XI. THE MIDDLE EAR OF INDIAN FROGS.

By Baini Prashad, *M.Sc.*

(With Plate IX.)

On each side of the head of the common frog the skin in the middle of the temporal patch is distinguished as the tympanic membrane or tympanum. The description of this structure in *Rana temporaria* may be given in the words of Marshall (13) : " Behind the eye on either side is an obliquely placed elongated patch of a dark colour, in the middle of which is a circular area—the tympanic membrane—supported by a marginal ring." Other text books of Zoology in their accounts of *R. temporaria* describe the condition in the same way as Marshall, while some say that the tympanic membrane is close to the surface and only covered over with skin.

Claus-Sedgwick (5) in the general account of the amphibia try to get over the difficulty in the following way : " In the Batrachians alone there is a tympanic cavity which is closed externally by a tympanic membrane, which is sometimes freely exposed on the surface and sometimes covered by the skin." Boulenger (2—4) in his systematic works describes the tympanum as distinct, indistinct or hidden under the skin, according as the area of skin is marked off from the surrounding skin or otherwise. Hoffman (12) is not definite as to whether the tympanum is a structure distinct from the skin covering it. Cope (6) states that there is a dermal membrana tympani connected with the stapes through a chain of ossicula auditis ; evidently he considers the tympanum to be a distinct structure from the skin covering it, though he does not definitely say so. Crombie (7) deals with the function and tension of the membrana tympani of the mammals only. Fox (8) in his paper on the development of the tympano-eustachian passage of the common American toad deals with the development of the tympanic cavity, the eustachian tubes and the ossicula auditis, but says nothing about the tympanum. Villy's admirable paper (16) on the development of the ear of the European frog does not contain any reference as to the development of this structure or its relations with the skin. Hasse in his two papers (10, 11) deals with the structure of the internal ear of the frog only. Norris (14) does not try to clear the problem. Retzius (15) is the only author who has definitely stated that there is a distinct tympanic membrane underlying the skin. Haslam in his translation of Ecker's " Anatomy of the Frog " (9) has rewritten the whole section on the ear from Retzius' paper cited above.

From the review of literature on the subject it will be clear that great deal of confusion exists regarding the tympanum being a str distinct from the skin or otherwise. It was with a view to do so towards the solution of this problem that the present work was undertaken.

MATERIAL AND METHODS.

I have investigated in detail the structure of the middle ear of the large Indian frog *Rana tigrina*, Daud.[1] There are several forms closely allied to this frog in India, but the form common in Lahore where the work was done is the typical one, as was ascertained by sending some specimens to Dr. Boulenger in London. Besides a large number of dissections of this frog I cut sections of decalcified specimens of both young and adult frogs; these sections were found to be very useful in clearing up the doubtful points and indicating the exact relationships of the various parts.

Through the kindness of Dr. N. Annandale, Director of the Zoological Survey of India, Calcutta, I was able to examine the large collections of frogs in the Indian Museum, Calcutta, and so am able to add an account of the structure as it occurs in a large number of other Indian frogs. I am also deeply indebted to Lt.-Col. J. Stephenson, D. Sc.. I.M.S., Professor of Zoology and Principal, Government College, Lahore, for kindly giving me leave to go to Calcutta to work in the Indian Museum, and for sanctioning a special grant towards the expenses.

Rana tigrina.

The structure of the middle ear in this frog will be described in the following order :—

(1) The tympanic area.
(2) The tympanic membrane.
(3) The tympanic cavity and associated skeletal structures.

The Tympanic area (fig. 1).—I have reluctantly changed the widely accepted nomenclature in order to remove the existing confusion, and have given the name of *tympanic area* (*T a.*) to the area of skin situated in the temporal patch on the side of the head. This area is continuous with the skin, but is tightly stretched over the marginal ring of the annulus tympanicus, and is slightly more depressed than the skin all round it. It is nearly circular in outline and is a little smaller than the eye. About the middle of this structure the attachment of the columella auris can be seen as a nodular protrusion.

The histological structure of this portion of the skin is quite similar to that of other parts of the skin, except that the number of cutaneous glands is much smaller; about the middle no cutaneous glands are to be seen (*text fig. 1*).

The Tympanic membrane (figs. 2, 3, and 4).—This is quite a distinct structure lying immediately underneath the so-called tympanic membrane of authors. It can be easily separated from the skin covering it. On the skin being reflexed by a cut, the tympanic membrane (*T m.*) is seen to be of a rounded-oval form slightly notched at the upper side, and produced into a little projection on its lower.

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ave satisfied myself by examination of specimens of *R. esculenta* and *R. tem-*
iat the structure in these frogs is also essentially similar to that of *R. tigrina*,

It is attached all along the circumference to the slightly up and inturned edges of the annulus tympanicus. The tympanic membrane is thin along the margin but is specially thickened in the middle on its inner side for the attachment of the distal end of the columella auris.

The membrane is formed of connective tissue fibres which radiate from the central point of attachment of the columella to the periphery. A few blood vessels, nerve cells and a large number of pigment corpuscles are also found scattered in the connective tissue. Along the margin some unstriated muscle fibres are also to be seen. Internally the tympanic membrane is lined by columnar epithelium (*text fig. 2*) which is continuous lower down with the mucous membrane lining of the tympanic cavity.

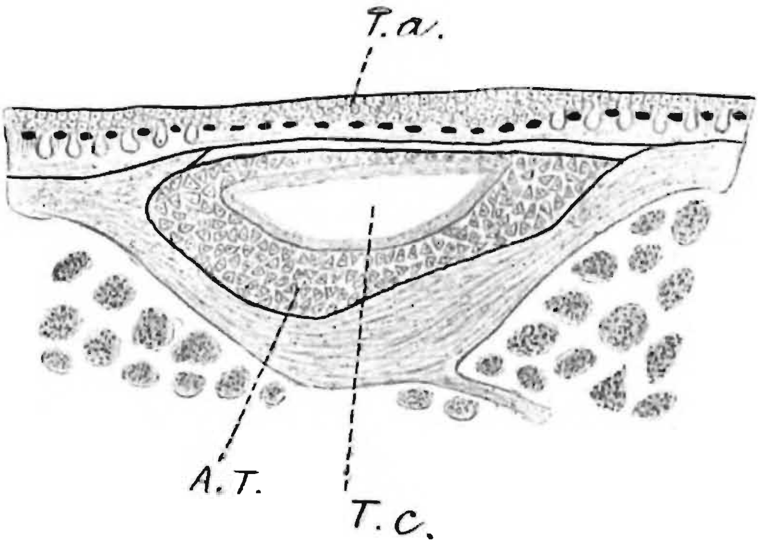

FIG. 1.—Transverse section of the ear of *R. tigrina.*

The Tympanic cavity and associated skeletal structures.—After the removal of the tympanic membrane the tympanic cavity is seen to be a funnel-shaped structure. The upper margin of the funnel is slightly turned inwards for the attachment of the tympanic membrane as seen in a transverse section (*text fig. 1*). The funnel-shaped tympanic cavity has its longer axis directed downwards and backwards from the anterior and upper side. This upper or outer portion of the tympanic cavity is formed by the annulus tympanicus (*A. T.*); from the lower end of the annulus tympanicus the tympanic cavity becomes very much reduced and continues as a slightly depressed tubular structure, the cross section of it hence is not circular but slightly elongated. The beginning of this second or inner portion of the tympanic cavity may be termed the *tympanic recess* (*T r.*), while the opening by which it communicates with the internal ear is known as the *fenestra ovalis* (fig. 4, *f. o.*). From the ventral surface of this deeper portion of the tympanic cavity a short wide eustachian tube puts the tympanic cavity of each side into communication with the pharyngo-oral cavity. The deeper portion of the tympanic cavity is bounded by the squamosal and prootic bones anteriorly, by the prootic dorsally, by the cartilaginous portion between the prootics and exoccipitals internally and by muscles posteriorly.

The tympanic cavity is lined all along by mucous membrane which is very vascular and pigmented.

The annulus tympanicus (figs. 4, 5, *A. T.*) is a cartilaginous framework of the shape of a short truncated cone, broad outwards and narrowing towards the inner side. The frame is not a complete structure, but is interrupted on the dorsal surface, the space between the two parts being occupied by a cartilaginous process (*a'*, Parker's *suprastapedial*) of the extrastapedial cartilage of the columella auris. The annulus tympanicus is supported on the anterior, dorsal and ventral surfaces by the squamosal bone, while posteriorly by muscles. The *columella auris* (fig. 6) has the oval outer surface of the extrastapedial cartilaginous portion (*a*) embedded in the tympanic membrane (*text fig. 2*), whilst the suprastapedial processes (*a'*) from its posterior surface

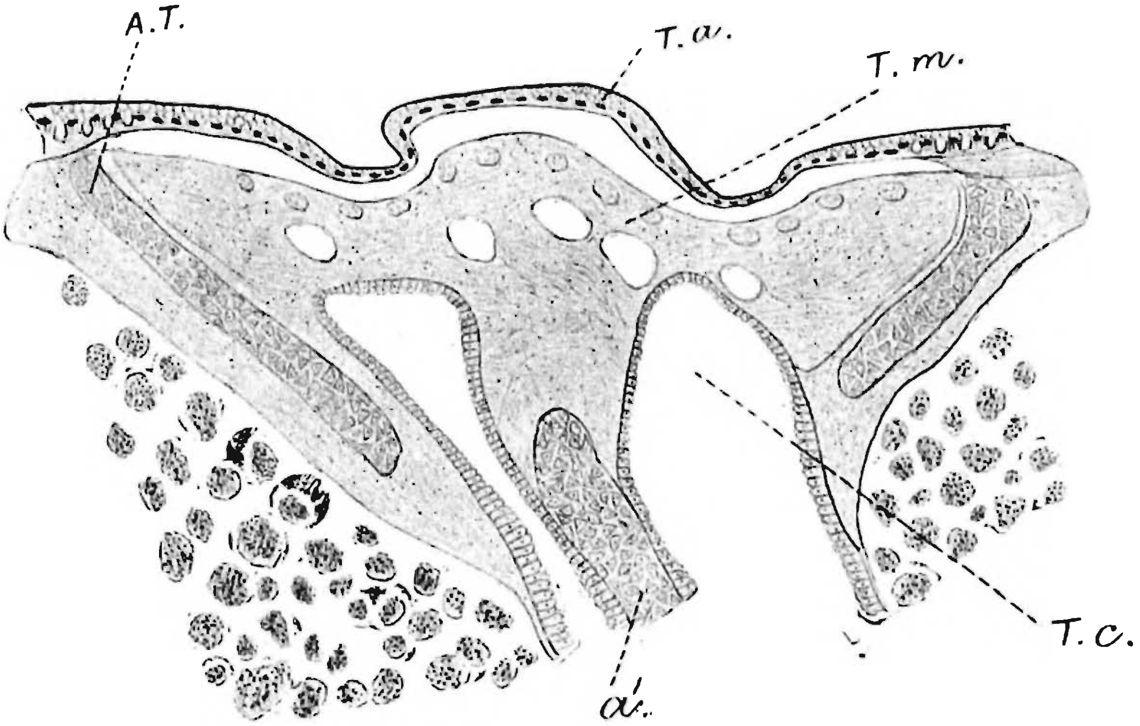

FIG. 2.—Transverse section of the ear of *R. tigrina* through the region of the columella.

goes to complete the annulus tympanicus as has been described above. The middle bony portion or the mediostapedial (*b*) after passing through the tympanic recess continues through the deeper portion of the tympanic cavity, to end in the cartilaginous interstapedial (*c*), which fits into the fenestra ovalis (fig. 4, *f. o.*).

Having described in detail the structure in *R. tigrina*, I will now describe the condition of the tympanic area of some other Indian frogs.

FIRMISTERNIA.

Family RANIDAE.—

Oxyglossus.—According to Boulenger (3) the tympanum[1] is indistinct in this genus. In specimens of *O. lima* and *O. lævis* the tympanic area is not distinctly marked off, but the attachment of the colu-

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[1] The word *tympanum* used here and further on is used in the sense in which it is used by Boulenger and is equal to *tympanic area* of the suggested nomenclature.

mella is visible as a distinct nodule raising up the skin. The tympanic membrane is quite a distinct structure underneath the skin.

Rana.—The tympanum in most species is distinct, but in a few may be hidden. The condition in *R. tigrina* has been described in detail. In *R. liebigii*[1] the tympanic area is not distinct, but the tympanic membrane is seen to be quite a distinct structure lying under the skin.

Micrixalus.—The tympanum may be indistinct or hidden. In a large series of specimens of *M. silvaticus* of different ages it was seen, that the tympanic area is quite distinct in the young, becoming indistinct in older specimens, and in the fully adult it is not to be distinguished. The tympanic membrane is quite a distinct structure.

Nyctibatrachus.—The tympanum in this genus is described as hidden. In some well preserved specimens of *N. major* the tympanic area was distinctly marked off as a light-brown patch of skin; in the other poorly preserved specimens however it was not distinct.

Nannobatrachus.—The tympanum for this genus also is described as hidden. The condition in specimens of *N. beddomii* examined was the same as described for *Nyctibatrachus major*; and the distinctness of the tympanic area depended largely on the condition of preservation.

Rhacophorus.—The tympanum is usually distinct. In *R. maximus* it is distinctly depressed and is overhung on the upper side by a fold of skin, which makes the structure very prominent.

Ixalus.—The tympanum may be distinct or hidden. In the two species *I. glandulosus* and *I. leucorhinus*, examined by me it was quite distinct.

Family ENGYSTOMATIDAE.—This family is peculiar in having the tympanic area shifted to a much more forward position than in the Ranidae; it lies quite close to and at a much lower level than the eyes, in some it lies just below the eyes.

Calophrynus.—The tympanum is distinct. In *C. pleurostigma* tympanic area was found to be definitely marked off, and covering over the tympanic membrane lying under it.

Microhyla.—The tympanum is described as hidden. In specimens of *M. rubra* examined by me the condition (fig. 10) was the same as in *Calophrynus* described above.

Kaloula.—The tympanum according to Boulenger is hidden. In three specimens of *K. obscura*, the tympanic area was not a distinctly marked off portion, but in two better preserved specimens it was quite distinct. In *K. pulchra* (fig. 9) the tympanic area was slightly depressed and so better marked.

Cacopus.—The tympanic area in specimens of *C. systoma* is quite indistinguishable externally (fig. 7) but on removal of the skin (fig. 8) the tympanic membrane is seen to lie under the skin quite close to the eye.

Glyphoglossus.—The tympanum is described as hidden. In two well preserved specimens of *G. molosus* the tympanic area was seen as a slightly depressed circular area with raised edges, and lying just

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[1] Dr. Annandale informs me that there is a very great confusion about this species, several species being confused under the name, but the form referred to is the true *R. liebigii*, Gthr.

below the eyes. The colour was the same as that of the skin covering the rest of the body.

ARCIFERA.

Family BUFONIDAE.—The conditions are essentially similar to those in the Ranidae.

Bufo.—The tympanum is distinct or hidden, seldom absent. In *B. himalyanum* (fig. 11) the tympanic area is a comparatively small structure, in some specimens it was partially covered over by the well developed parotid gland arching over it.

Cophophryne.—In *C. sikkimensis* no tympanic area is marked off externally, but on removal of the skin the tympanic membrane is seen to be quite distinct.

Family HYLIDAE.—

Hyla.—In *H. annectens* (fig. 12) there is a distinct tympanic area, but in some other species it is absent.

Family PELOBATIDAE.—Boulenger described the condition of the tympanum for the only Indian genus *Leptobrachium* (now united with *Megalophrys*) in his original account (3) as indistinct or hidden; in a later paper (4) for *Megalophrys* he says " distinct or hidden under the skin." In *M. carinense* (fig. 13) the tympanic area was seen to be quite distinct, lying very far back. The tympanic membrane was found to lie underneath it, and the annulus tympanicus was found to have shifted to a much lower position, being now supported by the vertical limb of the T shaped squamosal. This position is due to the greatly depressed condition of the head, and with it the great forward inclination of the squamosal bone.

SUMMARY.

The structure of the middle ear of *R. tigrina* is described in detail. A change of the usually accepted names is proposed in view of the present work. The name of the so-called " tympanic membrane " has been changed to " tympanic area," because the " tympanic membrane " is a distinct structure lying underneath the tympanic area stretched over the annulus tympanicus. An account of the tympanic area as seen in a large number of Indian frogs of the various families is also given.

The condition of preservation of the specimens was often found to be responsible for the distinctness with which the tympanic area was marked off from the rest of the skin; whereas it was quite well seen in well preserved specimens, it could hardly be distinguished in poorly preserved ones.

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EXPLANATION OF PLATE IX.

FIG. 1.—*Rana tigrina*, head of an adult female specimen.

„ 2.—Head of *R. tigrina* with the skin over the tympanic membrane and the side of the head reflexed.

„ 3.—Skull of *R. tigrina* showing the attachment of the tympanic membrane, side view.

„ 4.—Skull of *R. tigrina* showing the attachment of the annulus tympanicus, the tympanic membrane and the columella auris, seen from behind.

„ 5.—Annulus tympanicus of *R. tigrina*, seen from above.

„ 6.—Columella auris of *R. tigrina*, seen from the posterior side.

„ 7.—*Cacopus systoma*, head of an adult male.

„ 8.—Head of a *Cacopus systoma* with the skin over the side of the head reflexed.

„ 9.—*Kaloula pulchra*, head of a young specimen showing the tympanic area.

„ 10.—*Microhyla rubra*, head of an adult specimen.

„ 11.—*Bufo himalyanum*, side view of the head.

„ 12.—*Hyla annectens*, side view of the head.

„ 13.—*Megalophrys carinense*, side view of the head of an adult specimen.

REFERENCE LETTERING.

a. Extrastapedial portion of the columella. *a'.* Suprastapedial process of the extrastapedial. *A. t.* Annulus tympanicus. *b.* Mediostapedial portion of the columella. *c.* Interstapedial portion of the columella. *eo.* Exoccipital. *f. o.* Fenestra ovalis. *fp.* Frontoparietal. *m.* Maxilla. *n.* Nasal. *pm.* Premaxilla. *pt.* Pterygoid. *q.* Quadrate. *qj.* Quadratojugal. *s.* Squamosal. *se.* Sphenethmoid. *sm.* Septomaxillary. *T. a.* Tympanic area. *T. m.* Tympanic membrane. *T. r.* Tympanic recess.

XII. A NOTE ON THE SKELETONS OF *BALAENOPTERA EDENI*, ANDERSON, IN THE INDIAN MUSEUM, CALCUTTA.

By ROY CHAPMAN ANDREWS, *A.M., Associate Curator of Mammals, American Museum of Natural History, New York City.*

(With Plate XV.)

In 1871 a whale was stranded in an inlet off the Gulf of Martaban. The skull and a portion of the skeleton were recovered and deposited in the Indian Museum where they were subsequently examined by Dr. John Anderson and described by him under the name *Balaenoptera edeni*[1].

Since Dr. Anderson's paper there has been no critical study of this skeleton until my monograph[2] published in March, 1916, where it was considered in relation to *Balaenoptera borealis*, Lesson, which had been discovered in the Pacific Ocean in 1910.

After a detailed discussion of Anderson's account, I concluded my remarks upon the species in the following words: " While from the foregoing discussion of *B. edeni* it is evident that this species is either identical with, or closely allied to, *B. borealis*, I feel that without further information no positive assertions can be made regarding it. The characters of the skull and atlas which have already been pointed out are certainly of importance and to my mind cannot be disregarded or explained upon the grounds of individual variation. Since Dr. Anderson especially noted them from the specimen itself it would appear that they have not been exaggerated in the published figures. It is highly desirable that this skeleton be reexamined in the light of present knowledge of the large Cetacea, but until this is done, or other specimens have been obtained from the same waters, it appears to me that it is wisest to leave *Balaenoptera edeni* as a very doubtfully established species.

" It is especially unfortunate that Mr. Orjan Olsen, who has recently described *Balaenoptera brydei* from South African waters, did not furnish osteological details with his external descriptions. Further information regarding both these whales will be awaited with interest since it is not improbable that the two may prove identical, or both the synonyms of *B. borealis*. At present, however, the wisest course is to leave them as they are " (*l. c.*, p. 378).

In July, 1917, while *en route* to New York after a year of zoological exploration in Yün-nan province, China, I reached Calcutta and

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[1] Anatomical and Zoological Researches: comprising an account of the Zoological Results of the Two Expeditions to Western Yunnan in 1868 and 1875. London, 1878, pp. 551-564, pl. xliv.

[2] Monographs of the Pacific Cetacea. II.—The Sei Whale (*Balaenoptera borealis*, Lesson). *Memoirs of the American Museum of Natural History.* New Series, Vol. I, Part VI, March 1916, pp. 376-378.

through the courtesy of Dr. N. Annandale, Superintendent of the Zoological Department of the Indian Museum, was given the opportunity to examine the type specimen of *Balaenoptera edeni* as well as a skeleton[1] referred to the same species which was secured on January 21, 1890, at Sidhi Island, Noahkolly (Noakhali), Bengal, by C. E. F. Tonnerre, Esq. The latter, I believe, has not been reported upon. Unfortunately I had to leave Calcutta rather hastily and was not able to examine the Sidhi Island skeleton in detail but several of the bones were removed from the storage case for my inspection.

