rounded and somewhat produced. Its substance is delicate and fragile but not very thin. There is a very delicate periostracum. The suture, which is sometimes almost obsolete externally, has a peculiar involute structure owing to each whorl growing over and pressing closely round the base of the one preceding it. The shell is imperforate. Its mouth, which is not very oblique, is of moderate size and of distinctly pyriform outline, slightly produced posteriorly. The peristome is continuous and there is a rather thick columellar callus, but the outer lip is thin. The only prominent sculpture is a single smooth spiral ridge on the body whorl.

The operculum resembles that of *Fenouilia*.

The radula is also similar to that of that genus, but the denticulations of the teeth are for the most part longer and more

pointed. The cusp of the median tooth is simple and it bears several large latero-basal denticulations at each side. This tooth is not so high as in *Fenouilia* and has the base emarginate. The inner lateral tooth is relatively broad.

Type-species. *Paraprososthenia coggini*, sp. nov.

Distribution. Only known from the lake Erh-Hai, Yunnan.

In outline and general structure the shell of this subgenus resembles, as we have already noted, the North American Pleuroceratid genus *Goniobasis*. The size is, however, much reduced and the structure of the shell more delicate. The structure of the suture resembles that of *Pleurocera clevatum*, Say, shells of which we have examined.

Paraprososthenia (Parapyrgula) coggini, sp. nov.

The shell is narrow and elongate, sharply pointed at the apex and not at all expanded at the base. It is about twice as long as

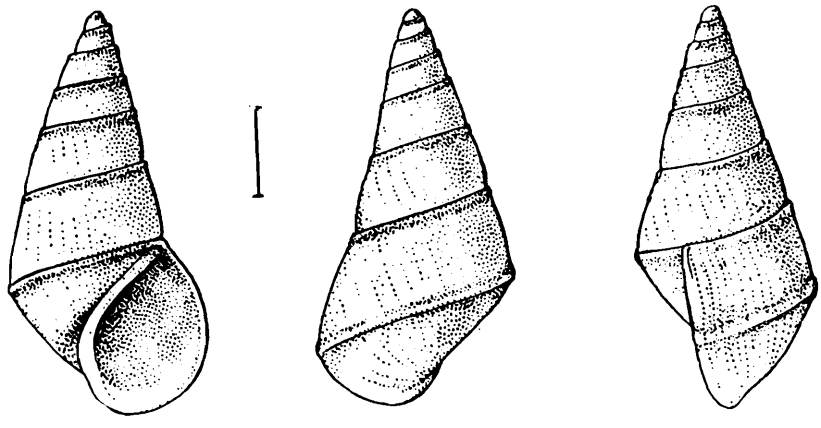

FIG. 2.—Shell of *Paraprososthenia* (*Parapyrgula*) *coggini*, sp. nov.

broad. The shell-substance is translucent bluish white like opal-glass, the periostracum pale yellow; but all the specimens examined are covered with a dense growth of diatoms which gives them an almost furry appearance. There are $7\frac{1}{2}$ or 8 whorls, but the terminal whorl or half-whorl is minute and slightly depressed. The other whorls increase gradually and evenly. The suture is oblique and linear when not obliterated externally. It is sometimes accompanied by a low flattened spiral ridge, which runs above it. The spiral ridge on the body-whorl is narrow but slightly flattened and not very prominent. The minute sculpture of the shell consists of numerous longitudinal and transverse striae. On the body-whorl fine longitudinal grooves are also sometimes disposed at fairly regular intervals, but they are often obsolete. The mouth of the shell is large, $1\frac{2}{5}$–$1\frac{3}{5}$ times as long as broad and a little more than $\frac{1}{3}$ as long as the whole shell. Anteriorly it is rounded and a little produced, while posteriorly it has a subcanaliculate structure. The callus is moderately developed, the outer lip strongly arched

and the columella curved. The main axis of the aperture forms an acute angle with that of the shell.

Measurements of shells (in millimetres).

	A (*type*)	B	C	D
Length of shell	10·3	9·5	8·5	8·8
Maximum diameter of shell	5	4·5	3·7	3·6
Length of spire (dorsal view)	6	5·3	4·5	4·8
Length of aperture .	3·4	3·5	2·4	2·4
Breadth of aperture	2·2	2·2	1·7	1·7

We have extracted the dried animal from a shell. It seems to resemble that of *Fenouilia* but is much shrivelled. The operculum is ovoid, thin, horny, of a dark brown colour and resembles that of *F. kreitneri* in sculpture.

We have already pointed out certain characters in which the radula differs from that of *Fenouilia*. The following is a more precise account of the differences. The central tooth is low in proportion to its breadth, its base is produced at either side and sharply pointed but broadly and rather deeply concave. The cusp is very large, extending downwards far beyond the base of the tooth. The lateral tooth is bent in such a way that the narrow basal part makes an obtuse angle with the broad upper part. The main denticulation of this tooth is very large, occupying nearly half the free margin. The inner marginal tooth is much broader than the outer marginal and its denticulations are blunt. The triangular membrane on the outer margin of the outer marginal tooth is short and confined to the upper third.

Type specimen: M 11598/2 in the collection of the Zoological Survey of India.

Locality. Erh-Hai (Tali Fu Lake), Yunnan, W China, alt. 6,700 ft.

The shape and structure of the shell are so like those of *Paraprososthenia gredleri* (Neumayr) from the same lake that we do not consider a complete generic separation possible in the present state of our knowledge. It must be remembered, however, that we know as yet nothing but the shell of *P. gredleri*. The resemblance in the shell to that of *Pyrgula*, Cristofora & Jan (of which the anatomy seems to be equally unknown) is probably quite superficial. If we are right in thinking that the anatomy resembles that of *Fenouilia*, as the radula undoubtedly does, there can be no relationship to *Oncomelania*, Gredler (= *Hypsobia*, Heude), the soft parts of which, according to Heude,[1] are of the Hydrobiid type. In considering the value of the radula as a guide to affinities, however, it must be remembered that the same author (*op. cit.*, pl. xxxiii, fig. 8) figures the teeth of *Delavaya* (which also appears to be of the Hydrobiid type and is regarded by Bavay and Dautzenberg on shell-characters as no more than a subgenus

[1] Heude, *Mem. Hist. Nat. Emp. Chinois* I, pl. xxxiii, figs. 1-7 (1890).

of the undoubted Hydrobiid genus *Pachydrobia*, Crosse & Fischer) as being not unlike those of *Fenouilia* in certain respects.

ADDENDUM.

Just as this paper was going to the press to be printed off, I received through the courtesy of the Rev. Father Courtois, S.J., a small but valuable collection of Chinese shells from the Zi-Ka-Wei College. It includes specimens of *Delavaya rupicola*, Heude, apparently cotypes. These shells could not be separated generically from *Paraprososthenia coggini* on conchological grounds, but they seem to be specifically distinct. If Heude's figures are correct, there are considerable differences in the radula and possibly the anatomy, and should our species prove to be so closely related to *D. rupicola* as it appears to be on shell-characters, the subgeneric name *Parapyrgula* will have to give place to *Delavaya*, of which *Paraprososthenia* will become a subgenus. The relationship between *Fenouilia* and these forms may therefore be less close than we thought, for no great reliance can be placed on apparent resemblances in the soft parts of dried specimens. I doubt in any case that *Delavaya* is really congeneric with *Pachydrobia*.

20th September, 1919. *N. Annandale.*

XXIX THE POSSIBLE OCCURRENCE OF *SCHISTOSOMA JAPONICUM*, KATSURADA IN INDIA.

By R. B. SEYMOUR SEWELL, *F.A.S.B., Capt. I.M.S., Surgeon-Naturalist to the Marine Survey of India and Offg. Superintendent, Zoological Survey of India.*

(With Plate XXV).

During the past few months I have been engaged in investigations directly or indirectly connected with the introduction into India of the African and Mesopotamian forms of the human-infecting Schistosomes. These investigations are a continuation and elaboration of those begun by Mr. S. W Kemp;[1] in the course of them I have undertaken the systematic examination of large numbers of freshwater molluscs in various parts of India and have discovered numerous cercariae hitherto unknown. Most of these belong to groups that have little interest to others than zoologists, but quite recently I have discovered in one of the tanks in the Calcutta area a cercaria that is a true Schistosome and that seems likely to have considerable practical importance from a medical point of view. I have therefore decided, having found it possible to give a full description, not to delay publication of my results in this respect.