The most important characters in which *B. edeni* differs from other species according to Anderson are in the skull and atlas. He says that the skull of this species is remarkable for the " *little downward shelving of the upper surface of the maxillae* ;" also " in the character of its beak, which is long and slender, and much more forwardly directed than the beak of *B. schlegeli* " (=*B. borealis*).

These characters appeared to me to be of considerable importance from a study of Dr. Anderson's figures and I find that they truly represent the condition of the specimen. They are borne out, in a somewhat less degree, by a skull from Arakan (which was reported upon by Anderson) and in the Sidhi Island skull ; unfortunately when I examined the latter the premaxillae were not in position but the bones appeared to be similar to those of the type.

The beaks of all three skulls are narrower at the base in proportion to the length and the breadth at the middle than are those of *B. borealis* and consequently the beak has a somewhat different shape. These characters appear to me to be of considerable importance but the others which Dr. Anderson mentions in his description are probably not beyond the limits of individual variation.

The atlas (pl. XV, figs. 1, 2) of this species is very interesting. Dr. Anderson remarks " The neural canal has considerable breadth (3 inches) and is much broader than high. The notch for the reception of the odontoid swelling of the axis lying below it is much contracted. The transverse process of the atlas is well-defined, rather long, but basally shallow ; very different from the deep wing-like twisted transverse process of *B. schlegeli*, as figured and described by Flower. The articular surfaces of the axis practically meet below, being separated from each other by 0·25 inch in the dried bone, and have thus no facet between them as in *B. schlegeli* (=*B. borealis*), (*l. c.*, p. 558).

I verified Dr. Anderson's observations and drawings of the atlas from the type specimen and they are substantiated by the atlas of the Sidhi Island skeleton, figures of which are represented herewith. Comparison of the atlas of either of these specimens with any published figures of the corresponding bone of *B. borealis* will show immediately that the differences are just those which are pointed out by Dr. Anderson in the paragraph quoted above.

All of the skeletons of *B. borealis* upon which observations have been recorded, with one exception, have possessed cervical ribs ankylosed with the first thoracic ribs. Dr. Anderson remarks that a fragment of

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[1] Specimen *b* in Sclater's *Cat. Mamm. Ind. Mus.*, II, p. 314 (1891).

the first left rib of the type of *B. edeni* was preserved and that it was "single-headed." The Sidhi Island skeleton exhibits a bifurcated first rib exactly as in *B. borealis* as may be seen from the accompanying figures (figs. 3, 4). While the presence or absence of a cervical rib has no specific value, nevertheless it is interesting since in *B. borealis* its presence is almost universal (see Andrews, *l. c.*, pp. 367-368).

The Sidhi Island skeleton, so far as I was able to examine it, appears to substantiate the characters pointed out by Dr. Anderson in the type specimen of *B. edeni.* While in almost any other group of mammals these would be deemed sufficient reason for separation from even closely allied forms, yet any naturalist who is familiar with the extraordinary individual variation among cetaceans will realize that it is unwise to make positive statements based upon a limited amount of material.

It is difficult for me to believe that the differences exhibited by these skeletons can be individual, and yet they must be strengthened by a knowledge of the external anatomy before the species can be said to rest upon a firm foundation. There is no doubt that it is a form very closely allied to *B. borealis* and it may possibly prove to be identical with the recently described *Balaenoptera brydei* from South Africa of which only the external characters are known.

EXPLANATION OF PLATE XV.

Bones from specimen of **Balaenoptera** from head of Bay of Bengal (Noakhali).

FIG. 1.—Articular surface of atlas vertebra.

,, 2.—Lateral view of atlas vertebra.

FIGS. 3 & 4.—First rib.

Specimen (*b*), Sclater, Cat. Mamm. Ind. Mus., II, p. 314.

XIII. ON THE ANATOMY OF CERTAIN INDIAN UNIONIDAE.

By Ekendranath Ghosh, *M.Sc., M.D.*

(With Plate XVI.)

Introduction.

The genera and species of Unionidae discussed in this paper are :—*Lamellidens marginalis* (Lamarck), *Solenaia soleniformis* (Benson), *Physunio ferrugineus* and *Ph. micropteroides*, Annandale. These species resemble one another so closely in anatomical structure that I have considered it best to treat them together in a comparative manner.

The method of study was (1) simple dissection of the soft parts of the animals after removal from the valves, checked by (2) longitudinal (sagittal) section of the entire animal and (3) serial transverse section of the whole animal (into thin slices, 2-4 mm. thick) from one end to the other. The gills were studied microscopically after sectioning by the usual paraffin method. They have been specially studied with reference to the formation of the marsupium.

As regards the materials, the specimens of *Lamellidens* were procured from tanks about Calcutta, while the others were received from the Zoological Survey of India through the kindness of Dr. Annandale.

I. Mantle-lobes.

The *mantle-lobes* are free from each other from the antero-dorsal aspect of the anterior adductor muscle down along the ventral margins to the posterior margin as high as the postero-dorsal aspect of the posterior adductor muscle. Behind, the two lobes are joined to one another between the exhalent and inhalent apertures by a horizontal shelf formed by their fusion with the free dorsal margins of the outer lamellae of the outer gills and of the other lamellae of the gills to one another. The point of fusion of the mantle-lobes is placed just at the antero-dorsal aspect of the anterior adductor muscle in *Lamellidens* and *Solenaia*, but at a higher level in *P. ferrugineus* and less so in *P. micropteroides* ; further, this point forms the most anterior end of the lobes, and in the case of *Lamellidens* and *Solenaia* is placed at the level of the ventral border of the anterior adductor muscle. A small gap between the margins of the mantle-lobes is left above the posterior adductor muscle, exposing the dorsal wall of the rectum in both *Lamellidens marginalis* and *Solenaia soleniformis.* This gap is absent in both species of *Physunio.*

Above, each mantle-lobe is fused with the body-wall, the line of separation passing along the ventral aspect of the anterior adductor muscle, the base of the anterior lip of the mouth, and the attached dorsal margin of the anterior half of the outer labial palp ; the line of separation is then reflected forwards in an acute angle along the ventral aspect of a triangular membrane attaching the dorsal margin of the labial palps to the side of the visceral mass, and ultimately curves backwards round the anterior end of the inner and then the outer gill (the line of curvature forming about $\frac{1}{3}$ the circumference of a circle). It then passes obliquely downwards and backwards nearly in a straight line along the ventro-lateral aspect of the non-glandular portion of the kidney. Behind the foot, a canal [1] intervenes between the non-glandular portion of the kidney and the line of separation. In *Lamellidens* the line is placed on the dorsal aspect of the canal, whereas in both *Solenaia* and *Physunio* it lies on the outer side of the canal itself. Furthermore, the line of attachment of the outer lamella of the outer gill is placed below the line of separation in *Lamellidens* and *Solenaia*, but in *Physunio* in this line. This line is oblique and situated on the outer side of the kidney ; it forms an acute angle with another line drawn from the anterior end of the outer gill to the posterior end of the attachment of the labial palps on their dorsal aspect in *Physunio* (more so in *P. ferrugineus* than in *P. micropteroides*), a right angle in *Lamellidens marginalis* and an obtuse angle in *Solenaia soleniformis*. Lastly, the line of separation passes along the ventral margin of the posterior adductor muscle to its posterior aspect, where it is joined to the opposite mantle-lobe through the intervention of the gills. It then curves round the posterior aspect of the posterior adductor muscle to join its fellow at the postero-dorsal aspect of the muscle.

The inhalent and exhalent apertures are bounded by the thick, pigmented margins of the mantle-lobes. The inhalent aperture is twice the exhalent aperture in height. The margin of the inhalent aperture is beset with tentacles in all the genera here described ; in *Lamellidens* and *Solenaia* the tentacles are short and stout and are nearly of the same size, and are arranged in a single row, but in *Physunio* they are elongate and conical and of three sizes which are arranged irregularly in three rows, the largest ones (larger than those in *Lamellidens* and *Solenaia*) being placed internally.

The exhalent aperture is smooth in *Solenaia* and *Physunio*, but provided with a row of minute tubercles in its extreme lateral margins in *Lamellidens*. The margins of the aperture extend further downwards in *Physunio* than in *Lamellidens* and *Solenaia*.

II. LABIAL PALPS.

The *labial palps*, outer and inner, are continuous in front with the anterior and posterior lips of the mouth ; they are elliptical in *Lamellidens* and *Solenaia*, but a little more elongate in *Physunio*. The point at which they are fused with the lips of the mouth forms a shallow concavity on the ventral margin in *Lamellidens* and *Solenaia*, but presents a slight flattening in *Physunio*. The labial palps are free from one another except in three-fourths the length of the dorsal margin from the anterior end ; they are connected with the body by a triangular membrane attached to their fused dorsal margin. The apex of the membrane

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[1] To be described with the kidney.

is directed forwards and the base forms a free margin behind; the side fused with the wall of the visceral mass is overlapped by a small portion of the ventral margin of the inner gill.

III. MUSCLES.

(1) The *anterior adductor muscle* is irregularly triangular in shape in *Lamellidens* and *Physunio*, and rather obliquely pyriform in *Solenaia*. The relative position of the muscle and the pseudocardinal tooth or teeth in the intact animal varies with the different species described. In *Lamellidens* the anterior end of the tooth or teeth is placed just above the middle of the attachment of the anterior adductor muscle, while in *Physunio* it extends to the antero-dorsal angle of the muscle with a gap between the two.

In all the species described here the muscle is divided into an upper and lower portion by an oblique septum extending between the two valves.

(2) The *posterior adductor muscle* is triangular (with the apex above and the angles rounded) in *Lamellidens* and *Physunio*. In *Solenaia* it is elongated horizontally, with nearly parallel upper and lower borders and rounded ends; in the anterior and upper corner there is a notch to receive the posterior end of the muscle.

(3) The *anterior retractor muscle* of the foot arises from the base of the foot on its side, just behind the mouth; it passes obliquely upwards and forwards beneath the posterior lip of the mouth and on the inner side of the lower portion of the protractor muscle to be inserted into the valve just behind the anterior adductor muscle. In *Lamellidens* the surface of attachment lies along the lower two-thirds or more of the posterior margin of the adductor muscle, being widest below and tapering above. In *Solenaia* it is placed behind the upper third of the posterior margin of the adductor muscle, and is nearly circular in shape. Lastly, in *Physunio* it is elongately triangular with the apex below, and is placed behind the upper half of the posterior margin of the anterior adductor muscle.

(4) The *protractor muscle of the foot* arises on each side from the visceral mass above the base of the muscular foot. The fibres radiate from an obliquely placed triangular area and are collected into a very short column, which passes obliquely downwards and forwards to be inserted into the valve near the anterior adductor muscle. In *Lamellidens marginalis* the muscle is placed below and behind the adductor at a little distance from it; in *Solenaia* it is placed behind and a little below the anterior retractor, at a distance behind its ventral aspect. In *Physunio* it is placed behind the adductor at the level of its lower end and also at a distance from it.

(5) The *posterior retractor muscle of the foot* on each side arises from the extreme posterior and dorsal aspect of the visceral mass; the two muscles lie side by side in the middle line, pass obliquely upwards and backwards between the two kidneys (at their posterior portions) and are inserted into the valves above the level of the upper border of the kidneys and in front of the posterior adductor muscle. In *Lamellidens marginalis* the surface of attachment is more or less triangular in shape,

lying in contact with the upper end of the anterior aspect of the adductor muscle. In *Solenaia* also, it is triangular, but lies in contact with the notch in the posterior adductor muscle. In *Physunio* again it is triangular, but is placed above and in front of the dorsal aspect of the adductor muscle.

(6) The *elevator muscles* are arranged in two patches one on each side, on the dorso-lateral aspect of the visceral mass.

In *Lamellidens marginalis* each patch is placed at the junction of the anterior one-third and posterior two-thirds of the body length and consists of very short columns of muscles 5—7 or more in number and arranged irregularly ; they are at once inserted into that portion of the valve lying in front of the umbonal cavity. In *Solenaia* they are placed behind the region of the umbo. In *Physunio* they are placed above and behind the anterior adductor muscle far forward in position as compared with those of *Lamellidens* or *Solenaia.*

IV. GILLS.

The *gills* are more or less similar in *Lamellidens* and *Physunio.* They are elongated and placed obliquely, and are approximately 4 times as long as broad. The *inner gill* is wider and longer, and extends a little more forward than the outer one. The *outer gill* is narrow and pointed in front, narrow and tapering behind. The inner gill is wider than the outer and extends below the outer gill. In *Lamellidens* the outer gill is nearly of the same width all through except at the tapering posterior and rather abruptly narrowed anterior end. The inner gill projects downwards beneath the outer one more in the anterior two-thirds of its length than in its posterior one-third. In *Physunio* the outer gill is comparatively narrow, being widest near the middle of its length and tapering at both ends ; it presents a notch in the ventral margin near the anterior end ; the inner gill projects downwards most in front, slightly behind and least in the middle.

In *Solenaia* the gills are much narrowed and elongated, being about ten times or more as long as they are broad ; the inner gill extends a little more forward than the outer, as in the other species, and projects a little below the outer gill equally in its entire length except at the anterior end ; the anterior and posterior ends of the outer gills are narrower and more pointed than those of the inner gill.

ATTACHMENTS OF THE GILLS :—

(1) The *outer lamella of the outer gill* is attached to the inner surface of the mantle-lobe. In *Lamellidens* the line of attachment lies a little below the separation of the mantle-lobes from the body-wall, so that the outer wall of the outer suprabranchial chamber is formed by a portion of the mantle-lobe ; the case is similar in *Solenaia.* In *Physunio*, however, the line of attachment lies at the line of separation of the mantle-lobe from the body-wall. The attached margin of the outer lamella is placed on a higher level than that of the inner lamella in *Lamellidens* and *Physunio,* but at a lower level (or at least in the same level) in *Solenaia.*

(2) The *inner lamella of the outer gill* is attached to the side of the visceral mass, at its anterior end, the ventro-lateral aspect of the non-

glandular portion of the kidney and to the outer lamella of the inner gill behind the visceral mass and foot, from beneath the posterior adductor muscle.

(3) The *outer lamella of the inner gill* is similar to the preceding in its mode of attachment.

(4) The *inner lamella of the inner gill* is attached to the side of the base of the visceral mass and behind it to the inner lamella of the opposite inner gill to form the floor of the cloacal chamber. In *Lamellidens* the attached dorsal margin of the inner lamella is placed just below the glandular portion of the kidney, but towards the posterior end of the visceral mass it is displaced downwards from the kidney, so that the inner wall of the inner suprabranchial chamber in this region is formed by a portion of the side wall of the visceral mass ; in *Solenaia* the case is exactly similar to that in *Lamellidens.* In *Physunio* the attached margin is placed beneath the glandular portion of the kidney near the posterior end of the visceral mass, where it is suddenly displaced downwards, as in the other forms.

Suprabranchial canals.—(*a*) The *outer suprabranchial canal* is placed on a higher level than the inner in *Lamellidens* and *Physunio*, but on a lower level in *Solenaia.* In *Lamellidens* the canal is small in the beginning, but gradually widens out posteriorly and opens into the cloacal chamber on the undersurface of the posterior adductor muscle in the middle of its antero-posterior thickness. Elongately triangular anteriorly, it widens out into an equilateral triangle behind in transverse section. In *Physunio* the canal is elongated and slit-like in front, but elongately triangular (with base directed upwards) behind the visceral mass in transverse section ; it ends in the cloacal chamber at the anterior end of the ventral aspect of the posterior adductor muscle.

In *Solenaia* the canal is triangular in front, but quadrilateral at the posterior end of the visceral mass in transverse section, and terminates in the cloacal chamber in the middle of the antero-posterior length of the ventral aspect of the posterior adductor muscle.

(*b*) The *inner suprabranchial canal* in both *Lamellidens* and *Physunio* is slit-like in the beginning, becomes triangular posteriorly in transverse section and is nearly of the same height in its entire length. In *Solenaia* the canal is also slit-like in the beginning but becomes quadrilateral in transverse section at the end of the visceral mass ; it is, however, of greatest width (from above downwards) anteriorly, forming about half the width of the inner gill, but becomes less so posteriorly.

The *renal aperture* is placed in the inner suprabranchial canal ; in *Lamellidens* and *Physunio* at about the junction of the anterior one-third and posterior two-thirds of the line drawn from the anterior end of the inner gill to the posterior end of the visceral mass. In *Lamellidens* the aperture is slit-like and placed longitudinally, with a thick white rim ; in *Physunio* it is rounded and without any thick white margin. In *Solenaia* it is slit-like and placed longitudinally some distance behind the middle of the length of the visceral mass.

The *genital aperture* is placed below and a little in front of the renal aperture in the same canal in both *Lamellidens* and *Physunio.* In *Solenaia* the aperture could not be made out.

The *common canal*, formed by the union of the two *suprabranchial canals* behind the visceral mass, is shorter than the antero-posterior length of the cloacal chamber in *Lamellidens* and *Solenaia*, but nearly of the same length in *Physunio.*

STRUCTURE OF THE GILLS.—The specimens of *Solenaia soleniformis*, Benson, and *Lamellidens marginalis*, Lam., supplied me with gravid females, while the specimens of the two species of *Physunio* were all sterile. In *Solenaia* all the four gills act as marsupia, while in *Lamellidens* the outer gills only give rise to ovisacs. In *Physunio* the structure of the gills seems to show that the outer gills are concerned in carrying the embryos. The arrangement of the gill filaments and the formation of lateral tubes are shown in the following table :—

	Number of gill-filaments corresponding to one water tube or lateral tube.	Lateral tube.
Solenaia—		
Outer gill,	20—22	Only outer lateral tube.
Inner gill,	12—18	Only inner lateral tube.
Lamellidens—		
Outer gill,	16—20	Outer tube much more developed than the inner tube.
Inner gill,	12—15	
Physunio—		
P. ferrugineus—		
Outer gill,	25—28.	
Inner gill,	14—16.	
P. micropteroides—		
Outer gill,	20.	
Inner gill,	15—16.	

V ALIMENTARY CANAL.

(*a*) The *mouth* is a transverse slit-like aperture bounded in front and behind by anterior and posterior lips continuous with the outer and inner labial palps respectively.

(*b*) *Oesophagus.*—The course of the oesophagus is different in the three forms : in *Lamellidens* it is slightly curved or broadly S-shaped, passing obliquely upwards and backwards through the digestive glands. In *Solenaia* it consists of a short nearly vertical portion (wide in the middle and narrow at both ends) and an elongated horizontal portion continuous behind with the stomach. In *Physunio* it consists of a vertical portion lying behind the anterior adductor muscle and a short horizontal portion (half as long as the vertical portion) continuous with the stomach behind.

(*c*) The *stomach* is surrounded by a digestive gland ; its cavity is very irregular with folds and furrows which are fairly constant in arrangement.

Behind the opening of the oesophagus and in the floor of the stomach is a transverse fold (tongue-like in *Lamellidens*, but rather conical and papilla-like in *Solenaia* and *Physunio*), with a furrow behind ; the fold is directed upwards and backwards from below and produced laterally to the lateral walls of the stomach. In *Solenaia* and *Physunio* there is another fold in front of the conical elevation at the junction of the oesophagus and stomach, which in *Solenaia* extends backwards and upwards from below, and in *Physunio* only marked in the right side. Behind the conical elevation is another slight eminence which receives the opening of the intestine in *Solenaia.* In *Lamellidens* the opening lies on or behind the eminence, while in *Physunio* it is placed behind it at the bottom of a cup-shaped depression itself surrounded by a raised margin. In all cases the opening of the intestine is placed to the left side of the middle line.

The posterior wall of the stomach is raised into a transverse fold in the middle of its width giving rise to two blind pouches ; the fold is continued into the lateral wall of the stomach, more in the case of *Lamellidens* than in the two other genera. The dorsal pouch is directed upwards and backwards, while the ventral pouch is directed transversely backwards.

In *Solenaia* there is another fold in the backwall of the dorsal pouch above the transverse one which passes obliquely outwards and downwards to meet the transverse fold at the side ; this ridge is faintly marked or absent in *Lamellidens,* but in *Physunio ferrugineus* a similar ridge, arising from the dorso-lateral corner of the dorsal sac, passes downwards and forwards to meet the transverse ridge at the postero-lateral wall of the stomach ; it is present only on the left side but a faint trace of it can also be made out on the right side. In this species also a fold arises from the right side of the cup-like depression (in which the opening of the intestine is placed), which passes obliquely upwards and to the right on the posterior wall of the stomach and ends below the transverse fold in the postero-lateral corner ; two other smaller and less prominent ridges are seen, one arising from the postero-lateral aspect of the margin of the same cup-like depression to the right and the other a little above the preceding from the oblique ridge, both passing to the left. Another strongly marked ridge is also found in the right lateral wall of the stomach at the level of the margin of the cup-shaped depression, continued behind to the origin of the oblique ridge from the margin of the cup. It forms a deep pouch on the ventro-lateral aspect of the stomach, the lower boundary of which is formed by the raised lateral margin of the cup-shaped depression.

In all the three genera the transverse ridge from the posterior wall of the stomach, as it passes to the *left side,* fuses with one from the antero-dorsal wall above and with another from the ventral wall of the stomach at its junction with the oesophagus, with the formation of a separate portion of the dorsal pouch on the left side.

(*d*) *Intestine.*—The coils of the intestine in the visceral mass are similar in fundamental arrangement in all the genera considered here. They may be best described in a tabular form :—

Loop of the Intestine.	*L. marginalis.*	*Solenaia soleniformis.*	*Physunio.*
(1) First loop, from the stomach to the posterior end of the visceral mass (course backward and downward on the left side of the middle line).	Course backward and downward.	Much more backward than downward.	Much more downward than backward.

Loop of the Intestine.	*L. marginalis.*	*Solenaia soleniformis.*	*Physunio.*
(2) Second loop, passing forwards and upwards to the dorsal aspect of the visceral mass.	Course nearly straight, half the first loop in length.	Course slightly curved, about half the length of the first loop.	Course curved with convexity upward and backward, about the same length as the first loop.
(3) Third loop, passing downward and backward and lying behind the second loop.	Course like that of the second loop and slightly longer than the same.		
(4) Fourth loop, passing forward and lying beneath the posterior portion of the first loop.	Course straight, slightly upward and about half the length of the first loop, lies below the first loop.	Like *Lamellidens* but not upward (or very slightly so).	Course rather short, less than half the length of the first loop.
(5) Fifth loop, passing backward and downward. The junction between the fourth and fifth loops crossing the first loop.	Course straight, slightly shorter than the fourth loop, lying above the first loop.	Course straight, about half the length of the fourth loop, lying above the first loop.	Course about half the length of the fourth loop.
(6) Sixth loop, passing upward and forward to end in the rectum.	About the same length as the fifth loop, lying above the fifth loop.	Very short, about half the length of the fifth loop.	

(*e*) The *rectum* is recognised by a thick, prominent typhlosole from the ventral wall. Beginning in the visceral mass, it passes forwards and upwards to reach the space between the digestive gland and the stomach in front and the pericardial sac behind. It then passes vertically upwards and at once bends backwards to enter the pericardial chamber ; it passes through the chamber, being surrounded by the ventricle, and leaves the chamber at its posterior end. Lastly, the rectum passes backwards along the dorsal aspect of the posterior adductor muscle and ends in the anus placed at the summit of a conical papilla projecting into the cloacal chamber from above the posterior adductor muscle. In *Lamellidens* the course of the rectum through the pericardial chamber is straight and horizontal ; furthermore, it presents two bulb-like swellings in front of and behind the ventricle ; the conical papilla is flattened from side to side and the anus is a longitudinal slit with two lateral dentate margins which ordinarily keep the aperture closed. In *Solenaia* it is similar to that in *Lamellidens* in all respects except that the swellings are absent. In *Physunio* the course through the pericardial chamber is oblique (upwards and backwards from in front) and is slightly curved posteriorly with the convexity upward after it has left the pericardium ; there is no bulbous swelling in the wall and the anus is more or less rounded, being surrounded by a fringe specially prominent on the dorsal aspect.

VI. DIGESTIVE GLAND.

The *digestive gland* forms a brownish mass round the stomach; it extends above and in front from the antero-dorsal aspect of the stomach to the postero-dorsal angle of the anterior adductor muscle above the oesophagus, and above and behind from the postero-dorsal aspect of the stomach to the rectum ventrally; the gland extends from the oesophagus in front to the first loop of the intestine behind. In all species, except *Physunio ferrugineus*, the ducts of the gland are not clearly seen under a magnification of ten diameters; there are numerous tubular crypts in the wall of the stomach into which the gland seems to open. In *Physunio ferrugineus* the racemose nature of the gland is quite distinguishable under a magnification of 10 diameters, and the gland is divisible into 4 lobes—one antero-dorsal, one postero-dorsal, and 2 ventral. A long duct from each lobe is distinctly seen to open into the cavity of the stomach.

VII. VASCULAR SYSTEM.

The *vascular system* has been studied in *Lamellidens marginalis* by injecting the blood vessels with a coloured fluid through the ventricle, as living and fresh specimens are available. In other forms only the heart, the vena cava, and a few other vessels could be studied properly.

(*a*) PERICARDIUM.—In *Lamellidens* and *Physunio* the pericardial sac is elongately oval, with rounded ends; the sac is slightly more flattened in *Lamellidens* than in *Physunio.* In *Solenaia* the sac is narrow and elongated, the anterior end being flattened from above downwards. A distinct gap is seen between the posterior end of the pericardial sac and the dorsal aspect of the posterior adductor muscle in which the rectum is placed, being surrounded by connective tissue. In all a longitudinal fold of integument rises vertically upwards from the mid-dorsal line of the wall of the pericardium; this is only slightly marked in the case of *Lamellidens* and *Solenaia*, being more prominent in the latter behind the pericardium and over the posterior retractor and anterior half of the posterior adductor muscle. In *Physunio* this membrane is extraordinarily developed, and is prolonged as a thin median flap between the dorsal wings of the two valves. The *reno-pericardial aperture* is placed on the ventro-lateral aspect of the rectum as the latter enters the pericardial sac.

(*b*) HEART.—The *ventricle* in *Lamellidens* seems to be bilobed when it is fully expanded and placed in the middle of the pericardial sac (occupying about the middle-third of the entire length of the sac); it is bounded in front and behind by the bulbous swelling round the rectum. In *Physunio* the ventricle is placed close to the posterior end of the pericardial sac. In *Solenaia* it is about half the length of the pericardium and is placed in the middle of the sac.

The *auricles, right* and *left,* are placed at the sides of the ventricle. Each auricle in *Lamellidens* is triangular in shape, with the apex directed forwards. The outer side is attached to the conjoined margin of the inner lamella of the outer and outer lamella of the inner gill, just external to the dorsal aspect of the kidney. It is attached to the ventricle in the middle third of its length. The auriculo-ventricular opening is a slit-like aperture guarded by 2 semilunar valves, above and below. There are 3 to 4 apertures inside the outer border of the auricle to receive blood from the efferent branchial vessel. In *Solenaia* the auricle is trapizoid in shape ; of the two parallel sides the short one is attached to the ventricle and the long one to the gills. There seems to be a single aperture to receive blood from the gills. In *Physunio* the shape of the auricles is similar to that in *Lamellidens* ; the apertures inside the outer side to receive blood from the gills are 4 or 5 (?) in number.

The following blood vessels have been traced in *Lamellidens* by injecting them with carmine (suspended in water) through the ventricle.

The *anterior aorta* passes forwards along the dorsal aspect of the rectum and reaches the posterior end of the digestive gland where it divides into right and left *viscero-pedal* arteries. Each *viscero-pedal artery* runs forward and a little outward into the substance of the superficial portion of the digestive gland, and then curving downwards and forwards gradually comes to reach the postero-ventral aspect of the anterior adductor muscle at the corner of the mouth, where it divides into two branches, *pallial* and *palpal* arteries. The *pallial artery* passes forward in the substance of the mantle-lobe along the ventral margin of the anterior adductor muscle to reach the antero-ventral angle of the latter, where it divides into two branches again : the first, the *dorsal pallial artery*, curves upwards and backwards along the anterior margin of the anterior adductor muscle (in the substance of the mantle lobe), supplying small arteries to that portion of the mantle which lies in front of the muscle and to the muscle itself ; the other, the *anterior pallial artery*, curves downwards and backwards and then runs backwards along the dorsal aspect of the thick rim of the mantle lobe, to the posterior end near the inhalent margin where it seems to divide into a net-work of capillaries ; it gives rise to numerous branches from both sides in its course along the mantle margin.

The *palpal artery* passes through the anterior lip of the mouth to the outer side and divides into *outer* and *inner* palpal branches ; the *outer* branch passes into the outer labial palp in a conspicuously sinuous course lying in the outer lamella of the two, of which each palp is composed ; the inner branch passes into the inner labial palp in a slightly undulating manner lying in the inner lamella.

The *anterior aorta* in its course through the visceral mass gives off minute branches to the stomach, and the digestive gland ; it also gives rise to a large *pedal artery* near the posterior end of the stomach.

The *pedal artery* passes downwards and forwards through the visceral mass and reaches the muscular foot at the junction of the anterior and middle thirds of its length and then passes nearly to the extreme margin ; it supplies branches to the intestine, rectum and the genital organs.

The *posterior aorta* is a very small artery arising from the ventral aspect of the posterior end of the ventricle beneath the rectum. It passes along the ventral surface of the rectum between the two posterior retractor muscles of the foot where it divides into 2 branches, one on either side. Each branch gradually passes outwards along the posterior retractor muscle and reaches the posterior surface of the posterior adductor muscle. Each supplies the corresponding half of the posterior adductor muscle, the posterior retractor muscle of its side and the posterior portion of the rectum.

The *pallial sinus* (*vein*) begins in the substance of the mantle flap at the level of the inhalent aperture just behind the thick rim of the lobe. It passes upwards and forwards in a curved manner below the posterior adductor muscle and ultimately opens into the auricle of its side at the postero-external corner. This sinus is also present in the other two genera.

The *vena cava* (*median ventral sinus*) at first lies between the two glandular portions of the kidneys, but gradually shifts downwards in its posterior course so as to lie at the point of union of the two glandular and non-glandular sacs; the ventro-lateral wall of the vena cava on either side is perforated with a row of apertures, the openings of vessels from the wall of the glandular portion of the kidneys; they are distinctly seen under a magnification of 10 diameters. In *Solenaia* and *Physunio* the relation between the vena cava and the kidney is similar to that in *Lamellidens.* In *Lamellidens* and *Solenaia* the transverse section of the vena cava is oval, with the short diameter vertical; in *Physunio* it is also oval but with the short diameter horizontal.

The two *afferent branchial veins* lie along the line of attachment of the inner lamella of the outer and outer lamella of the inner gill—in all the three genera.

The *single afferent branchial vein* lies along the base of the inner lamella of the inner gill in all the three genera. It is interesting to note that in *Anodonta* it lies along the base of the outer lamella of the outer gill.

VIII. EXCRETORY SYSTEM.

The *kidney* is doubled on itself, as usual, and is divisible into (*a*) glandular and (*b*) non-glandular portions.

The *glandular portion* of the kidney lies beneath the non-glandular; at its anterior end it communicates with the pericardium and is separate from its fellow by a distinct interval, and further behind by the interposition of the vena cava. In *Lamellidens* the sac is flattened from above downwards in front, lying on the ventral aspect of the non-glandular sac. Then the sac becomes oval in transverse section and, lastly, towards the posterior end of the visceral mass it is twisted on itself coming to lie on the inner side of the ureter, at first obliquely (*i.e.*, with the long diameter in a section placed downwards and outwards from above) and then vertically. The vena cava is now placed beneath the pericardial sac, with a small portion of the inner wall of ureter and glandular sac laterally and further back with the glandular sac only, the ureter being displaced to the outer side.

In *Solenaia* the glandular sac is separated at first from its fellow of the opposite side by the vena cava, and behind by the foot, which intervenes between the two. The inner wall of the sac is fused with the upper portion of the side of the foot, while the non-glandular portion placed dorsally at first is displaced to the outer side.

In *Physunio* the glandular sac lies beneath the non-glandular portion in the beginning, but is gradually placed on its inner side between it and the foot and the posterior retractor muscle of the foot of its side; the glandular sac is comparatively wider than the non-glandular. The walls of the non-glandular sac are generally seen applied to one another.

The glandular sac ends in front of the posterior adductor muscle. The nature of the communication between the glandular and non-glandular sac is rather different in the three genera.

In *Lamellidens* the glandular sac opens into the non-glandular by means of a slit-like aperture on the dorsal aspect at its posterior end; a pigmented sac is found at the beginning of the ureter, open in front but blind behind; it lies on the outer side, having its outer wall fused with the outer wall of the ureter and its inner wall lying free in the cavity of the same; the blind posterior end of the sac lies just in front of the posterior adductor muscle, the inner surface of the sac is thrown into irregular folds and gives the appearance of a broad meshed spongy structure.

In *Solenaia* the glandular portion is placed on the inner side of the non-glandular sac. Towards the posterior end of the foot we get the beginning of a canal bounded externally by the mantle, internally by the non-glandular sac, above by the pericardial chamber and below by the outer suprabranchial chamber; the canal widens out as it passes backwards. Behind the foot it forms a big sac lying on the outer side of the glandular sac, while the non-glandular sac narrows down into a small canal lying on the outer side of the posterior retractor muscle of the foot above the canal. Further backwards, the non-glandular sac terminates in a small blind sac just in front of the posterior adductor muscle. On reaching the under surface of the posterior adductor muscle the canal comes to lie on its ventro-lateral aspect and ultimately becomes continuous with the glandular sac by the disappearance of the septum between the two. In the lumen of the canal, as it lies at the level of the posterior retractors of the foot, there is an obliquely vertical septum, attached above to the outer wall of the canal a little below the dorsal aspect, and below to the inner wall a little above the ventral aspect. The free anterior and posterior borders of the septum is deeply concave. Above the upper attachment of the septum is an elongated aperture through which the ureter communicates with the canal. A similar arrangement but rather different in details has been described in *Anodonta.*

In *Physunio* the glandular portion is placed on the inner side of the ureter behind and both are flattened from side to side and slightly curved on themselves, with the convexity outwards; in this situation it is separated from its fellow of the opposite side by the posterior retractor muscles of the foot. The glandular sac communicates with the non-glandular by an elongated aperture on its dorsal aspect, near the posterior end. The glandular sac in this situation is divided into two portions by an oblique partition, attached on the inner side to the ventro-internal corner, on the outer side to the outer wall a little below the dorsal aspect and behind to the outer wall just in front of the posterior end of the sac; it is free anteriorly. Of the two sacs thus formed the upper one communicates with the ureter, while the lower one ends blindly.

(*b*) The *non-glandular portion* passes forwards beneath the pericardial chamber. The relation of the non-glandular to the glandular sac has already been described. At the anterior end, the non-glandular sac is separated from its fellow by the vertical portion of the rectum. The excretory aperture is placed at the outer ventro-lateral aspect of the sac. The interrenal aperture is elongated in *Lamellidens* and *Solenaia*, but is less so in *Physunio.*

IX. REPRODUCTIVE SYSTEM.

The *gonads* are placed as usual amongst the coils of the intestine and a portion of the rectum in the visceral mass. In *Lamellidens marginalis* male specimens were available. The head of the spermatozoon is rod-shaped, about thrice as long as broad, rounded anteriorly, truncate or slightly concave, and widest posteriorly; there is a slight constriction in the middle. The tail is very fine and is about 3 or 4 times as long as the head.

X. NERVOUS SYSTEM.

The position of the ganglia is practically the same as that in *Anodonta.* The ganglia and the connectives could not be dissected out in *Solenaia.*

The *cerebro-pleural ganglion* of each side gives off (1) an *intercerebral connective* in front of the mouth, (2) a *pallial nerve* from the antero-lateral aspect, (3) a *cerebro-visceral commissure* and (4) a *cerebro-pedal commissure.* No other nerve was found arising directly from the cerebro-pleural ganglion.

The *pedal ganglion,* on each side, gives off 6 *nerves from the side* and receives the *cerebro-pleural commissure.* The otocyst lies inside the pedal ganglion.

The *visceral ganglion,* on each side, receives the cerebro-visceral commissure and gives off 3 nerves, a *branchial,* a posterior *pallial nerve,* and a small nerve to the posterior adductor muscle.

In *Lamellidens* the *branchial nerve* passes along the conjoined margin of the inner lamella of the outer and the outer lamella of the inner gill. It divides into two branches, one passing along the same margin and the other along the fused margins of the inner lamellae of the inner gills. The *posterior pallial nerve* divides into 3 branches :—(1) a small nerve to the mantle-lobe which passes to the attached margin of the outer lamella of the outer gill, a little in front of its posterior end; (2) a nerve to the mantle-lobe at the posterior end of the attached outer lamella of the outer gill; (3) a nerve to that portion of the mantle-lobe which forms the lateral wall of the cloacal chamber.

The *cerebro-visceral commissures* are placed side by side between the two glandular portions of the kidneys beneath the vena cava in *Lamellidens.* They are separated from one another by the lower end of the vena cava in *Physunio.*

SUMMARY.

The anatomy of the three genera of Unionidae dealt with in this paper agrees in general structure with that of *Anodonta* and *Unio* as

already described by various malacologists. The difference observed between the three genera and others consists mainly in the relative position of the different organs, a remarkable point being the arrangement of the various loops of the intestine which are practically identical in four species described here. Further, the main differences in general structure between the three genera described here are only due to the elongation of the body in the antero-posterior direction, this being greatest in *Solenaia* and least in *Physunio*, with *Lamellidens* occupying an intermediate position between the two. Considering the individual organs, it is important to note that in *Solenaia* all the four gills seem to give rise to ovisacs, and the kidneys also are more complicated than in the other two, somewhat resembling those of *Anodonta*.

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XIV THE DESCRIPTION AND LIFE-HISTORY OF A NEW SPECIES OF *ANOPHELES* THAT BREEDS IN HOLES IN TREES.

By B. PRASHAD, *D.Sc.*

(Plate XVII.)

Though it may not be considered right to describe a species of mosquito from a single specimen and that specimen a male one, yet the specimen on which I base the following description possesses some very distinctive features. It is these features together with its breeding habitat and the presence of well preserved larval and pupal stages which have decided me to describe the form in question.

I have very great pleasure in naming it *Anopheles annandalei*, after Dr. N. Annandale, Director of the Zoological Survey of India, as a mark of regard and gratitude which I always feel for him.

THE IMAGO.

Detailed description of the male specimen: A medium sized mosquito; wing measured 2·9 mm. General colouration light.

The *antennae* have the basal joint of a light brown colour; in the succeeding joints the proximal portion from which the hairs arise is dirty yellow, and the distal portion is of a creamy colour; the hairs themselves are pale yellowish; the last joint is densely covered with small hairs, there being no definite terminal hair. *Palpi* (fig. 1) 1·7 of length of thorax, ·6 of that of wing, distinctly smaller than the proboscis; they have a distinctly banded appearance. Basal segment with large black scales on the outer and smaller ones on the inner side; the penultimate segment has the base and the apex creamy white, the rest of the segment being dark brown; the terminal segment has the base, the outer and upper surfaces brownish, the rest being yellowish white; the club has the inner and lower surfaces of a much lighter tinge, appearing creamy white. The club is well developed, having a swollen terminal portion, and is covered by large scales with a few hairs. *Proboscis* dark-scaled: *labellae* whitish. *Clypeus* not covered by scales; *vertex* with long hair-like scales of a whitish colour; further back these hair-like scales are much darker in colour; besides the hair-like scales there are broad truncated squames of a snow-white colour on the posterior portion of the vertex; the *nape* is covered by black scales of the usual anopheline type.

Prothoracic lobes pointed anteriorly with a tuft of dark brown scales on their anterior edge, and with a few yellow chaetae. *Mesonotum* ashy grey all over except for a black line in the middle of the posterior third; but for a few white spatulate scales on its anterior edge it is covered by long golden yellow bristles arranged in a median and two dorso-lateral areas, the rest of the surface being without any scales or hairs; each of the areas mentioned above has three to four distinct rows of bristles arising from black rounded spots. A few bristles also arise from the dorso-pleural suture. *Scutellum* whitish except for a black band in the middle. *Postscutellum* with alternating bands of grey and brown in a longitudinal direction. Laterally the thorax is dark brown except at the sutures, which are light yellow.

Wing (fig. 2) 2·7 the length of thorax, base to subcostal junction ·61, anterior forked cell ·23, posterior forked cell ·15 of the whole wing. Wing veins densely covered with spatulate scales. Costa dark-scaled all along except at the base near the junction of the humeral cross-vein, where there is a yellow-scaled spot involving the base of the first longitudinal also. The second yellow spot is a large one at the apex of the wing opposite the termination of the first longitudinal and extending more than half the length of the anterior forked cell. All the veins clothed with dark yellow scales except for the following five patches of black scales: (1) at the base of the second longitudinal vein, (2) at the forking of the second longitudinal vein, (3) at the base of the third longitudinal and at the same position on the second and fourth longitudinal veins covering the cross-veins as well, (4) at the origin of the fourth longitudinal vein and (5) at the forking of the fourth longitudinal vein. The wing-fringe is of a darkish hue with jet black patches at the tips of the posterior branch of the second longitudinal and the anterior branch of the fourth longitudinal veins; between these two dark patches the fringe is of a yellow colour. The arrangement of large and small scales in the fringe is quite normal.