The cercaria is, as far as it is possible to judge from the very detailed description and clear figures published by Cort,[2] and the further particulars given by Faust[3], morphologically indistinguishable from that of *Schistosoma japonicum*, Katsurada, a very important parasite of man in China and Japan.

Cercariae Indicae xxx.

This type appears to be a true Schistosome and is almost identical, if not absolutely so, with *Sch. japonicum*. The cercaria is a small one and is a feeble swimmer, as viewed in a watch glass. It appears to move tail first, dragging the body behind it, by vigor-

[1] Kemp and Gravely, *Ind. Journ. Med. Res.* (in the press).

[2] Cort, W. W. "The cercaria of the Japanese blood-fluke, *Schistosoma japonicum*, Katsurada." *Univ. Californ. Publ. Zool.*, Vol. XVIII, No. 17, pp. 485-507, 3 figures in text: Berkeley, 1919.

[3] Faust, E. C. "Notes on South African cercariae. *Journ. of Parasitology*, Vol. V, No. 4, p. 164: Urbana, 1919.

ous lashing of the tail. Under a cover slip it only makes feeble progress owing to the fact that its anterior end appears to be not a true sucker but an organ devised for penetrating the host tissues. The body is frequently bent from side to side and is capable of a very great degree of extension and retraction. Furthermore, the anterior end forms a protrusible snout which is sometimes thrust out to form a round papilla and from time to time is retracted within the anterior end of the animal, thus forming a depression which at first sight might be thought to be the cavity of an anterior sucker. The animal has a marked tendency to shed its tail while under observation.

Owing to the extreme degree of extension and retraction of the animal it is difficult to get the exact measurements in the live state. So far as my observations go the measurements of the cercaria are as follows :—

When the body is extended it measures 0·196 mm. in length × 0·025 mm. in breadth and when contracted 0·090 mm. × 0·050 mm. The tail seems to be capable of a certain degree of extension and varies in length in different specimens from 0·186 to 0·221 mm. The furcal rami are short and are capable of extension and contraction, having in a contracted condition a wrinkled appearance. They vary in length from 0·071 to 0·096 mm. The body is comparatively transparent and in consequence it is very easy to make out the details of the structure. The whole of its surface is covered by minute spines which extend as far forward as the limit where the body-wall joins the sides of the anterior sucker-like structure. The tail is rather more sparsely covered with spines that appear to be slightly hooked and are comparatively large and both furcal rami are armed with spines along the margins. The anterior sucker-like structure is pyriform in shape and measures 0·043 mm. by 0·032 mm. when the animal is in the state of retraction but during the extension of the body this pyriform mass becomes considerably longer and narrower. Behind the point where the body-wall joins the anterior " sucker " the wall of this latter organ is thick and is provided with a strong layer of circular muscle-fibres. Internally the great bulk of the organ is filled with a granular mass, the head gland, while laterally and posteriorly are a number of small parenchymatous cells, also granular in appearance: the ducts from the cephalic glands, of which there are five on each side, enter this pyriform structure on its ventro-lateral aspect and pass forwards to open at the tip of the protrusible snout. Each duct is tipped at its orifice by a hollow conical spine of which there are ten in all. The acetabulum is small and is situated about $\frac{1}{4}$ the distance from the posterior end of the body, its external opening is Y-shaped, the two limbs of the Y pointing forwards and one limb backwards: it measures in diameter 0·014 mm. Its external surface is covered with a number of fine spines and it is capable of some degree of protrusion and retraction but normally forms only a small projection on the ventral aspect.

The most obvious feature in the body is the large group of five pairs of cephalic glands that occupy the posterior ½ to ⅔ of the body. These glands are pyriform in shape and each cell has a wide and conspicuous duct that runs forward to enter the head gland as noted above. These cells appear to be of two kinds. The anterior two pairs are coarsely granular while the posterior three pairs are finely granular, and each possesses a large and conspicuous nucleus. Cort (*l.c.*, p. 501) makes no mention of any such differentiation in the cephalic gland cells of *Sch. japonicum.* He states that all five pairs of cells possess acidophilic cytoplasm, as is also the case in the present species. The ducts belonging to the two groups of cephalic gland cells can also be distinguished; those from the three posterior pairs are large and lie ventrally in a **U**-shape, while those from the anterior two pairs are small and are situated side by side in the opening of the **U** on the dorsal side.