Halteres with the capitellum of a dark brown colour, the scape and scabellum being yellowish.

Coxae scaleless, of a creamy colour with a few hairs; *trochanters* also with a few hairs and of the same colour as coxae. Fore legs uniformly brown except for the white spots at the femoro-tibial and the tibiotarsal joints. The femur of the middle legs has a three-coloured band owing to the arrangement of the scales; it is formed of white scales in the middle, black above and brownish at the tip of the femur. In the hind legs the femur (fig. 3) has, just below the middle, a large tuft of black scales surrounding it entirely; below this tuft there is a very prominent tuft of snow-white scales reaching to the knee-joint, the condition appears to be simply a much more exaggerated one than that found in the femur of the mid-legs, except that the brown band at the tip of the femora of the middle pair of legs is absent. The tibial and tarsal portions of the mid and hind pairs of legs are uniformly brown except for a whitish band at the tibio-tarsal joints. *Ungues* simple.

Abdomen dark brown, without any scales except a few black ones on the last segment and on the genitalia; it is covered by a large number of golden yellow bristles.

The structure and form of the egg is not known.

THE LARVA (fig. 4.)

The *head* is of a dark brownish colour with three pairs of branched hairs on its dorsal surface. The *clypeal hairs* are rather small, the inner pair being unbranched and lying close together; the distance between them being about half that between each external and the corresponding internal hair of the side; the inner hair is more than one and a half times the length of the outer branched hair. The *antennae* are long (little less than half the length of the head) cylindrical structures broader at the base, with minute spines on the shaft, with the processes at the apex well developed with a branched terminal hair arising from amidst them. From close to the base of the antenna there arises on the outer side a much branched *basal hair* of the type described for *A. culiciformis* by Christophers and Khazan Chand (6). *Mandibles* (fig. 5) with a single pointed and slightly curved, and three comb-like spines at the apex externally, a well developed anterior and a much smaller internal buccal fan of setae; four main teeth and seven accessory small ones; a brush-like large spine external to these and a prominent row of small tooth-like structures on the inner side; on the main lobe near the outer side a large number of small setae are present on the upper surface, and a number of hairs arising from near the base probably representing the branched basal hair. *Maxillae* of the ordinary pattern, with large curved hairs on their anterior margins, the inner edge ending on the top in a curved hook-like structure; on the main plates two minute papillae are present and the upper surface is covered by a large number of hairs. The maxillary palp is a prominent structure with five spines at its upper end, and a large much branched hair external to the processes a little below the tip. The *submental plate* shows nine well developed teeth.

Thoracic hairs as in other anopheline larvae. The *submedian* hairs consist of two branched hairs on each side, an external and an internal one. There are no palmate hairs on the thorax.

The first and second abdominal segments carry on each side two large and a small feathered hair; the third segment has one large and a single small feathered hair laterally and two small simple hairs dorso-laterally; the fourth and the fifth segments have one large and three small feathered hairs on each side besides two simple hairs as in the third segment; the sixth segment has a single large and two small feathered hairs and two unbranched ones as on the fifth segment; the seventh and the eighth have only two small feathered hairs on each side.

Palmate hairs are present on the abdominal segments 2—7 only. Each palmate hair (fig. 6) consists of 15—18 leaflets; the leaflets are long and pointed with one or two serrations on each side. The *pecten* (fig. 7) is short and broad with teeth of different lengths irregularly alternate, and with a few hairy projections on the basal parts only.

THE NYMPH.

The nymphal trumpets (fig. 8) are rather elongated structures somewhat triangular in shape, and with a broad opening. The dorsal plumose hairs of the ordinary shape are present on the first abdominal segment. There is a lateral spine on segments 2—8; the one on the last segment being plumose. Besides the spines mentioned above there is a long plumose seta, about the length of the segment bearing it, on the segments 5—7; the one on the fifth segment is a little smaller than the others. The tail-fins (fig. 9) are much longer than broad; they have a well marked fringe of fine hairs, and a long terminal hair which is $\frac{1}{8}$ of the tail-fins in length.

HABITS.

The only adult specimen was hatched from larvae collected by Dr. N. Annandale and Dr. F. H. Gravely from a tree hole at Sureil (altitude about 5,000 ft.) in the Darjeeling district, Eastern Himalayas on October 28th, 1917. The tree was in dense jungle close to the source of the water supply of the Sureil bungalow. The water, which was of a brownish colour, contained a large number of dead leaves, and besides the anopheline larvae there were in it some culicine larvae as well. Only two other Indian anopheline mosquitoes have been described as breeding in tree-holes, these are *A. plumbeus*, Haliday (5) and *A. culiciformis*, Cogil (6).

REMARKS.

The present species belongs to the group of anophelines in which Alcock (1) included *A. asiatica*, Leicester, *A. barbirostris*, Van der Wulp, and *A. wellingtonianus*, Alcock (2) ; Christophers, however, in his admirable revision of the anophelines (3) includes in this group *A. asistica*, *A. lindesayi*, Giles, *A. wellingtonianus*, and doubtfully *A. atratipes*, Skuse, and thinks that *A. barbirostris* has no relations with this group. *A. annandalei* though closely related to *A. asiatica* (6), differs from it in the following important characters among many others :—

1. Wing markings.
2. Palpi being banded.
3. Markings of the legs.
4. General colouration.

The larva is quite different from that of *A. asiatica* as described by Strickland (*Parasitology*, Vol. VII, pp. 12—17, 1914).

Type specimen in the collection of the Zoological Survey of India, No. 8061/H. I. Larvae and pupa No. 8062/H., I.

I would here call attention to a paper by F. W. Edwards of the British Museum on "Tipulidae and Culicidae from the lake of Tiberias and Damascus" published in the *Journal of the Asiatic Society of Bengal*, new series, Vol. IX, pp. 47—51, in which he has, after careful comparison of the types come to the conclusion that *Anopheles nursei*, Theob. is only a synonym of *Anopheles* (*Pyretophorus*) *palestinensis*, Theob., and not a valid species. The paper has unfortunately been overlooked by all workers on Indian Culicidae.

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EXPLANATION OF PLATE XVII.

FIG. 1.—Palp of the male *A. annandalei.*
„ 2.—Left wing of the same.
„ 3.—Hind femur of the same.
„ 4.—Larva of the same, dorsal view.
„ 5.—Mandible of the larva.
„ 6.—Palmate hair of the larva.
„ 7.—Pecten of the larva.
„ 8.—Breathing trumpet of the nymph.
„ 9.—Tail-fins of the nymph.

XV STUDIES ON INFUSORIA.

By EKENDRANATH GHOSH, *M.Sc., M.D.*

I. ON A NEW SPECIES OF *Anoplophrya*, STEIN, *emend.* CÉPÈDE.

The genus *Anoplophrya*, Stein, as restricted by Cépède (2) may be diagnosed as follows :—Infusoria with flattened ribbon-shaped body (cylindrical in one species) entirely and uniformly covered with cilia arranged on longitudinal striae close to one another (rarely distant) ; no cytostome ; with well defined macro- and micro-nuclei ; c. v. in single or double longitudinal rows, or rarely scattered, or very rarely absent. Division by transverse fission, sometimes with formation of chains (*i.e.*, with satellites) due to incomplete and retarded separation of the daughter individuals. Endoparasites of various annelids.

Anoplophrya lloydii, sp. nov.

The species may be diagnosed thus : Elongately oval with subtruncate posterior end ; curved longitudinally with the dorsal side convex and the ventral concave ; macronucleus irregularly ribbon-shaped, extending to nearly the whole length of the animal ; micronucleus small, spherical, placed at the side of the macronucleus ; c. v. 3, on the right side. In seminal vesicles of an earthworm (*Pheretima posthuma*). Unfortunately the measurements are not noted.

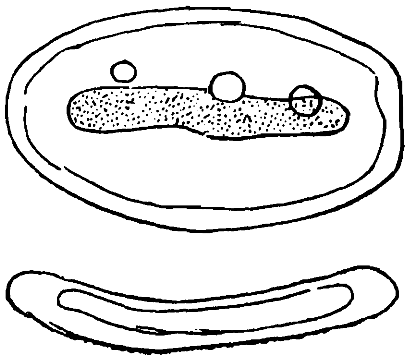

FIG. 1.—*Anoplophrya lloydii*, sp. nov.

The species comes nearest to *A. striata* in many respects.

Up to the year 1915, the number of well recognised species of *Anoplophrya* was 16, making a total of 17 with the present one.

These species of *Anoplophrya* may be tabulated in the following synopsis :—

a. No C. V.

  a¹. Body elongately oval, pointed anteriorly, truncate (when with satellites) or tapering and pointed posteriorly ; macronucleus ribbon-shaped, with a knobbed end.

  1. *A. maupasi*, Cépède (2), p. 411.

  b¹ Body ovoid or uniform ; rounded anteriorly, swollen and acuminate posteriorly ; only 4 or 5 longitudinal ciliary striae ; macronucleus spherical or ovoid, in posterior body half.

  2. *A. minima*, Leger and Duboscq (3) ; Cépède (2).

b. With C. V.

a^1. C. V. in a single row.

a^2. Body oval.

a^3. Body straight dorso-ventrally.

a^4. Body elongately oval, length = 3 to 5 times the breadth; sometimes obliquely truncate posteriorly. C. V. 9-10 or more; macronucleus elongated and axial.

3. *A. naidos*, Stein (*A. inermis*, Kent.)

b^4. Body elongately oval with rounded ends; length equal to or less than twice the breadth; C. V. large, 3-5 in number; macronucleus elongately oval.

4. *A. ovata*, Clap.

b^3. Body curved dorso-ventrally in a longitudinal direction, oval with rounded ends; C. V. 4-6 in number; long ribbon-shaped macronucleus with rounded ends.

5. *A. convexa*, Clap.

b^2. Body not oval in shape.

a^3. Body bilobed with a constricted portion in the middle; anterior lobe swollen and oval; posterior lobe less so and pointed behind; C. V. 4-7 in number; macronucleus oval and placed at the anterior end.

6. *A. cochleariformis*, Leidy.

b^3. Body not bilobed.

a^4. Body elongately club-shaped; dilated anteriorly and obliquely truncate; posterior end attenuate, rounded or acuminate; C. V. 6 or 7; longitudinal striae few in number with distinct intervals.

7. *A. clavata*, Leidy.

b^4. Body elongated and vermiform.

a^5. Body cylindrical, little or not flattened, rounded anteriorly and acutely pointed posteriorly; cilia long; C. V. 7; macronucleus with club-shaped anterior end.

8. *A. paranoides*, Pierantoni (5).

b^5. Body flattened; macronucleus ribbon-shaped; C. V. numerous (about 30 in number).

a^6 Animal free-swimming with ordinary movement, micronucleus spherical and granular.

9. *A. filum*, Clap.*

b^6. Animal moving by vermicular contractions of the body; micronucleus inconspicuous.

10. *A. vermicularis*, Leidy.*

b^1. C V. in 2 rows.

a^2. Body oval in shape,

a^3. Body oval, more pointed anteriorly than posteriorly, sometimes both ends rounded: macronucleus with lateral expansions (not distinctly branched) and with a distinct nucleus membrane; micronucleus fusiform and placed obliquely in the outermost layer of endoplasm at a distance from the macronucleus.

11. *A. alluri*, Cépède.

b^3. Body elongately oval, widest anteriorly, often with a number of satellites (*A. prolifera*), macronucleus axial, band-like; micronucleus fusiform in posterior body half.

12. *A. nodulata*, Müller,
(*A. brasilii*, Leg. and Duboscq).

c^3 Body triangular, narrow and rounded anteriorly, truncate posteriorly.

13. *A. pachydrili*, Clap.

c^1. C. V. scattered irregularly.

a^2. Body curved dorso-ventrally in a longitudinal direction.

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* The species *A. filum* and *A. vermicularis* are considered identical by Schewiakoff (6), but are taken to be distinct and separate by Cépède (2).

a^3. Body elongately oval; length equal to or less than twice the breadth: longitudinal ciliary striae at distant intervals; macronucleus with lateral expansions and approaching the concave face; fusiform micronucleus placed obliquely near the left border.
14. *A. striata,* Duj.

b^3. Body elongately oval with subtruncate posterior end; longitudinal striae close; macronucleus irregularly ribbon-shaped; micronucleus spherical and placed at the side of the macronucleus; C. V. 3, on the right side.
15. *A. lloydii,* n. sp.

b^2. Body straight in profile.
a^3. Body oval in shape; C. V. 10 in number.
16. *A. aegitensis,* Cépède (2), p. 543.

b^3. Body irregularly oval, tapering and rounded anteriorly, wide and truncate posteriorly; C. V. 2, on one side, one in the middle and one near the posterior end; macronucleus irregularly oval, placed transversely; longitudinal striae close.
17. *A. simplex,* Andre (1).

Insufficiently described species :—

1. *A. socialis,* Leidy. Oval, cordioform, fusiform or globular in shape; C. V. numerous.
2. *A. notei,* Foulke, 1885 (*Amer. J. Sci.* XXIII, pp. 377-378), resembling *A socialis*, but without ciliary striae, cilia long and much thickened.

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II. TWO NEW SPECIES OF *Conchophthirus*, STEIN.

The genus *Conchophthirus*, Stein, may be diagnosed by the following characters: Body colourless and non-contractile, strongly compressed, generally oval in shape (sometimes elongated), with ventral surface usually more convex than the dorsal and somewhat notched in the ventral region; right side (back) more arched than the left; peristome a cup-shaped, funnel-shaped or short tubular cavity, sometimes prolonged into a long, recurved, tubular cytopharynx (non-ciliate); ciliary striae distinct; cilia uniform, moderately long and mostly tufted, sometimes a strong adoral zone in the anterior peristomial margin. C. V mostly one, subcentral or postero-terminal, macronucleus spherical oval, or irregularly triangular, one, rarely seven in number, subcentral or terminal. Anus terminal. Ectoparasites in mantle chamber of various molluscs.

The genus included 3 species in Kent's *Manual of Infusoria* (1880-1882), *viz.* :—*C. anodontae, C. steenstrupei* and *C. curtes. Plagiotoma acuminata* Clap. and Lach. seems to be identical with *C. anodontae.*

Bütschli (2) in Protozoa, Bronn's *Thierreich* (p. 1720) included three more species: *C. actinarium* [*Plagiotoma actinarium* Clap. (5)], *C. magna* [*Tillina magna,* Gruber (7)] and *Plagiopyla nasuta* var. *marina* Gourret and Roeser (6). The first species is now made the type of a new genus *Foettingeria* by Caullery and Mesnil (3) and is also noted by Andre (1).

The second one is not recognised by Schuberg (10) as a species of *Conchophthirus* the cytopharynx of *Tillina* being ciliated. The third species also cannot be considered to belong to the present genus.

Schuberg also refused to admit *C. curtes* as a distinct and separate species from *C. anodontae* as they were found in the same host; he considered the former as a variety of *C. anodontae.* But as *C. curtes* has only been found in *Lamellidens marginalis* with two new species of *Conchophthirus* (to be presently described), it cannot be considered to be the same species as *C. anodontae.*

Lastly three other species have been described by Certes (4), Andre (1) and Mermod (9), raising the number to 6 in all.

The two new species of *Conchophthirus* have been found in the mantle chamber of *Lamellidens marginalis* with *C. curtes* in the same specimens, the latter being exceedingly rare in occurrence.

Conchophthirus elongatus, sp. nov.

Body elongated, about 2½ times as long as broad, wide anteriorly, anterior end rounded and sloping to the back (left side); rather abruptly tapering and bluntly pointed at the posterior end; right side nearly straight, slightly convex in front and behind, and faintly concave in the middle; left side with a shallow notch just behind the anterior one-third of the body-length, where the peristome is situated; peristome small, elongately conical, directed forwards and to the right; longitudinal ciliary striae very marked at the anterior end, less so on the remainder of the body. Macronucleus oval, posterior and subterminal. C. V single at the junction of the middle and posterior one-third of the body-length, sometimes slightly displaced. Length 0·05 mm.

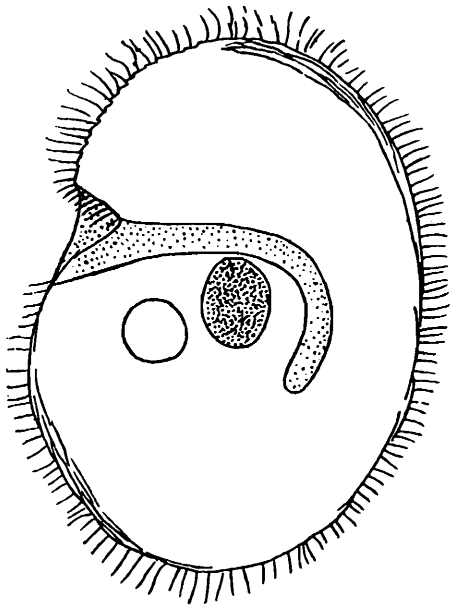

FIG. 2.—*Conchophthirus elongatus,* sp. nov.

Conchophthirus lamellidens, sp. nov.

Body ovate, about 1½ times as long as broad, bluntly pointed at both ends; right side strongly convex, left side convex and minutely dentate in the anterior and slightly notched in the posterior half. Peristome in the anterior portion of the notch, short and tubular, being directed forwards, and to the left. Generally a dark granular zone in the anterior one-third of the endoplasm. Longitudinal striae very distinct, specially in the anterior half of the left margin. Macronucleus oval or triangular, posterior and subterminal. C. V one, subcentral, generally in the middle third of the body-length at its posterior end. Length 0·09 mm.

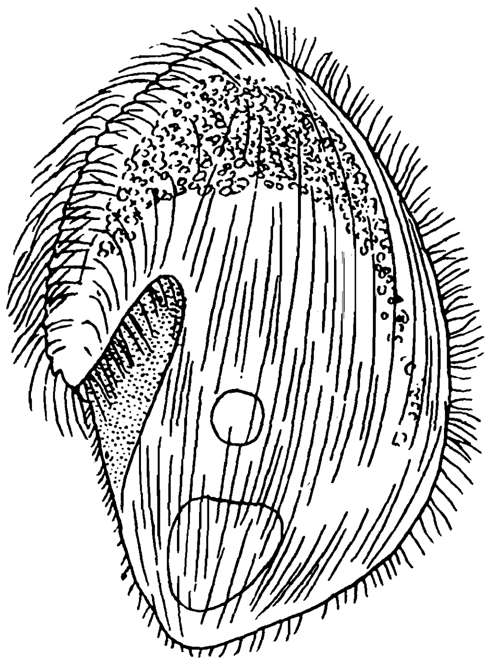

Fig. 3.—*Conchophthirus lamellidens*, sp. nov.

Conchophthirus curtes, Engelmann.

My specimens differ from the specimens described by Engelmann in the following points: The oval macronucleus is mostly placed with its long axis in the same line as the long axis of the body. C. V. without accessory vesicles. The cytopharynx is not only directed backwards (to the right side) but also curves posteriorly at a little distance behind the macronucleus.

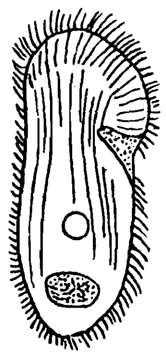

Fig. 4.—*Conchophthirus curtes*, Engelm.

The species of *Conchophthirus* are thus raised to 8 in number. They may be tabulated in the following synopsis :—

a. Peristome in the anterior body half far removed forward from the middle of the body-length.
    a^1. Peristome widely cup-shaped, at the anterior end of the left side; a small fascicle of bristles anteriorly; macronuclei 7 in number (moniliform ?); C. V. sub-central; body oval, body length$=1\frac{1}{2}$ times the width, length 0·13 to 0·093 mm.

1. *C. steenstrupei*, Stein.

b^1 Peristome small, near the anterior end; no fascicle of bristles anteriorly; macronucleus single.

a^2. Peristome ending in a short recurved cytopharynx; macronucleus spherical or oval, subcentral; C. V posterior; body elongately oval, length = twice the breadth, length 0·07 mm.—0·110 mm.

2. *C. antedonis,* Andre.

b^2. Peristome small and conical, at about the junction of the anterior and middle thirds of the body length; macronucleus oval, posterior; C. V. at about the junction of the middle and posterior thirds of the body length; body elongated, length = 2½ times the breadth; length 0·05 mm.

3. *C. elongatus,* sp. n.

b. Peristome in or near the middle of the left side.

a^1. Peristome ending in a long recurved cytopharynx passing to the right side.

a^2. Surface of the body smooth.

a^3. Body elongately oval, rounded at both ends; length = twice the breadth; macronucleus spherical and posterior; C. V. subcentral.

4. *C. anodontae,* Ehrbg.

b^3. Body broadly oval or rounded with dorsal surface strongly convex and ventral surface flattened; macronucleus oval, subcentral; C. V. one, near the macronucleus, with or without accessory vesicles.

5. *C. curtes,* Engelm.

b^2. Surface of body with longitudinal ridges in its middle two-thirds; body ovate, narrow anteriorly; macronucleus reniform; C. V. posterior and subterminal.

6. *C. metschnikoffi,* Certes.

b^1. Peristome not ending in a long recurved cytopharynx.

a^2. No adhesive disc; body oval with a notch in the posterior half of the left margin; body length = 1½ times the width; body length 0·09 mm.; peristome tubular; macronucleus oval and posterior; C. V. in posterior body-half.

7. *C. lamellidens,* sp. n.

b^2. An adhesive disc occupying ⅔rds of the ventral surface; peristome oval, behind the middle of the left side; body oval, rounded at both ends; right side convex; ventral surface flat and dorsal surface convex; C. V. in posterior body-half; macronucleus spherical or ovoid. Length 0·092—0·127 mm.

8. *C. discophorus,* Mermod.

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XVI. THE EVOLUTION OF THE CAUDAL FINS OF FISHES.

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Government College, Lahore.

(With text-figures 1—3.)

There is ample justification for the assumption that the most specialized of caudal fins among fishes have been evolved from a simple type which formed a part only of a once continuous median fin-system, extending from immediately behind the head on the dorsal side round the posterior end of the body to the vent on the ventral side ; thus there was no caudal fin as a differentiated structure. The whole of this primitive median fin-system was almost certainly provided with similar skeletal elements throughout, probably of the nature of interspinous bones or radials, not unlike those now found to support the dorsal and anal fins of modern fishes. The caudal extremity was therefore perfectly symmetrical both externally and internally, the dorsal contribution meeting the ventral in a line continuous with the chordal axis. Such a type of caudal fin is referred to as ' protocercal.'

Embryology is not of much assistance in verifying the exact details of skeletal structure in the primitive caudal fin, for modifications of this primitively symmetrical type set in very early before skeletal elements are properly laid down. Yet it is reasonable to suppose that no specializations were present in the primitive caudal fin ; the early fishes undoubtedly moved by serpentine action, undulations of the whole body producing a forward motion resembling the progress of the modern eel. Thus the posterior extremity of the body had no special demands made upon it as a propulsive organ beyond those shared by the rest of the body.

Before proceeding further it will be advisable to describe the types of caudal fin now met with among fishes. It is probably quite safe to say that no fish at the present time possesses a protocercal caudal fin ; hence any tail fins which shew perfect symmetry both externally and as regards internal skeletal supports will be secondarily symmetrical, that is gephyrocercal. When, however, it would not be safe dogmatically to assert the primary or secondary nature of caudal symmetry, it is convenient to employ a non-committal term signifying symmetry only ; diphycercal is the term which conveys such a meaning, thus protocercy will be synonymous with primitive diphycercy and gephyrocercy with secondary diphycercy.

Now undoubtedly the protocercal fin is the earliest in evolutionary order ; heterocercal forms no doubt succeeded the protocerca in the ascending scale towards the highly specialized tail fin of the Teleosts. Heterocercy is characteristic of the Elasmobranchs and the Ganoids ; it differs from protocercy in one important feature, *viz.*, that symmetry has been disturbed. In general, the asymmetry affects both the external form and the inner skeleton, though modification of the latter may not always be very strongly marked. The ventral contribution to the caudal fin is larger than the dorsal, and in most cases markedly so, as illustrated in the Ganoids *Acipenser*, *Polyodon* and *Amia*. Associated with this, as would be expected, the skeletal supports of the ventral fin-rays are more strongly developed than those on the dorsal side.

Though often less marked in Elasmobranchs than in the Ganoids, from the base of the fin there is an upward bend of the axis which is continued to the extremity, and when centra are present, they remain distinct throughout this upwardly directed part. We thus see that the main characteristics of the heterocercal tail are (1) an enlarged ventral lobe compared with the dorsal; (2) a bending upward of the axis at its end; (3) the retention of individual centra, when present, to the end of the axis.

Turning now to the homocercal type, there can be no question as to its having succeeded directly the heterocercal form. Reference to the skeletal structure of the caudal fin of *Amia* will readily shew that this particular fin requires but slight modification to convert it into a homocercal form, for homocercy is characterized by (1) external symmetry; (2) strongly asymmetrical internal skeletal structure by which the majority of the fin-rays are always supported by ventral elements; and (3) the presence in the larval or adult stage of a urostyle which represents a much shortened axis.

The caudal fin of *Amia* has always been recognized as deserving of some special distinctive designation, and it has usually been referred to as hemi-heterocercal; however since its distinctive feature is its close approach to the homocercal form, I have elsewhere[1] proposed that a better term would be hemi-homocercal.

It is well known that the earliest fishes of the Devonian period possessed heterocercal tail fins and that diphycercal forms appeared later. Thus the evidences of embryology have been said to be at variance with those of palaeontology; it is true that the evidences mentioned do not agree, but it would seem that there is no ground for denying that the embryological data are indicative of the sequence of forms in the evolution of the caudal fin. Professor Dollo[2] in dealing with the Dipnoi recognized the difference between the embryological and palaeontological evidences and suggested a way out of the difficulty. He argues that since the caudal fins of the earliest fossil fishes found are heterocercal, and later forms diphycercal, these later forms are secondarily diphycercal, *i.e.*, gephyrocercal.

Now gephyrocercy implies the complete loss of the original caudal fin elements, a great reduction of the axis having brought this about; and also that the new tail fin is in reality the result of a " bridging over " of the gap thus produced, by the dorsal and anal fins, each having an equal share in the formation of the new fin. *Fierasfer* is the best illustration of a gephyrocercal fin; the larva is known to possess a long filamentous termination to the chordal axis, which is entirely lost in the

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[1] *Proc Zool. Soc. London*, October 1910, where most of the caudal fins mentioned in this paper are figured.

[2] The Phylogeny of the Dipnoi.

adult fish; in the adult, the dorsal and anal fins have not completely joined round the extremity and the vertebral column has exactly the appearance of having been artificially abbreviated.

It does not, however, necessarily follow that all the symmetrical forms of the tail which follow the asymmetrical have once been heterocercal and that this fin has been lost entirely to be replaced by a gephyrocercal form. It is possible that something of this nature occurred: both the later heterocercal and diphycercal forms were descendants of a primitively symmetrical (protocercal) type; at a certain period, a divergence took place, some forms adopting the heterocercal tendency, while others continued in the line of their ancestors and retained their symmetry. This may be represented by a simple diagram (fig. 1).

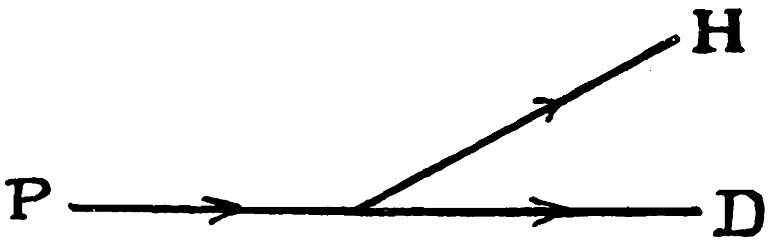

FIG. 1.

It should be noticed that this does not necessarily regard all diphycercal fins as protocercal; a reduction of the terminal axial elements might proceed by which the original caudal element might be eliminated and the dorsal and anal elements made to contribute to the new caudal fin. Thus the question of the symmetrical fin is left open, and the fossil diphycercal forms might be regarded either as protocercal or as gephyrocercal.

This interpretation would appear to be a perfectly natural one; an order of things which might easily have occurred, for the modification of such an organ is only the result of a change in habit; it cannot be expected that all fishes adopted the same form of locomotion in early times, since it is not likely that all adopted the same change of habit.

I have said that the development of heterocercy was due to a change of habit, and it is necessary to enquire what change was consequent on the adoption of the heterocercal caudal fin, or rather how heterocercy could bring about any change. An explanation is not easy even if possible. In this connection we may recall Ryder's theory of the use of heterocercy; he likens the use of the tail fin to the sculling action of the boatman, who propels his boat by a side to side motion of a single oar from the hinder end. The analogy is a good one and explains the use of the tail as a propeller, but it still leaves it uncertain why the axis turned upward and not downward; why the ventral side was chosen for enlargement and not the dorsal. It is a question mainly for the physicist to answer, and innumerable enquiries I have addressed on the point to physicists have all failed to obtain an answer.

It is thought that early fishes were bottom dwellers, and that in the attempt to explore the upper waters there was a mechanical stimulus, the response to which caused the ventral lobe to increase in order to cope with the demand made upon it. The rearing of the trunk to reach upward, causing a bend in the body convex to the bottom, would be accompanied by a lash of the tail; it would be an advantage to have the propelling force more or less in line with the anterior end of the body, and thus the ventral side of the caudal fin would have a greater demand made upon it than the dorsal.

If the fish is represented as rising from the bottom by the bent arrow in the diagram (fig. 2), the broken line will indicate the posterior continuation of the line of progress after the tail has completed a lash; the dotted lines would represent the form of fin useful for this purpose. This is merely a suggestion put forward until a better one is forthcoming, but correct or no mechanically, certain it is that all fishes with heterocercal tendencies developed the lower lobe of the caudal fin and never the upper.

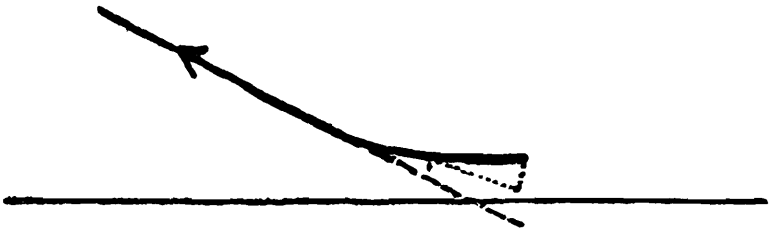

FIG. 2.

Having discussed the probable stimulus effecting heterocercy, there still remains the question as to why it was at all necessary to develop this asymmetry. When we remember that heterocercy is but a stage in the production of homocercy, it is clear that external symmetry was the ideal to be reached; why then was the symmetry of protocercy abandoned only to be again attained? Again the answer is one of mechanics; had the protocercal form been merely expanded, the internal skeletal supports of this fin could not have met the demand made upon them. The epural and hypural elements would have been long and practically parallel with the axis; this in itself would not have been mechanically strong. Moreover, the centre of the caudal fin would have been weak, there being no direct support for the fin-rays in the middle line, and it is here that strength is most needed. An essential, therefore, for a strong caudal fin is a firm support for the dermotrichia forming the greater part of the fin especially near the centre.

It is in the final product of homocercy that one must look for an interpretation of the meaning of heterocercy. The examination of such a caudal fin as that of *Scomber*, well known as one of the fastest of swimmers, shews how the result has been attained; the upturned axis provides the supports of the fin-rays with a firm attachment, and the supports are seen to radiate from a centre which is in line with that of the axis. In the majority of Teleosts the hypurals, which always support the greater number, and sometimes even the whole of the caudal fin-rays, are firmly fused to the vertebral elements. It will therefore be seen that the reason for the heterocercal stage is that the ventral fin-ray supports may be brought into the same line as that of the axis, and at the same time afford a strong attachment for them. It was the only way these ends could be achieved; symmetry had to be abandoned during heterocercy in order again to restore an external symmetry of a more efficient type.

There is still another morphological question that the above evolutionary process involves. What is the true nature of the homocercal caudal fin ? Is it a true modified caudal or is it an anal fin which has come to occupy a relatively posterior position ? If we examine almost any heterocercal caudal fin, such as that of *Acipenser* or *Polyodon*, we see that the greater part of the fin is supported by hypurals some considerable distance from the end of the chordal axis. Should the axis again be straightened, this portion would certainly be regarded as anal fin from its very position. That the vertebral axis of Teleosts, and it may be of all fishes, has been very much reduced in length is certain ; the continuation of the spinal cord beyond the last centrum is sufficient proof of this, and with this reduction the original caudal rays have gone too, unless a few dorsal rays associated with the opisthure are the last remnants. The upturning of the chorda therefore almost certainly involved the bringing of a more anterior fin, an anal, into a relatively posterior terminal position.

The question as to whether separate median fins had been yet differentiated need not seriously affect this view, for during development it can be seen that the skeletal elements of the differentiated fins are laid down before heterocercy sets in, and thus differentiated fins might be regarded as having been established during the protocercal condition in some cases at least. Differentiation, however, may not have been developed in all cases, and then it is only a matter of extended growth of a part of a continuous fin. Thus this question is not one of primary importance since certainly dorsal, caudal and anal fins are only names for portions of a once continuous series.

The supporting elements for the caudal dermotrichia are of three kinds : firstly hypurals ; secondly epurals ; and thirdly radials, either dorsal or ventral. These terms are here used according to the definitions given by me in an earlier work,[1] and it may be useful to quote them briefly. A hypural is defined as any hypaxial element having direct connection with the chordal axis, and bearing one or more caudal fin-rays distally ; an epural is the corresponding epaxial element ; a radial is synonymous with ' somactid ' and ' interspinous bone.'

One constantly sees statements which refer to hypurals as haemal arches ; Sedgwick writes [2] " In all fishes the ventral part of the caudal differs from the other median fins in the fact that the dermotrichia (fin-rays) are supported directly by the haemal arches." Such a reference is typical of text-books in general concerning caudal fins, but the matter is one deserving of discussion. As far back as 1854 Stannius in his text-book on the Vertebrata clearly stated that the fin-ray supports were compound structures, consisting of arch and radial combined. Ryder[3] in 1884 seems to have come to the same conclusion but this interpretation seems to have been ignored in more recent works.

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[1] Loc. cit.

[2] *Students' Textbook of Zoology*, 1905.

[3] " Evolution of the Fins of Fishes," *Rep. Comm. Fish and Fisheries*, Washington, 1884, published 1886.

Before entering into the question, I would again draw attention to the presence of independent radials as supports of caudal fin-rays. Dorsal caudal radials as I have called them are usually present, and are the bones referred to by Huxley[1] as epurals; ventral caudal radials are also frequently present though much less than their corresponding dorsal homologues. In all Gadidae, *Solea*, *Zeus*, *Gobius* and others, radials persist ventrally.

Now since radials are the normal supports of the dermotrichia in other median fins, we may assume that they once were in the caudal, which is merely a part of the same system. Haemal arches, therefore, cannot be regarded as the original supports of fin-rays, and if they are considered to have taken over this function, they must be regarded as having lengthened and expanded distally with a view effectively to fulfil their new function. On the other hand, radials are the natural supports of fin-rays. It is also interesting to notice which of the two elements, radials and arches, are the more persistent when subjected to eliminating influences. The flexion of the extremity of the chorda affected the dorsal and ventral side of the fin differently; epaxial elements had less room assigned to them, while the hypaxial structures were afforded scope for extended development. The response to this influence is very marked; on the ventral side fin-ray supports have expanded to fill the widening cleft between them, but dorsally suppression has resulted. But which structures dorsally have succumbed to this crowding-out process ? Not the radials but the neural arches; as long as dorsal fin-rays remain to be supported, the radials retain their function, while neural arches have disappeared or been reduced. We are forced therefore to regard radials as more persistent than arches.

When the caudal fin became a definitely propulsive organ, more rigid support was required for the fin-rays; to accomplish this there were clearly two ways open; (1) by the transference of the supporting function from radials to haemal spines, and (2) by the mere fusion of the radials with the haemal spines. The first alternative involves, one might almost say, a preconceived purpose on the part of the spines to acquire a new function; they must lengthen, expand and, in so doing, eliminate structures already performing the work they are to take over. Such a change of function is usually accompanied by a stimulus, in response to which the change takes place; but it is difficult to see what stimulus could have been applied to the haemal arches to initiate a change. The radials clearly had a stimulus, a mechanical one, and one cannot avoid concluding that they responded thereto, thus obtaining as it were a start on any other competitor.

It has been shewn that radials are more persistent than arches dorsally; is it likely therefore that in a region where extended scope for development is afforded, as is the case ventrally, that structures already well adapted for the support of fin-rays, and indeed actually fulfilling that rôle, should abandon their function in favour of structures in no way so fitted, especially when, under adverse conditions, as dorsally, they tenaciously retain that function ? It is inconceivable, and one is tempted to ask what would happen during the period of transference.

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[1] "On Some Parts of the Skeleton of Fishes," *Q. J. M. S.*, 1859

It is far easier to conceive of the very simple process of fusion of radial with the rigidly attached haemal spine, for this is exactly what would be expected. Without labouring the theoretical aspect further, it may be mentioned that there is abundant evidence among Teleostean fishes, as well as Elasmobranchs and Ganoids that such fusion has occurred; the following examples may be quoted as affording evidence: *Acanthias*, *Galeus*, *Heterodontus*, *Acipenser*, *Polyodon*, *Synodontis*, *Plotosus*, *Anguilla*, *Conger*, *Gadus*, *Gadiculus*, *Molva*, *Motella*, *Centriscus*, *Belone* (Stannius' example), *Box*, *Zeus*, and *Pleuronectes*. In all these cases the line of fusion between arch and radial can still be seen.

There is, however, another aspect worth mentioning; it has been maintained that radials are derived in the first place from neural and haemal arches by segmentation, a view which receives support from the Dipnoi, where the radials rest directly upon the spines. But the most favoured opinion does not lend support to this view since, except for the caudal, in the median fins of Elasmobranchs radials are so far removed from the axis. Were this segmentation theory correct, it might have been argued that the caudal region retains the primitive condition, but in this connection the presence of radials in the caudal fin would present a difficulty. Thus the study of the caudal fin-structure entirely supports the view that radials are elements developed independently of the axial structures.

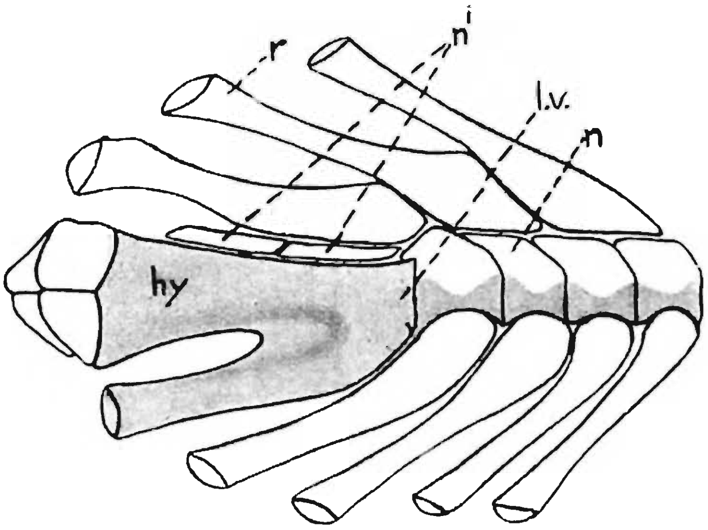

Fig. 3.—Caudal extremity of *Torpedo ocellata*.

hy., hypural; l.v., last centrum; n., neural arch; n'., neural arches of centra now suppressed; r., radial.

In concluding these remarks on homocercy, I would like to refer to the internal structure of the caudal fin of the electric torpedo, *Torpedo ocellata* (fig. 3); this fin has never to my knowledge been previously described, and I have refrained from discussing it earlier, because material has not been available to allow me to examine more than a single specimen. But even if this particular specimen was abnormal, which I doubt, it certainly is extremely useful in shewing that tendencies to the homocercal type may occur among the Elasmobranchs; indeed more than mere tendencies, in fact a homocercy which, had it been found in the Teleostei, would not have been considered strange.

The specimen was dissected by me some years ago and I believe affords the only instance of homocercy yet recorded among the Elasmobranchs. As is well known, the external form of the tail fin of *Torpedo* is symmetrical; internally, however, the ventral fin-rays are directly borne by hypurals, the two terminal ones being strongly developed, fused at their bases both to one another and to the last centrum. Above the last hypural are to be seen the remains of the neural arches of vanished centra, occasioned by the abbreviation of the vertebral column; they are still to be found because they are necessary to provide protection for the terminal portion of the spinal cord. All the ventral supports are hypurals, while dorsally the rays are borne exclusively by radials which have not fused with the neural arches.

It is possible that an investigation into the tail fin of the Rays may prove to be of considerable value; while *Torpedo* thus possesses what may be regarded as a fairly specialized type of homocercy, others may shew a simpler tendency in that direction.

XVII. STUDIES ON THE ANATOMY OF INDIAN MOLLUSCA.

2. THE MARSUPIUM AND GLOCHIDIUM OF SOME UNIONIDAE AND ON THE INDIAN SPECIES HITHERTO ASSIGNED TO THE GENUS *NODULARIA*.

By B. PRASHAD, *D.Sc., Superintendent of Fisheries, Bengal, Bihar and Orissa, Calcutta. (Communicated by permission of the Director of Fisheries, Bengal.)*

(With text-figures 1—3.)