The alimentary canal is extremely reduced. The mouth opens ventrally by a small orifice situated far forward just in front of the junction of the body-wall with the head-gland. A narrow intestine passes backwards as far as the anterior two pairs of cephalic glands and there is no trace whatever of any pharynx.

The excretory system is of the typical Schistosome type and agrees exactly with Cort's description of the excretory system in *Schistosoma japonicum.* Three pairs of flame cells are situated in the body. Of these the anterior pair is situated laterally, external to the ducts of the mucin-gland canals about midway between the head-gland and the anterior pair of cephalic gland cells. The second pair of flame cells is situated in the interval between the coarsely granular and finely granular cephalic gland cells, rather to the lateral side; while the posterior pair of flame cells is situated opposite the last pair of cephalic glands. A small excretory bladder is situated at the extreme posterior end of the body and from this two wide canals pass forwards and outwards, reaching as far forward as the anterior margin of the acetabulum; they then curve backwards and divide into anterior and posterior branches. The main canal is in two places somewhat dilated and each dilation contains a vibratile flagellum of the same type as the flagella of the flame cells but longer and narrower. The presence of these extra vibratile structures is important as one is very liable at first sight to confuse them with true flame cells and thus to consider the number of flame cells to be five pairs instead of three. The anterior and posterior "collecting tubules" each divide into two branches running to the flame cells. The second branch from the posterior "collecting tubule" leaves the body and passes into the tail to the fourth pair of flame cells that is situated on either side of the caudal excretory tube close to the root of the tail. The caudal tube enters the posterior end of the bladder by a typical "islet" opening: at the posterior end of the tail the tube bifurcates, a branch passing along each fork to open to the exterior in a cup-like depression situated at the extreme tip of the ramus.

The genital gland forms a mass of small round cells situated ventrally and immediately behind the posterior margin of the acetabulum. In addition to this group of cells there is along the posterior and lateral border a series of five or six large round cells with clear protoplasm and a small granular nucleus. It would seem probable that these large cells represent the rudiments of the testes, while the central mass of small cells represents the rudiments of the ovary.

The cercariae develop in elongate sausage-shaped sporocysts. In some cases, however, the sporocysts appear to be more or less oval or pyriform. Each sporocyst contains two or three mature cercariae; occasionally some of the cercariae appear to become encysted either in the sporocyst or in the substance of the liver outside. In these cases the cyst is of an elongate oval shape and has a thin clear wall, the cercaria lying within the cyst in a partially extended state and not, as is the case in most encysted forms, curled up into a spherical ball. The cercariae appear to reach the full development within the sporocyst before leaving it to enter the host's liver tissue. The liver of an infected snail is of a yellowish brown colour and has a mottled appearance owing to the sporocysts appearing on the surface.

The host. The cercariae develop in either *Planorbis exustus*, Desh. or in a form of *Limnaea amygdalum*, Troschel, in a tank in Russa Road South, Tollygunge, Calcutta.

	Present species.	*Sch. japonicum.*
Size.		
Body.	90 — 196 μ × 50 μ.	100 — 210 × 66 μ.
Tail trunk.	186 — 221 μ × 25 μ.	150 μ × 20 μ.
Furca.	71 — 96 μ.	75 μ.
Oval sucker.	32 μ × in transverse diam. × 43 μ in length.	33 μ in transverse diam. × 54 μ in length.
Mucin glands.	5 pairs of pyriform cells with large nuclei and with granular acidophilic cytoplasm; the anterior two pairs coarsely granular and the posterior three pairs finely granular.	5 pairs of pyriform cells with large nuclei and granular acidophilic cytoplasm. Cort makes no mention of any difference in the various cells.
Mucin ducts.	Very thick.	Very thick.
Duct openings.	At anterior end of protrusible snout; capped by five pairs of hollow, piercing spines.	At anterior end of protrusible snout; capped by five pairs of hollow, piercing spines.
Germ cells.	Clustered mass of cells just behind antabulum along the postero-lateral margin 5-6 large round cells with granular nuclei.	Clustered mass of cells just behind antabulum.
Parthenita.	Sporocyst.	Sporocyst.