In part one[1] of this series I described the structure of the marsupium and the glochidium of two species of the genus *Physunio*, Simpson. The present communication consists of two parts, the first of which deals with the same structures in two of the common genera of Indian Unionidae *Lamellidens*, Simpson, and *Parreyssia*, Conrad, while in the second an account of the soft parts of the animal of an Indian genus hitherto confounded with the genus *Nodularia*, Conrad, is given. A new generic name, *Indonaia* is, therefore, proposed for the Indian species. An account of the structure of the glochidium of two of the species of this genus is also included. Further, a few records of the occurrence of encysted glochidia on the fins of some Indian fishes are given.

A full histological account of the structure of the gills in these genera is not included as I hope to come to this subject later and to deal with the Indian Unionidae as a whole.

The material for this investigation consists of a collection made by Babu D. N. Sen, Zoological Assistant, Bengal Fisheries Department, and the various collections made on different occasions by the officers of the Zoological Survey of India; these latter collections were very kindly placed at my disposal by the Director of the Zoological Survey of India.

I have also to express my indebtedness to Mr. T. Southwell, the Director of Fisheries, for the kind encouragement and the generous way in which he has met with my wishes at all times. To Babu D. N. Sen my thanks are due for the careful records of locality, preservation of specimens and willing help whilst working with me in the Fisheries Laboratory.

GENERAL.

The marsupium is of very great importance in the classification and natural grouping of the genera of the Unionidae, but unfortunately at the time of Simpson's[2] revision the anatomy of the Indian genera was not known in most cases. He, however, from a

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[1] *Rec. Ind. Mus.* XV, p. 183-185, pl. xxii (1918).

[2] *Proc. U. S. Nat. Mus.* XXII, p. 501-1075 (1900).

study of the shell characters alone, placed the genera in the groups established by him primarily on the structure of the marsupium. This tentative classification has necessarily proved to be wrong in many cases. It was shown in the first paper of this series, that the genus *Physunio* should be placed in the sub-group Mesogenae of the group Exobranchiae and not in the Endobranchiae as was done by Simpson. As a result of my investigations on three of the commoner Indian genera, it has been found that these also have been assigned wrong places. *Lamellidens* and *Parreyssia* were placed in the sub-family Hyrinae, which are, according to Simpson, primitive forms, and carry the glochidia in the inner pair of gills (Endobranchiae). Preston in the official " Fauna of British India "[1] has followed Simpson, *loc. cit.*, adding nothing new so far as the anatomy was concerned, and even neglected the various important contributions on the anatomy of some of the Indian Unionidae published since Simpson's revision was issued. These observations of mine are, in part, a confirmation of what was found by Ortmann[2] as a result of his study of the animals of *Parreyssia wynegungaënsis* (Lea) and *Lamellidens consobrinus*, Lea. Preston on page 180 of the volume cited above considers the latter to be only a subspecies of *Lamellidens marginalis* (Lamarck). Ortmann found that the position assigned by Simpson to the genera *Parreyssia* and *Lamellidens* was quite wrong. Both these genera were, from the structure of the marsupium, found to be exobranchous, and in his revision he placed them in the sub-family Unioninae of the family Unionidae. This sub-family he characterised as having the " Marsupium formed by all four gills or by the outer gills only ; edge of marsupium always sharp and not distending ; water-tubes not divided in the gravid female." Unfortunately the material which Ortmann had at his disposal was very small and consisted of sterile or unripe females from Bombay.

In the case of the third genus *Nodularia*, Conrad, it was found that in the two Indian species investigated the animal was quite different from that of *N. aequitaria* (Morelet), and *N. japanensis* (Lea), and that the Indian forms of this genus unlike the Japanese and the African endobranchous forms should be placed in the Exobranchiae. This subject is treated in detail further on in the account of the genus, which has for this reason been separated from the genus *Nodularia* and called *Indonaia*.

Lamellidens.

Two varieties of the common Indian species *L. marginalis* (Lamarck) were studied. The first is a variety very little different from the typical form and may for the purpose of the present paper be considered as such. The nomenclature of the varieties and subspecies of *L. marginalis* is in a very confused condition. Gravid specimens of this form were collected in a tank at Bora near Serampur in the Hughly district, Bengal, on the 1st of April, 1918. The outer pair of gills, which alone formed the marsupium, were found to contain large numbers of unripe glochidia. Specimens were kept in large bowls in muddy water, but no further

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[1] *Mollusca, Gastropoda and Pelecypoda*, p. 134 (1915).
[2] *Ann. Carnegie Mus*, VIII, pp. 222-365, pls. xviii-xx (1911-12).

development took place. In the other variety *obesa* (H. and T.) also only the outer pair of gills serve as the marsupium. I have found by a study of sections of the gills of males, gravid and sterile females that the differences in the structure of the respiratory and marsupial gills, originally described by Peck[1] for the gills of *Anodonta* and later on found by Ortmann[2] to be constant in a large number of other genera as well, are the same in *Lamellidens* and *Parreyssia*, and so need not be detailed here. In the marsupial gills the inter-lamellar junctions are more numerous than in the respiratory gills, the epithelial covering of the lamellar junctions is modified; whereas in the purely respiratory gills of the female and those of the male the inter-lamellar junctions are fewer and the epithelial covering is of the ordinary type. As expected by Ortmann the gills do not swell very much when full of glochidia and their lower margins are always sharp and distended. In the first variety no glochidia were found but the embryos were found to be agglutinated together to form a flat more or less elliptic plate, thick and broad above, thin and tapering below.

The glochidia of the second variety *obesa* (H. and T.) may be described as semi-elliptic (fig. 1*a*) with a rounded ventral margin, the hinge-line rather long and nearly straight and measuring ·248 mm. by ·210 mm.

Parreyssia.

The number of species and varieties of this genus which was studied was much larger than of the others. In the following table I give the locality, date on which collected, the gills in which the glochidia were found and the size of the glochidia. It is of interest to note that the specimens were from such widely separate localities as Eastern Bengal, Chota Nagpur and the Western Ghats in the Bombay Presidency. One of the forms which I have marked with a query seems to be either an undescribed variety of *P. favidens*, or possibly a distinct species.

Name.	Locality.	Date of collection.	Gills with glochidia.	Size of glochidia.
P. favidens (Benson)	Mirpur, E. Bengal.	1st week of June, 1917.	All four gills	·210 mm. × ·153 mm. (fig. 1*b*).
P. favidens var ?	Do.	Do.	Right inner gill	·190 mm. × ·073 mm. (fig. 1*c*).
P. favidens var. *assamensis*, Preston.	Do.	Do.	Inner pair of gills	·172 mm. × ·142 mm. (fig. 1*d*).
P. favidens var. *tripartitus* (Lea).	Do.	Do.	All four gills with embryos.	?
P. favidens var. *viridula* (Benson).	Chakradharpur, Chota Nagpur.	3rd February, 1918.	All four gills	·229 mm. × ·190 mm. (fig. 1*e*).
P. corrugata (Müller)	Medha, Bombay Presidency.	27th February, 1918.	Do.	·191 mm. × ·150 mm. (fig. 1*f*).
P. corrugata var. *nagpoorensis* (Lea).	Mirpur, E. Bengal.	1st week of June, 1917.	Outer left full, outer right with a few only.	·174 mm. × ·153 mm. (fig. 1*g*).

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[1] *Q. J. Microsc. Sci.* XVII, pp. 43-66 (1877).

[2] *Mem. Carnegie Mus.* IV, pp. 279-347, pls. lxxxvi-lxxxix (1911).

Though the glochidia were not found in all cases to fill up all the four gills, yet in *P. favidens* var. *tripartitus* all the four gills were full of embryos, and in the typical form of *favidens*, *P. favidens* var. *viridula*, and *P. corrugata* all the four gills contained glochidia. In the other varieties the structure of all the four gills was modified for a marsupial function and the absence of glochidia in some of the gills seems to be due to their having been shed before the specimens were collected.

The structure of the gills and the water-tubes is very similar to that in the genus *Lamellidens* described above.

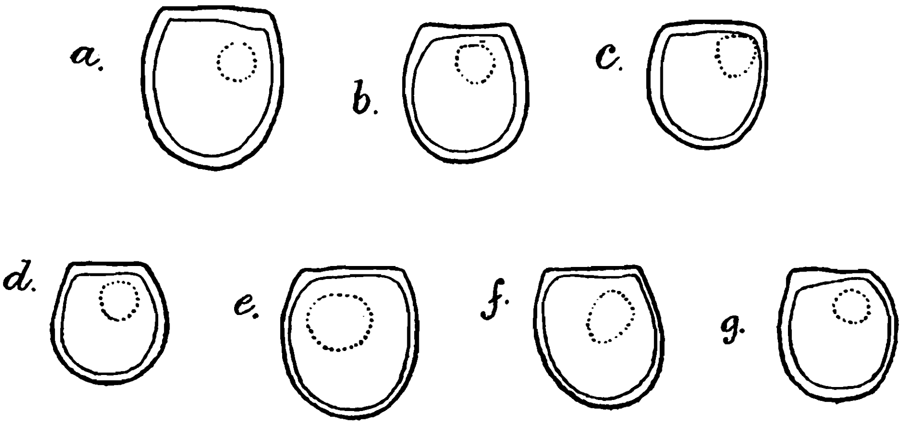

Fig. 1.

Glochidia of (a) *L. marginalis* var. *obesa*, (b) *P. favidens*, (c) *P. favidens* var. ? (d) *P. favidens* var. *assamensis*, (e) *P. favidens* var. *viridula*, (f) *P. corrugata*, (g) *P. corrugata* var. *nagpoorensis*.

The glochidia, as will be seen from the figures (fig. 1 *b*—*g*) all of which are drawn magnified 75 times, are semi-circular or semi-elliptic. In their structure, sculpture of the shell and the nature of the flange on the inner and lower surface of the shells they are quite like those of the genus *Physunio* described in my paper, *loc cit.*

Indonaia, gen. nov.

Simpson in the paper cited above included in the genus *Nodularia*, Conrad, a number of groups of shells of such wide range as Japan, China, Siam, India and Africa. The anatomy of some of the members was known, but the others like the Indian forms were included because of the shells having a close resemblance to those of the genus *Nodularia*. Haas[1] in his account of the genus *Nodularia* included only the species found in Siam, Cambodia, Annam, China, the Amur region, Korea and Japan, apparently considering the Indian species to belong to a distinct genus. As a result of my investigations of the soft parts of the animals of some of the Indian species, it was found that these species had no relationships with those that properly belong to the genus. Whereas the species *N. japanensis* (Lea), a Japanese form, and *N. aequitoria* (Morelet), an African one, carry the glochidia in the inner pair of gills (endobranchiae) and belong to the sub-family Hyrinae of the family

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[1] Martini und Chemitz, *Conch. Cab.*, (*ed. Kuster*) IX, Abth. 2, pt. 2, Die Unioniden (1910).

Unionidae of Simpson; the Indian species investigated carry the glochidia in all the four gills (endobranchiae), and will have to be placed in the sub-family Unioninae of Simpson or according to the later classification of Ortmann[1] in the restricted sub-family Unioninae, Ortmann. None of the older names being available, the generic name *Indonaia* is proposed for the Indian species with *Unio caeruleus*, Lea, as its type. I have as yet been able to examine the animals of *I. caerulea*, *I. caerulea* var. *gaudichaudi*, *I. pachysoma* and *I. pugio*. In these the description of the soft parts given below was found to be constant. It is to be expected that the structure of the animal in the other Indian species. hitherto assigned to the genus *Nodularia*, would be similar, and the genus *Indonaia* would therefore include all the species described by Preston, *loc. cit.*, pp. 135-146.

I have nothing to add to the following description of the shell given by Simpson for the group of *N. caerulea*, " shell elliptical, inflated, pointed about midway up behind, the post basal region produced, with a well developed posterior ridge; beaks sculptured with numerous fine, radiating riblets, the central ones of which join below, the whole often more or less zigzagged, and extending well over the disk; epidermis generally bluish-green."

The animal (fig. 2) may be described as having the inner gills much wider than the outer both in front and behind. The inner lamellae of the inner gills are not free but united with the abdominal sac throughout and with each other behind to the end. The palpi are rather large; the mantle has the margin simple and not toothed; the branchial opening is large with three to four rows of pointed papillae; the anal opening smaller than the branchial of a light brown colour without any tubercles; the supra-anal opening separated from the anal by a distinct mantle connection which is rather short. The supra-anal opening itself is

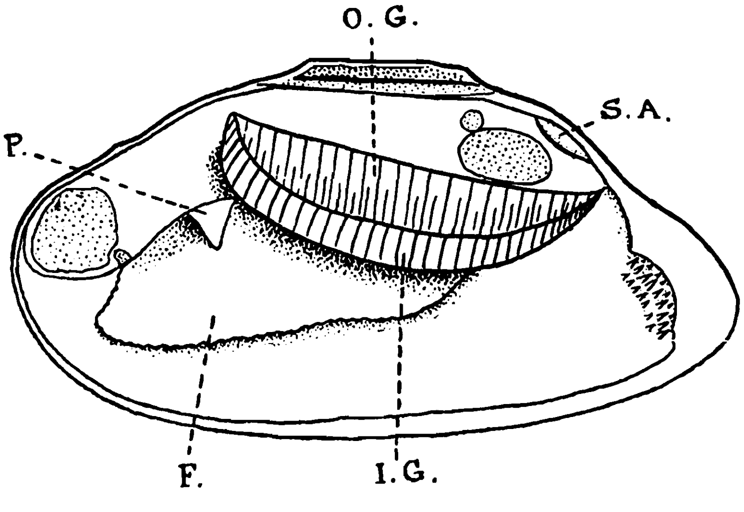

Fig. 2

Animal of *Indonaia caerulea* var. *gaudichaudi*. *F.*=foot, *I. G.*=Inner gill, *O. G.*= Outer gill, *P.*=Palp, *S. A.*=supra-anal opening.

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[1] *Ann. Carnegie Mus.* VIII, pp. 223-224 (1911-12).

smaller than the anal and of a brownish colour. The glochidia are carried in all the four gills.

The glochidia are nearly ovoid, with a very small, straight hinge-line and a small hook on each shell (figs. 3 *a-c*). Gravid specimens of two species were obtained, *I. caerulea* var. *gaudichaudi* and *I. pachysoma*. Females of *I. pachysoma* were collected on the 14th of January 1912, in a lake nine miles from Berhampur, Bengal; the glochidia (fig. 3 *a*, *b*) are ·248 mm. by ·115 mm. in size. The specimens of *I. caerulea* var. *gaudichaudi* were collected on the 1st of April 1918, from a pond four miles from Serampur, in the District of Hughly, Bengal. The glochidia (fig. 3*c*) measure ·289 mm. by ·182 mm.; they are of the same type as that of *I. pachysoma* except that they are bigger.

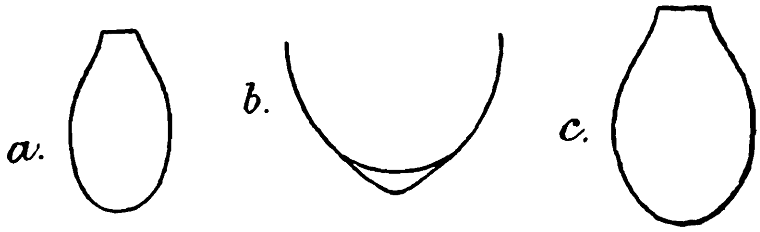

Fig. 3.

Glochidia of (*a*) *I. pachysoma*, side view. (*b*) Inner view of the lower portion of the shell of the glochidium of *I. pachysoma*, showing the hook. (*c*) Glochidium of *I. caerulea* var. *gaudichaudi*.

The glochidia of this genus are very different from those of the other known Indian genera. They differ in shape and show a distinct advance in that the flange on the lower margin of the shell of each side is becoming more highly evolved and is restricted to a hook in the centre.

FISH HOSTS.

In this section I do not attempt at any specific identification of the glochidia, which were found encysted on the fins of a large collection of fishes from the Satara and Poona districts of the Bombay Presidency. The localities and the conditions under which these fishes were collected are fully discussed by Dr. Annandale in the systematic account of these fishes to be published shortly in the "*Records*," and I need no more than give a list of the various species which were found to have glochidia on their fins.

Nemachilus savona (Ham. Buch.).
Nemachilus anguilla, Annandale.
Psilorhynchus tentaculatus, Annandale.
Cirrhina reba (Ham. Buch.).
Barbus malabaricus, Jerdon.
Barbus jerdoni, Day.
Barbus ticto, Day.
Rasbora daniconius (Ham. Buch.).
Danio aequipinnatus (McCl.).
Chela boopis, Day.
Ophiocephalus gachua (Ham. Buch.).
Gobius bombayensis, Annandale.

XVIII. NEW SPECIES OF SLUG-LIKE MOLLUSCS BELONGING TO THE FAMILY ZONITIDAE FROM THE DAWNA HILLS, TENASSERIM, COLLECTED BY DR. F H. GRAVELY.

By Lieut.-Colonel H. H. GODWIN-AUSTEN, *F.R.S.*

(Plate XVIII.)

So long ago as 1912 I received a collection of shells made in the winter of 1911 in the Amherst District, Tenasserim, by Dr. F. H. Gravely of the Indian Museum, Calcutta. Undoubtedly the most interesting new species obtained are those I now describe, slug-like forms belonging to the genera *Austenia* and *Girasia.* I am much indebted to Dr. Gravely for seeing them, and I have much pleasure in naming one *Girasia* after its discoverer. Unfortunately there are few examples to deal with, and I have hesitated to cut up type specimens to see the internal anatomy. It is, I know, very difficult at certain seasons to find many specimens of these molluscs ; if it be possible 6 at least should be collected, the whole anatomy can then be seen and a couple reserved for the Museum.

The photographs have been made by my friend Mr. J. S. Gladstone, they are very good and my best thanks are due to him.

These and allied genera are very abundant at the wettest season of the year, but with diligent search under stones and logs of wood they may be found at any time. Their preservation in alcohol is a difficulty and the collector must be prepared to face leeches and malaria. From the malacological point of view they form a most interesting group. Their exact distribution specifically is little known. Take for instance *Girasia peguensis,* Theobold.[1] Nothing is known of those inhabiting Hill Tipperah, the Chin Hills, Northern Burma and the Shan States, this large forest-clad area would yield many many species, probably even new genera.

This paper would have been published before now, but the large Abor collection took up much of my time. The times besides have been against and affected work of this kind.

Girasia ? sukliensis, n. sp.

(Pl. XVIII, figs. 1—3.)

Locality.—Sukli, Dawna Hills, 900-2,300 ft., Tenasserim, November, 1911 (*F H. Gravely*).

Shell extremely thin, filmy and undeveloped ; colour near the rounded apex white, rest pale green.

Size.—Major diameter about 9 mm.

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[1] *Moll. India,* vol. I, p. 227, pl. lix, figs. 6, 6*a*, 6*b* animal, 6*c*, 6*d* shell.

Animal (figs. 1 and 2).—About 26 mm. in length, contracted, pale grey in colour, with rather large scattered spots of black with smaller spots along the peripodial margin; mantle and head dark grey.

The side of the foot has a papillate surface, the oblique grooves from the margin close and distinct; foot sharply keeled up to the depression in which the shell rests, square at extremity, the mucous gland being a very narrow slit. Sole of the foot narrow with a well marked central area, bordered on each side by a very finely segmented one.

Right shell lobe very small, oblong, narrow, rounded at the posterior end. Cicatrical line well marked. Left shell lobe broadly covering the edge of the peristome. Right dorsal lobe small, the left large, spreading over the neck and round to the left posterior side, thus similar to *G. peguensis* (fig. 3).

The visceral sac extends far back to near the extremity of the foot. The short oesophagus passes into a very capacious stomach and then continues into the lobes of the liver. The generative organs were atrophied, but sufficiently developed to show they are like those of *Girasia.* Only the amatorial organ was conspicuous.

Girasia gravelyi, n. sp.

(Pl. XVIII, figs. 7, 8.)

Locality.—Sukli, Dawna Hills (east side), Tenasserim (*F H. Gravely*).

Shell polished, shiny; apex very small, with the very slightest sign of a coil.

Size.—Major diameter 10 mm.

Animal (figs. 7 and 8).—Length contracted in alcohol 28 mm., of a general dark grey colour with distinct irregular blackish spots on the side of the foot, peripodial (the fringed) margin narrow with two grooves above, its segmentation fine, and this applies to the foot above, the usual oblique grooves being indistinct and close together with the surface broken up into minute quadrate and pentacular areas, becoming almost papillate. The foot behind is square to the sole, with a slit-like mucous gland, it is sharply keeled up to the depression in which the shell and visceral sac rests. The sole of the foot has a central area, but is not crossed by segmental grooves. The mantle is very dark, rather smooth; a distinct cicatrix proceeds from the respiratory orifice upwards and backwards separating the narrow oblong right shell lobe, its rounded end just covering the anterior margin of the shell. The dividing line between these shell lobes and the right dorsal and left dorsal lobes is well seen.

In its general form this species comes nearest to *G. sikkimensis,* G.-A., *Moll. Ind.*, Vol. 1, p. 239, plate lix, figs. 2-2*a* (animal), 2*b* (shell).

Austenia dawnaensis, n. sp.

(Pl. XVIII, figs. 4–6.)

Locality.—Dawna Hills (west base), at 1,400 ft., only one specimen (*F. H. Gravely*).

Shell spatulate, coil of apex fine; sculpture none, surface smooth and shining; colour ochraceous with a green tinge; suture short impressed; whorls 1½.

Size.—Major diameter 15·5; minor diameter 9·5 mm.

Animal (figs. 4 and 5).—Spirit specimen much contracted, 39 mm. in length. Two peripodal grooves lie above the edge of the foot, the area between them regularly segmented, the segments of the fringed margin extending beneath the foot, but do not cross the median area of the sole of the foot.

Mucous gland a narrow slit, nearly vertical and very slightly overhanging above, extremity of foot keeled for a short distance, then rounded as it approaches the shell, the apical part of which rests in a depression. Regular segmental grooves becoming close-set extend from the irregular upper peripodial groove to the keel.

The right shell lobe is very small, the left extends all round the peristome as a narrow band, leaving much of the shell exposed, a short cicatrix divides them running to the respiratory orifice; the right dorsal lobe is small, the left is very broad and ample up to the posterior margin.

The frontal side of the animal (fig. 6), although much contracted, gives an interesting view of the mouth, and shows the segmented sides of the foot and its plain central area.

Austenia ? dawnaensis, young.

Locality.—Dawna Hills, Tenasserim (*F H. Gravely*).

Shell broken by sudden contraction in the spirit, very thin and spatulate.

Size.—Major diameter 13·0 mm.

Animal.—Pale coloured, dark on head and neck, and darkish on the forepart of the mantle.

The margin of the foot is fringed, but the usual grooves above it cannot be discerned, in fact the whole body is quite smooth, from some change, probably after being put into alcohol. Sole of foot similarly quite plain.

There is a small right shell lobe, while the left shell lobe overlaps the edge of the peristome right round from the respiratory orifice to the left side. The right dorsal lobe is very small, the left very ample. The extremity of the foot is truncate, the mucous gland a narrow slit.

This specimen may be compared with *A. dawnaensis* (No. 6063) in its general external characters and may possibly be a young specimen.

EXPLANATION OF PLATE XVIII.

FIG. 1.—*Girasia sukliensis*, n. sp., view of right side. × 2.

,, 2. ,, ,, ,, view of dorsal side. × 2.

,, 3. ,, ,, ,, mantle seen from above, with visceral sac, shell removed. × 4·5.

,, 4.—*Austenia dawnaensis*, n. sp., view of right side. × 1·5.

,, 5.— ,, ,, ,, view of dorsal side. × 1·5.

,, 6.— ,, ,, ,, view of frontal side. × 3·25.

,, 7.—*Girasia gravelyi*, n. sp., view of right side. × 2.

,, 8.— ,, ,, ,, view of dorsal side. × 2.

XIX. CONTRIBUTIONS TO THE ANATOMY OF AQUATIC DIPTERA.

1. LARVAL AND PUPAL STAGES OF AN INDIAN *CHAOBORUS* AND *DIXA*.

By BAINI PRASHAD, *D.Sc., Superintendent of Fisheries, Bengal Fisheries Laboratory, Indian Museum, Calcutta. (Communicated by permission of the Director of Fisheries, Bengal.)*

(With Plate XIX.)

In a previous communication[1] I described the anatomy of an Indian Chironomid larva of the genus *Polypedilum*. The present paper deals with the larval and pupal stages of two other Nematocera—*Chaoborus* and *Dixa*. It is hoped that it may be followed by others on various aquatic Diptera, our knowledge of the Indian forms being in a very unsatisfactory condition. Most of the material for the present investigation was put at my disposal by the Director of the Zoological Survey of India; some I had collected myself.

The larvae and pupae of the Corethrid *Chaoborus* were collected by Dr. Annandale in the *Limnocnida* pool in the river Yenna, at Medha in the Satara district, Bombay Presidency, during the first week of March, 1918; the material was well preserved, and both larvae and pupae were found in abundance. Besides this I had a large number of larvae collected in the third week of April, 1912, at the same place by Dr. F. H. Gravely. No pupae were obtained on this occasion, though larvae were abundant. I also had for comparison a single specimen collected by myself in a shady pool in the Lawrence Gardens, Lahore, in the month of November, 1916; observations were made on this living larva whilst it was kept in a small aquarium in the Zoological Laboratory of the Government College, Lahore, for a period of over two months; the larva even after this long period did not pupate and was preserved in formalin. A few remarks about the name of the fly to which the larvae and pupae belong would not be out of place here. Giles[2] in 1910 described the fly as *Corethra asiatica* as a new species from Shahjahanpur, and it was referred to as such by Theobald.[3] Edwards, however, has recently[4] shown that the form is specifically identical with the one described by Schiner in 1868 as *Corethra manilensis* (*Reise Novara, Diptera*, p. 30). Further, the species does not belong to the genus *Corethra* as now restricted, but is a *Chaoborus*. The name of the fly must, therefore, be *Chaoborus manilensis* (Schiner).

The larvae and pupae of *Dixa* were collected by Major S. R. Christophers, I.M.S., from the hill streams at Kasauli in February, 1914. A large number of flies was reared by him, and the whole collection of

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[1] *Rec. Ind. Mus.*, XIV, pp. 71-74, pl. xxiii (1918).

[2] *Journ. Bombay Nat. Hist. Soc.*, XIII, p. 610 (1910).

[3] *Genera Insectorum, Diptera*, p. 43 (1905).

[4] *Bull. Ent. Res.*, IV, p. 242 (1913-14).

larvae, pupae and flies presented to the Indian Museum, Calcutta. The fly has been identified as *Dixa montana*, Brun., by Dr. Annandale after comparison with the type-specimen. Mrs. Adie [1] has recorded the finding of a large number of larvae of a species of *Dixa*, in a pond in the Lawrence Gardens, Lahore. On many occasions I tried in the same place to obtain specimens but without success.

LARVA OF *CHAOBORUS MANILENSIS*.

The larvae at Medha were found in seven to twelve metres of water, over a hard rock bottom covered with a thin layer of vegetable débris and fine gravel, the water was muddy and opaque, and a slight trickle of water was running in and out of the pool. The pond at Lahore is an artificial one, overhung by large trees, and is about twenty feet across and three to five feet deep ; it is full of dead leaves and the water is of a muddy darkish colour ; it is every now and then replenished from a canal.

Observations made on the living larva at Lahore showed that its habits are identical with those of the European species described by Miall.[2] It may be mentioned, however, that those described by him (*op. cit.*) and by Wiesmann[3] as *Corethra* belong, like the form considered in this paper, to the genus *Chaoborus*, Lichtenstein. The larva of the genus *Corethra*, Meigen, is quite distinct, and is what is described by Miall on page 121, as the larva of *Monochlys*. Very good figures of the larvae of *Chaoborus* and *Corethra* are given by Howard, Dyar and Knab.[4]

The full grown larvae are 7—8 mm. long. When living they are transparent with the four air-sacs opaque and coppery. The alimentary canal has a faint reddish tinge, especially in the middle region of the abdomen. In older larvae the mass below the abdomen was tinged with orange. The preserved specimens are milky white, the air-sacs brownish black, the head round the eyes dark brown, elsewhere of the same colour as the body ; the eyes themselves are of a dense black colour. The division of the body into head, thorax and abdomen is very distinct ; the neck is very small and in many specimens, owing to the head being drawn underneath the thorax, cannot be seen. The *head* is a very small structure, narrower than any of the body segments except the last abdominal. Seen in a side view it is more or less triangular, while in a dorsal view the basal part appears quadrangular with the eyes at the anterior angles. The anterior part of the clypeus is of the shape of a very much elongated and vertically flattened process, with the extremity of which the antennae are articulated ; there being no pre-antennal portion of the head. On the ventral side a little behind the point of attachment of the antennae there is a large bunch of setae hanging down from the vertical process of the clypeus mentioned above. Behind the group of setae there are two elongated triangular flaps attached to the same process ; these flaps are mobile and have their pos-

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[1] Patton and Cragg, *Entomology*, p. 190 (1913).

[2] *The Natural History of Aquatic Insects*, pp. 113-122 (1903).

[3] *Zeits. f. Wiss. Zool.*, XVI, pp. 45-127, pls. iii-vii (1866).

[4] *The Mosquitoes of North and Central America and the West Indies*, I, p. 168, pl. viii (1912).

terior margin fringed with minute hairs. Further back is the *labrum* (fig. 2), which is an elongated structure and has a large number of setae arranged in a brush-like manner at its tip. The *mandibles* (fig. 3) are large, plate-like, with a narrow base, and have six large teeth on their anterior and upper margin and five small rounded serrations on the inner; besides there is near the upper margin on the outer side a small projection with six very long and broad bristles arising from its surface. The first pair of *maxillae* are reduced to small protuberances, each with two setae at the tip, and the *labium* is only a very small plate. The *eyes* are rather ovoid structures with a single large ocellus lying in a depression on the posterior margin of the eye. The *antennae* are large prehensile organs, consisting of a single joint; the line of attachment to the head is nearly straight; the outer margin of the antennae is concave; along the inner margin there is a deep notch close to the base, beyond which the line is straight; the tip is armed with four very long bristles. A few scattered setae are to be seen on the clypeus and just behind the eyes.

The *thorax* is a fairly massive structure; in full grown specimens it is thrice as broad as the head. On the dorsal surface of the thorax there are three groups of setae on each side; the first or the prothoracic group has two plumed setae, the second a simple and three plumed and the third only three plumed ones. The *air-sacs* are more or less kidney-shaped with the pigment arranged in small triangular or squarish areas; they are rather small as compared with those of the common European and American forms, being about one-sixth of the total thoracic length.

The *abdomen* consists of nine segments. The first six segments increase regularly in length and breadth, and the seventh and eighth gradually taper to the ninth segment. Each of the segments I—VIII bears a single plumed seta on each side dorsally and two plumed setae ventrally. The *air-sacs* on the seventh segment are, like those of the thorax, of a comparatively small size. The ninth segment has, close to its base, a papilla in the mid-dorsal line with two setae arising from it; posterior to it are two more papillae but without any setae; ventrally there is the large fin formed of nineteen long fringed bristles of the same type as described by Miall, *op. cit.* At the tip of the abdomen (fig. 4) there are four small triangular gills close to the anus. Above the gills are four very long feathered bristles arising in groups of two; below the gills is a large area something like the abdominal feet of *Chironomus*, and covered like these with two kinds of hooks (fig. 5), which are arranged, the larger and slightly curved ones in the centre and the smaller and more curved ones at the edges.

PUPA OF *CHAOBORUS MANILENSIS*.

A point in which the habits of these pupae differed from those of Palaearctic species was that they did not rise to the surface but remained floating in a vertical position close to the bottom; the large baloon-shaped breathing trumpets keeping them in this attitude. The very minute openings of the breathing trumpets, to be described later, seem to be due to the peculiar habitat in which they live, as finely powdered mud would choke up open trumpets, there being no large setae to guard the openings as there are in other Culicidae; and the gradual closing of the openings of the trumpets seems to have been evolved as a direct response to the surroundings in which these pupae are found. In captivity the adults were hatched only late at night and no observations were therefore made on the manner in which they rose to the surface. The pupa (fig. 6) is easily distinguished by the very long abdomen, and the comparatively small cephalo-thoracic mass, the peculiar breathing trumpets and the well-developed tail-fins.

The pupa is 6·9 mm. long, and the size of the cephalo-thoracic mass is 2·1 mm. by 1·7 mm.

In the cephalo-thoracic mass of the advanced pupae the large compound eye of each side with the single ocellus behind it and the antennae can be distinguished. The legs, the wing and the halter of each side can also be seen in their envelopes. Near the upper edge, arising from the dorso-lateral margins, a single seta is present on each of the pro-, meso- and metathoracic regions. The nymphal *breathing trumpets* are large swollen structures appearing baloon-shaped in the living pupae. They are broadest in the middle gradually narrowing to the point of attachment. The wall of the trumpet is formed of small quadrilateral areas. The outer openings are very minute slits on the upper margin.

In the abdominal portion, the segments regularly increase in length from the thorax onwards, except for the last one, which is very small. Dorsally each segment bears two setae one on each side, and there is a similar arrangement ventrally. From the last segment two triangular flaps hang out below the tail-fins. The tail-fins (fig. 7) are large, broad structures with a very thick inner margin owing to a tracheal tube running along the edge; this edge is setose; the outer edge is thinner and has no setae; in the substance of the tail-fins of each side four other thickenings due to tracheal tubes can be distinguished.

LARVA OF *DIXA MONTANA*.

The larvae were collected in mountain streams at Kasauli in the Western Himalayas.

Full-grown larvae (fig. 8) measure about 9 mm. in length, smaller ones from 3—6 mm. are also present in the collection. The general colour of the preserved specimens is brownish-black alternating with paler areas on the dorsal surface, while the ventral surface is light yellow. The head and the tail-fins are dark brown.

The *head* is a small but massive structure formed of thick chitin. The post-antennal portion is quadrilateral, the anterior pre-antennal, which is much darker in colour, being triangular with the apex rounded off. The *eyes* are rather small, ovoidal, situated ventro-laterally behind the point of insertion of the antennae. The *antennae* (fig. 9) are slightly curved single-jointed structures about two-thirds of the length of the head, with the shaft and tip covered with closely-set minute spines.

Mouth-parts.—The pre-antennal portion of the head ends in the large *labrum* which, with its very well developed pair of feeding brushes, overhangs the mouth-opening. The *mandibles* (fig. 10) are large and elaborate in structure; from the outer angle of the upper margin arises a stout curved bristle hanging freely forwards. Internally the apex of the margin, which in the natural position faces that of the mandible of the other side, bears a large fringe of setae arranged on a crescentic ridge a little behind the edge; these setae together with the feeding brushes of the labrum are constantly in motion and sweep the food particles into the buccal cavity. A little above the middle there are two large teeth while the lower half is finely serrated. The first pair of *maxillae* (fig. 11) are quadrangular in outline with a well developed palp inserted near the base on the outer side; the palp like the antennae is spinose and of the same shape, though a little smaller. The inner margin of the plate of the maxillae is beset with long hairs, those at the apex being specially well developed and curved. The *second pair of maxillae* are united to form a triangular *labium*, which forms the floor of the buccal cavity.

The three segments constituting the *thorax* are quite distinct. Seen from above the segments are rectangular in outline. The middle segment is the largest of the three. The first segment has five simple setae on each side, arising near the anterior edge, and a single one behind this group. The second bears laterally two setae on each side; the third has no setae.

The eight segments of the *abdomen* are quite distinct. The first and second segments are peculiar in having two small feet, one on each side; these feet bear two types of hooks, the arrangement of which is the same as those described in *Chaoborus*, the larger ones in the centre and the smaller ones along the edges. The second to the seventh abdominal segments bear the so-called " shields " (Miall, *op. cit.*) on their dorsal surface. These are only the dorsal surfaces of the segments marked off as ovoid or nearly circular structures by the setae arranged along their margins. The setae are both simple and plumose, and are of use in supporting the surface-films of water, when in the looping movements the larva brings it above the surface. The absence of these shields in certain other species of *Dixa* larva suggests that they, together with the setae, may be efficient suckers of use to larvae living in rapid torrents in the hills, but I have no definite facts to support this assertion. On the ventral surface of segments five to seven there is, in addition to the shields mentioned above, a comb-shaped structure formed of minute brown spines attached in a transverse axis near the posterior margin of the segments. The structure of the eighth segment is very peculiar, having special bearings on the relationships of *Dixa*, and has, so far as I know, not been adequately described for any species. The segment itself is very large, the basal part being rectangular, with an elongated conical portion of a brownish colour projecting from the basal part. The tip of this conical portion bears three long setae on each side. On the two sides, and arising from the hind edge of the rectangular portion, are two triangular chitinous plates of a dark brown colour; these will be referred to again in the account of the respiratory or breathing portion. With each of these plates a rather elongated ovoid fin of a dark brown colour articulates; both the plates and the fins have a fringe of long setae along the inner and outer margins.

The spiracles, or the openings of the respiratory system of the larva are two in number, one on each side, situated in a slight depression on the dorsal surface of the eighth segment near the posterior margin of its rectangular portion. The spiracles are surrounded by six chitinous plates. When the larva is floating on the surface, the plates are spread out (fig. 8), and expose the spiracles to the air; when, however, the larva goes down from the surface, the plates, as in the larva of *Anopheles*, fold and with the fringes on their margins form a nearly closed cavity over the spiracles, enclosing air, which prevents water from entering the spiracles. The arrangement and shape of these plates is as follows: Anteriorly there is a large transverse plate bearing seven or eight groups of four to five setae each; from its position and the attachment of setae this thick plate appears capable of being turned over the spiracles, which from their situation would then be drawn underneath it. Arising behind the spiracle on each side is a chitinous plate of the shape of a tennis-racket; it is attached by the base of its handle; the broader portion, which stands free outside, is setose all along the margin. The chitinous plates further behind consist of a large crescentic plate, broad in the middle and drawn out along the two edges; these drawn-out portions are supported by the triangular plates with which the fins articulate.

This arrangement of the breathing mechanism of *Dixa* appears to be homologous with that of *Anopheles*, only it is on a lower grade of organization, all the essentials being the same. Both the mouth-parts and the breathing apparatus of *Anopheles* can be very easily derived from those of *Dixa*; and the resemblances do not seem to be of the nature of convergence, but rather to show a near relationship.

PUPA OF *DIXA MONTANA*.

The pupa (fig. 13) is comma-like in appearance owing to the abdomen being bent under the large cephalo-thoracic mass. It is of a dark yellowish colour.

The cephalo-thorax measures 2 mm. by 9 mm. The divisional lines between the various abdominal segments are very well marked, and there are well developed ridges on the abdominal segments; there being no hairs or setae anywhere. The opening of the breathing trumpets is small, more or less squarish and lateral in position as usual. The tail-fins (fig. 14) are peculiar in being very much reduced triangular flaps, which are produced into a long regularly tapering spine a little smaller than the fins.

XX. FRESHWATER SHELLS FROM MESOPOTAMIA.

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Zoological Survey of India.

(With Plate XX.)

The shells discussed in this paper were found for the most part in what may be called a subfossil condition. Some of them may now be extinct in the districts in which they were collected, but this seems to be improbable in most cases, and some have certainly been deposited by recent inundations. The collection was made at two localities; in the neighbourhood of Nasariyeh on the Euphrates, near where it now joins the Tigris, and at Samara on the latter river. For most of the specimens I have to thank Lieutenant-Colonel W H. Lane, whose valuable notes have been of great use in considering the environment in which the different species lived; for others I have to thank Bombardier R. Hodgart, who in civil life is a collector attached to the Zoological Survey of India, and while on active service has not neglected to obtain specimens for presentation to the Indian Museum.

The specimens from the neighbourhood of Nasariyeh are from three different deposits, probably of different age but in no case of great geological antiquity. Some are from a place annually inundated by the Euphrates, others from an almost superficial deposit now separated from the bank of the river but once probably the bed of a pool or backwater connected with it in the floods if not perpetually, while others again are from the bed of a shallow lake that has been filled from time to time with sand. There is some evidence that this last deposit was laid down in water that was or had recently been brackish. The specimens from Samara were found in the dry bed of an ancient tank and all the shells are white and opaque. Amongst the freshwater forms I found a number of money cowries (*Cypraea* (*Aricia*) *moneta*, L.), the presence of which is evidently fortuitous and due to man, and also shells of at least two species of Helicidae, which I shall not attempt to name.

The shells from the most recent deposit on the banks of the Euphrates at Nasariyeh belong to the following species :—

GASTROPODA.	PELECYPODA.
Neritina jordani	*Corbicula fluminalis*
Melania tuberculata	*Corbicula cor*
Melanopsis nodosa	*Unio calliopsis*
Limnaea spp.	*Unio tigridis*
Planorbis convexiusculus	*Unio ciconius*
Bullinus contortus	*Gabillotia euphratica*

All these shells, except those of the Unionidae and Cyrenidae, are for the most part white and opaque. Some of those of Pulmonates, however, retain a certain translucency; those of the *Melania* have often vestiges of epidermis, while those of *Neritina* retain their colour to some extent. Those of the *Melanopsis* are particularly white and chalky.

The shells from the swamp deposit in the same neighbourhood, separated from the Euphrates by a narrow stretch of flat land and the remains of an old embankment, belong to the following species:—

GASTROPODA.

Neritina jordani
Bithynia badiella
Melania tuberculata
Melanopsis nodosa
Limnaea tenera
Limnaea sp.
Bullinus contortus

PELECYPODA.

Unio sp.