In the accompanying table, adapted from Faust (*l.c.*, p. 167), I have given the main characters of the present type and of the cercaria of *Schistosoma japonicum* in parallel columns. The present form appears to be very slightly smaller as regards the body and a trifle longer in the tail, but owing to the degree of contractility

possessed by the animal these differences are of so slight a character as to be negligible and the difference in shape between my examples and the figure given by Cort of *Sch. japonicum* is of no importance in so protean an animal; the differentiation of the cephalic gland cells in the Indian form into coarsely-granular and finely-granular cells is a physiological rather than a morphological difference.

The occurrence of animal-infecting forms of Schistosome in India has been known since the researches of Montgomery [1]—and the finding of a cercaria, stated to be that of *Schistosoma spindalis*, Montgomery, has been recorded by Glen Liston and Soparkar,[2] but as no details of structure are given by these authors it is impossible to compare their specimens with the present form.

The final test of the identity of this form with that of *Schistosoma japonicum* lies in the similarity or otherwise of the adults and experiments are now being carried out to obtain the fully-grown sexual stage of this parasite.

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[1] Montgomery. "Observations on Bilharziosis among animals in India." *Journ. of Trop. Vet Sci.*, Vol. I, p. 16, 1906.

[2] Glen Liston and Soparkar. "Bilharziosis among animals in India. The life-cycle of *Schistosomun spindalis*." *Ind. Journ. of Med. Res.*, Vol. V, p. 567, 1918.

EXPLANATION OF PLATE XXV.

FIG. 1.—Cercariae Indicae xxx; the whole animal, ventral view.

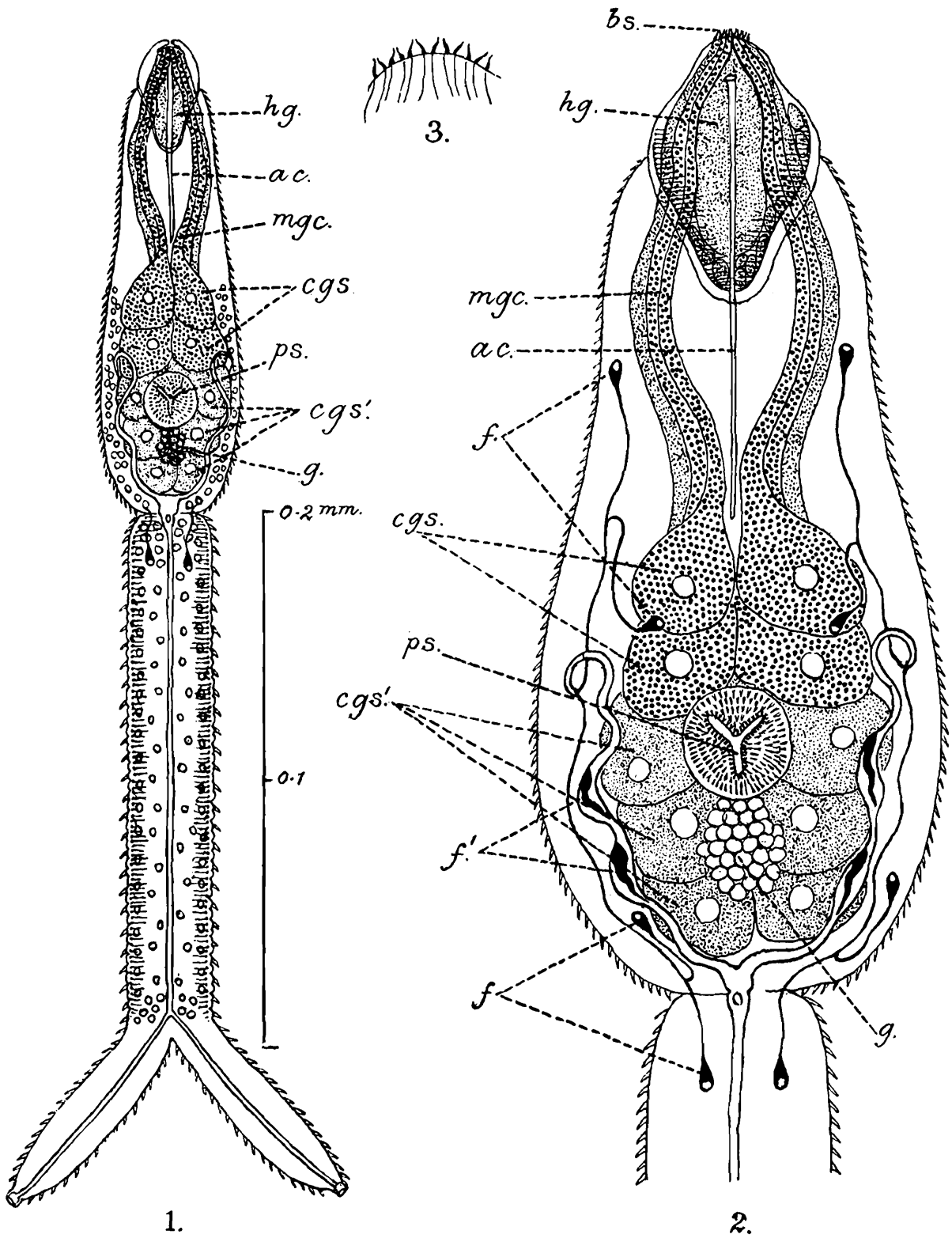
,, 2.—Cercariae Indicae xxx; the body enlarged, ventral view hollow.

,, 3.—Cercariae Indicae xxx; the hollow boring spines capping each mucin duct.

EXPLANATION OF LETTERING.

ac = intestine: *bs* = boring spines: *cgs* = coarsely granular cephalic-gland cells: *cgs'* = finely granular cephalic-gland cells: *f* = flame cells: *f'* = flagellae working in the main excretory tubes *: *g* = gonad (ovary): *hg.* = head-gland: *mgc* = mucin gland canals: *ps* = posterior sucker.

* These are shown much larger than is actually the case for purposes of clearness. They are actually much smaller than the flame cells.



R. B. S. S. del.

CERCARIAE INDICAE : TYPE XXX

MISCELLANEA.

MOLLUSCA.

On the Genus *Mysoria*, Godwin-Austen.

This was described in the *Records of the Indian Museum*, Vol. XVI, pt. iii, April 1919; type *Bithynia costigera*, Küster. I find the name is preoccupied, Mr. G. K. Gude has kindly pointed this out to me. It has been used for a genus of the Insecta, *Zoological Record*, 1893, p. 248. I have therefore to propose in lieu the title *Mysorella*. In connection with this genus Dr. Annandale in a recent letter dated 4th June alludes to species of *Valvata* from the intertrappean beds of Nagpur. It is interesting we had come independently to the same opinion. When looking at Plate XIV, *Geology of India* by Medlicott and Blanford my attention was called to the figure of the species *multicarinata* placed in *Valvata*, and which appeared much more likely to be a *Mysoria* or rather a *Mysorella*. *Valvata minima*[1] it would be necessary to see in its fossil state, it is so small, and only one view of it is given

The generic position of many species on this plate appear to me very doubtful, particularly those of *Lymnea subulata*, *telankhediensis* and *spina*, those assigned to *Paludina* and even *Physa prinsepii*. It would be most interesting to examine the fossils; this I hope to do, should they be represented in the Natural History Museum. They certainly require critical examination. They belong to a very distinct molluscan fauna and further close search in beds of this age would no doubt yield many more species. It is apparent very much has to be done in these intertrappean beds, with their distinct, widely separated vertical horizons. Very recently I met Capt. B. G. Gillett who was employed before the war constructing a reservoir near Khandala and was returning to Bombay. He told me he had noticed fossil shells in the sections excavated and promised to look them up and collect specimens.

H. H. Godwin-Austen, Lt.-Col.

Nore, 9th *July*, 1919.

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[1] I have recently examined specimens of "*Valvata*" *minima* and believe them to belong to *Gyraulus*.—*N. Annandale*.