Except the *Unio*, all the specimens of which are white, broken and crumbling, the shells are in much the same condition as those from recently inundated land.

The collection from the lacustrine deposit at Nasariyeh, to which Colonel Lane paid particular attention, includes specimens of the following:—

GASTROPODA.

Neritina jordani
Bithynia badiella
Bithinella palmyrae
Melania tuberculata
Melanopsis subtingitana, Nevill, Ms.
Melanopsis nodosa
Potamides fluviatilis
Limnaea peregriformis
Limnaea subpersica
Limnaea sp.
Planorbis convexiusculus
Bullinus contortus

PELECYPODA.

Unio sp.
Corbicula fluminalis
Corbicula cor
Corbula (*Erodona*) *mesopotamica*, sp. nov.

There is also a single shell of the barnacle *Balanus amphitrite*, and many tests of Ostracod Crustacea.

The collection of freshwater shells from Samara is a small one; only the following species are included:—

GASTROPODA.

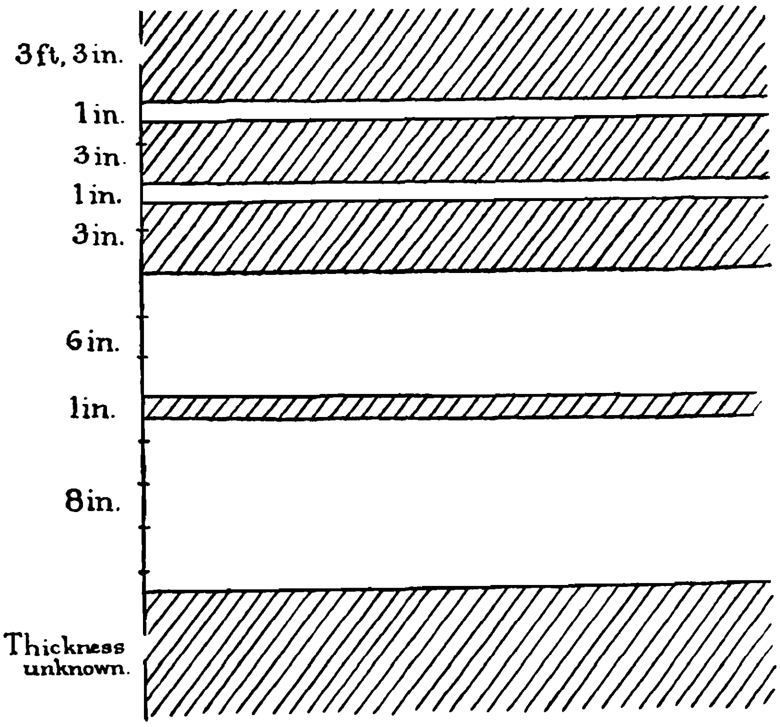
Melanopsis nodosa
Limnaea sp.
Bullinus contortus

PELECYPODA.

Corbicula fluminalis
Unio dignatus var. *semiramidis*
Unio mossulensis

The shells had all been dead for some time and were quite opaque.

The most interesting of these deposits, and also the most fully investigated, is that of the lake-bed near Nasariyeh. Colonel Lane has sent me several diagrams to illustrate its position and structure. I reproduce (in a slightly modified form) one of his drawings, which is of a section of the deposit as seen in a trench. The sandy layers evidently represent the sudden and repeated filling in of the lake by sand-storms, the layers of clay (shaded) the bottom at different periods. There has probably been some denudation of the surface. In the sandy layers the shells are well preserved, while in those of clay conditions were unfavourable for preservation and the only recognizable remains are those of thick and heavy shells such as *Unio* and the tests of Ostracods. Fragments of vegetable matter are abundant in the clay. There is some uncertainty as to which sandy layer many of the specimens are from, but there is sufficient evidence that some of the species came from all these layers; the *Potamides* and the *Corbula*, brackish-water forms, were certainly found in the upper as well as the lower ones; most of these shells are probably from the 6 inch layer. All the thinner shells from the deposit are dwarfed and many of those of *Limnaea* are distorted, but this is also the case with many specimens from recently inundated land in the same neighbourhood. Without examining fresh specimens it is impossible to say whether all of the latter are recent.



From a geographical point of view the most interesting feature of the collection is the additional evidence it affords of the close relationship between the aquatic fauna of lower Mesopotamia and that of the Jordan valley. The abundant occurrence of *Neritina jordani* in the former district is particularly significant in this connexion.

GASTROPODA.

Order *PECTINIBRANCHIATA.*

Family NERITIDAE.

Genus **Neritina,** Montfort.

Three species of this genus have been described from Mesopotamia and I have here to put on record the occurrence of a fourth hitherto known from Palestine. The four species are easily distinguished. They are *N. mesopotamica,* Mousson, *N. cinctella,* Martens, *N. euphratica,* Mousson and *N. jordani,* Sowerby. The first two are only known from upper Mesopotamia, but although *N. euphratica* is stated to be widely distributed through the whole country, none of the specimens I have examined can be assigned to it.

The four species may be distinguished as follows :—

I. Shell with an obtuse ridge on the body-whorl	*N. cinctella.*
II. Shell with a broad, shallow constriction running round the main whorl, distinctly taller than broad, marked with dark and pale zig-zag lines ; the inner lip without denticulation or emargination	*N. jordani.*
III. Shell without transverse constriction or ridge—	
A. Shell slightly taller than wide, of a uniform blackish colour ; inner lip entire ...	*N. mesopotamica.*
B. Shell wider than tall, marked with dark and pale zig-zag lines, with a slight emargination in the middle of the inner lip	*N. euphratica.*

Neritina jordani, Sowerby.

1899. *Neritina jordani,* Kobelt in Rossmässler's *Icon. Land-u. Süssw. Moll.* (n. f.) VIII, p. 2, pl. ccxi, fig. 1319.
1899. *Neritina jordani* var. *turris, id., ibid.,* p. 3, pl. ccxi, fig. 1320.

There are numerous shells of this species in collections from the bank of the Euphrates at Nasariyeh and from both lacustrine and paludine deposits in the same neighbourhood. They agree very closely, except in being rather smaller, with shells of the var. *turris* of Mousson collected by myself in the Lake of Tiberias. All are variegated, but there is considerable variation in the relative breadth of the dark and the pale zig-zag markings.

Family HYDROBIIDAE.

Bithynia badiella, Parreyss.

1874. *Bithynia badiella,* Mousson, *Journ. de Conch.* XXI, p. 45.

Shells are abundant in lacustrine and paludine deposits at Nasariyeh. They agree well with specimens from northern Palestine. The species is common in Syria, the Lake of Tiberias and Lower Mesopotamia.

Bithinella palmyrae, Dautzenberg.

1894. *Bithinella palmyrae,* Dautzenberg, *Rev. biol. Nord France* VI, p. 348, fig. 4.

Several shells, of which only one is complete, from the old lake-basin at Nasariyeh seem to agree with Dautzenberg's figure. The species is otherwise known only from Palmyra in the Syrian desert.

? Genus **Lithoglyphus,** Mühl.

A single broken shell from the same deposit perhaps belongs to this genus.

Family MELANIIDAE.

Melania tuberculata (Müller).

1918. *Melania tuberculata*, Annandale, *Rec. Ind. Mus.* XIV, pp. 114, 156, fig. 6, pl. xii, figs. 1, 2.

This common mollusc is well represented in all the deposits from which I have seen specimens. Most of the shells are of the typical form and of rather small size (not longer than 25 mm.). Mr. Hodgart has, however, sent some very large ones from the banks of the Euphrates at Nasariyeh, the largest of which must have been at least 45 mm. long by 16 broad when complete. Some of these large shells retain vestiges of their epidermis, but most are denuded and broken.

Melanopsis nodosa, Férussac.

1874. *Melanopsis nodosa*, Brot, "Die Melaniaceen," in Chemnitz's *Conch.-Cab.* (*ed.* Küster), p. 432, pl. xlvi, figs. 17-24.

This is apparently by far the commonest species of its genus in lower Mesopotamia. It is represented by numerous specimens from all the deposits at Nasariyeh and by a single much worn shell from Samara. All the shells I have examined have lost their epidermis and are white and chalky.

Melanopsis subtingitana, Nevill, Ms.

(Plate XX, figs. 1, 2.)

1884. *Melanopsis costata*, var., Nevill, *Hand-List Moll. Ind. Mus.* II, p. 262.

The shell is thick, of a very regular ovato-conical shape, narrow, sharply pointed at the apex, from which it increases gradually and evenly. The spire is conical, unbroken, with the suture little impressed and the whorls not at all swollen. Seven or seven and a half whorls persist in the two adult shells examined. The first three whorls are small and almost smooth; the others are decorated with broad and prominent, slightly sinuous longitudinal ridges, of which there are about fifteen. These ridges may become obsolete at the base of the body-whorl or may be divided into two longitudinal tubercles by a deep groove running round this whorl. The mouth of the shell is narrowly ellipsoidal and is produced backwards in the form of a narrow slit which is at first straight and then curves inwards and is not protected by an overhanging lip. The columella is almost straight and pointed at its extremity, which does not project or hardly projects beyond the lip; the callus is poorly developed.

Measurements of shells (*in millimetres*).

Specimen A is the type-specimen from Basra (?): specimen B is the adult shell from Nasariyeh.

	A.	B.
Length of shell	15	14
Breadth of shell	7·4	7·5
Length of aperture (including slit)	6·5	8·3
Breadth of aperture	3·5	3·2

Type-specimen.—No. 11390/2M, *Zoological Survey of India* (*Ind. Mus.*).

Localities.—Nevill gave the Ms. name here adopted to three shells labelled " Basrah, Biluchistan " from the collection of the late Dr. W. T. Blanford. The " Biluchistan " was probably a mistake. Two of these shells are very young and one of them appears to be merely a young shell of *M. nodosa.* The adult specimen I have made the type of the species. In Colonel Lane's collection from the old lake-bed at Nasariyeh I found two other shells, only one of them adult. They differ from Dr. Blanford's adult specimen in having the longitudinal ridges undivided and obsolete at the base on the body-whorl, but, considering the variability habitual in the genus, must belong to the same species. All four specimens were probably subfossil.

The species is closely related to *M. tingitana,* Morelet, which is probably confined to the western parts of the Mediterranean basin. It differs in its more regular form, narrower body-whorl, more conical spire and narrower aperture. It differs still more considerably in shape and proportions from any form of *M. costata,* of which I have examined a very large series of shells from Palestine, Spain, etc. From *M. saulcyi,* Bourguignat, it differs in sculpture as well as in the shape of the body-whorl.

Family CERITHIIDAE.

Potamides fluviatilis (Pott. & Mich.).

1838. *Cerithuom fluviatilis,* Potiez et Michaud, *Gall. Moll.*, p. 363, pl. xxxi, figs. 19, 20.

1916. *Potamides* (*Tympanotonos*) *fluviatilis,* Annandale and Kemp, *Mem. Ind. Mus.* V, p. 344.

Several worn and broken shells of this common estuarine species, the range of which extends from the Persian Gulf to the seas of China, Japan and Australia, are present in the collection from the sandy beds in the lake deposit at Nasariyeh. So far as I am aware, *P. fluviatilis,* though often abundant in water of low salinity, never lives in pure fresh water. The specimens, therefore, must represent, with those of *Corbula* and *Balanus,* a brackish-water element in this deposit.

Order *PULMONATA.*

Family LIMNAEIDAE.

Genus **Limnaea,** Lamarck.

The material at my disposal does not make it possible to deal in at all a satisfactory manner with the species or forms of this genus that occur in lower Mesopotamia. A large proportion of the shells I have examined are immature or broken; all are very small and many seem to be distorted or abnormal. Some species of the genus are extraordinarily plastic and an enormous number of forms have received varietal or specific names. Indeed, it is doubtful whether a final diagnosis is possible in many cases without an examination of the radula and genital system. I have not attempted, therefore, to name the majority of specimens in the collection. They include representatives of curious races or varieties that may belong to such species as *L. lagotis* and *L. ovata* but, except in a few instances, I have not been able to identify them with described forms. All are certainly different from any of the forms from central Asia and from Baluchistan, Persia or Palestine represented by specimens in the collection of the Zoological Survey of India. In three cases I have been able to select series of shells that agree fairly well with published figures of supposed species. To these I give the appropriate names, but in so doing I wish it to be understood that I do not intend to express an opinion as to the specific validity of the forms.

Limnaea tenera (Parreyss), Küster.

(Plate XX, fig. 3.)

1862. *Limnaeus tener*, Küster, " Die Gattungen Limnaeus," etc., in Chemnitz's *Conch.-Cab.* (*ed.* Küster), p. 54, pl. xii, figs. 1, 2.
1865. *Limnaeus tener*, Tristram, *Proc. Zool. Soc. London*, p. 540.
1874. *Limnaea Euphratica*, Mousson, *Journ. de Conch.* XXI, p. 40.
1894. *Limnaea tenera*, Dautzenberg, *Rev. biol. Nord France* VI, p. 335.

This may be no more than an Asiatic race of *L. ovata*, which in its turn is probably no more than a phase of *L. peregra*. It was described from Persia and according to Dautzenberg is common in swamps and lakes in Syria. I have selected a series of shells from the specimens collected by Colonel Lane in a swamp-deposit at Nasariyeh. The larger specimens, though considerably smaller than Küster's figures, agree with them otherwise in every respect except that the mouth is slightly narrower.

Limnaea peregriformis, Locard.

(Plate XX, fig. 4.)

1883. *Limnaea peregriformis*, Locard, *Arch. Mus. d'Hist. Nat. Lyon* III, p. 286, pl. xxiii, figs. 41-43.

Several specimens from the lake-deposit at Nasariyeh agree fairly closely with Locard's figures, except that they are much smaller (not longer than 10·5 mm.) and that the body-whorl is sometimes not quite so elongate. I am not at all sure that the form is specifically distinct from the same author's *L. lagotopsis* and *L. reneana*, and Kobelt[1] is inclined to regard the former as no more than an individual aberration of *L. lagotis* and the latter as a young form of Locard's *L. axiaca*, which Westerlund calls a variety of *L. stagnalis*. According to Kobelt, however,

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[1] Kobelt in Rossmässler's *Icon. Land-u. Süssw.-Moll.* (new edition) XVIII, pp. 2, 4, 5.

Westerlund calls *L. peregriformis* merely " *L. peregra* var. " *L. peregriformis*, whatever its precise status may be, has hitherto been recorded only from the Lake of Homs in Asia Minor.

Limnaea subpersica, Locard.

(Plate XX, fig. 5.)

1883. *Limnaea subpersica*, Locard, *op. cit.*, p. 285, pl. xxiii, figs. 38-40.

Some still smaller shells (greatest length 9 mm.) from the same deposit agree fairly well with Locard's figure, but show considerable variation in the form of the aperture. Westerlund (*fide* Kobelt, *op. cit.*, p. 7) regards the form as a variety of *L. lagotis.* It was found with *L. peregriformis* in the Lake of Homs.

Family PLANORBIDAE.

1906. Planorbidae, Pelseneer, " Mollusca " in Lankester's *Treatise on Zoology*, Vol. V, p. 185.

Genus **Planorbis,** Guttard.

The only species of this genus represented in the collection belongs to the section or subgenus *Gyraulus,* Agassiz.

Planorbis convexiusculus, Hutton.

1876. *Planorbis convexiusculus,* Hanley and Theobald, *Conch. Ind.*, pl. xcix, figs. 8, 9, 10.

1918. *Planorbis saigonensis* (?), Annandale, *Rec. Ind. Mus.* XIV, p. 112, pl. xi, fig. 1.

I have been in some doubt whether this form was more than a variety of *P. saigonensis,* Crosse & Fischer (=*P. compressus,* Hutton), but, having recently had an opportunity of examining good series of fresh specimens of both, I am now convinced that they are specifically distinct. *P. saigonensis* is a more constant species than *P. convexiusculus,* which exhibits considerable individual variability in the form of the shell. In most individuals of the latter species there is no peripheral keel or angulation, but it is not uncommon for a distinct angulation to be present. *P. saigonensis* has a larger, flatter, coarser and more irregularly sculptured shell, which is distinctly carinate. There is also a difference in the shape of the aperture. I have recently seen a number of specimens of *P. saigonensis* from Lahore which have traces of the bacterial velum so noticeable in *P. velifer*[1] ; some also possess spiral rows of epidermal cilia as in the var. *ciliata* of that species, from which both *P. convexiusculus* and *P. saigonensis* differ considerably in the shape of the mouth of the shell.

Shells of *P. convexiusculus* very like those from deposits in the Shan States are abundant in the samples from all the deposits at Nasariyeh and Samara. The species was described from Afghanistan and is common in northern India.

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[1] Annandale, *Rec. Ind. Mus.* XIV, p. 112, pl. xi, figs. 7-11 (1918).

Genus **Bullinus,** Adanson.

1757. *Bulinus,* Adanson, *Voy. Sénégal, Coquillages,* p. 5, pl. i, figs.
1815. *Bullinus,* Oken, *Lehrbuch Naturgesch.* III, p. 303 (*fide* Hedley).
1830. *Isidora,* Ehrenberg, *Symb. Phys.* II (unpaged).
1862. *Isidora* (in part), Küster, "Die Gatt. Limnaeus," etc., in Chemnitz's *Conch.-Cab.* (*ed.* Küster), p. 69.
1886. *Physa* (in part), Clessin, "Limnaeiden,'' in Chemnitz's *Conch.-Cab.* (*ed.* Küster and Dunker), p. 236.
1917. *Bullinus,* Hedley, *Rec. Austr. Mus.* XII, p. 3.

As this genus has now assumed a certain practical sanitary importance it may be well to discuss its synonomy and systematic position. It was originally described, from a West African form, by Adanson in 1757. He spelt the name with one "l," but as he derived it from "bulle" or *bulla* was evidently in error in so doing.[1] Apart, therefore, from any question of date, or from the fact that Adanson did not designate the species, Oken in 1815 was justified in changing the name to *Bullinus.* Oken's work is inaccessible to me, but I gather from recent writers that he merely adopted Adanson's description without seeing his species. This description is clear and adequate; the figures that accompany it, though a little crude, illustrate the form of the shell and the external anatomy of the animal with sufficient accuracy. They prove that in the species known to him, which was described by Bourguignat in 1856 as *Physa senegalensis,* the mantle did not extend over the shell and that the tentacles were filiform. These are characters which separate the living *Bullinus* from the living *Physa* at a glance.

In 1830 Ehrenberg erected for certain Egyptian and Syrian forms a new genus, which he called *Isidora* or the "Gift of Isis." He appears to have been ignorant of Adanson and Oken's genus and his description, which is fairly full both in reference to the shell and to the external soft parts, coincides closely with Adanson's. Moreover, the first two of the three species[2] he assigned to *Isidora* (*I. hemprichii, I. brocchii* and *I. forskalii*) are probably no more than varieties or phases of *Bullinus contortus,* which closely resembles *B. senegalensis* except in the poor development of the columellar callus. *Isidora,* therefore, seems to me to be an absolute synonym of *Bullinus.*[3] Germain,[4] however, treats it as a subgenus of that genus in his recent list of the molluscs of Syria and Palestine.

Pelseneer (*op. cit.,* 1906) places *Bullinus* with *Planorbis* in the family Planorbidae, which he defines thus: "Visceral mass and shell sinistrally coiled; inferior pallial lobe very prominent and transformed into a branchia; tentacles tapering." *Planorbis* he distinguishes thus: "shell discoid; branchia not folded": *Bullinus* thus, "shell ovoid with prominent spire; branchia folded." There is never any difficulty in distinguishing the flattened discoid adult shells of *Planorbis* from those

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[1] He says, "Je donne le nom de Bulin a un petit coquillage d' eau douce. Cette denomination m'a paru lui convenir, parceque l'animal pendant sa vie nage presque continuellement a fleur d'eau, et qu'après sa mort sa coquille flotte comme une petite bulle d'air transparente."

[2] The third species (*i.e.,* the third to be described) *I. forskalii,* is quite distinct.

[3] Hedley (*op. cit.,* 1917) revives the name *Isidora* for certain Australian species in supersession of *Isidorella,* Tate; but in view of what is said above this cannot stand.

[4] Germain, *Bull. Mus. Hist. Nat.* (*Paris*) 1912, p. 450.

of *Bullinus*, but very young shells[1] are in some species almost indistinguishable.

Bullinus contortus (Mich.).

(Plate XX, figs. 6—11.)

1874. *Isidora contorta*, Jickeli, *Nov. Act. Leop-Carol. Ak. Natur.* XXXVII (1), p. 203, pl. iii, fig. 4, pl. vii, fig. 14.
1874. *Physa (Isidora) Brochii*, var. *approximans*, Mousson, *Journ. de Conch.* XXI, p. 42.
1886. *Physa contorta*, Clessin, *op. cit.*, p. 314, pl. i, figs. 9-11.
1886. *Physa natalensis*, *id. ibid.*, p. 8, pl. i, figs. 12-14.
1916. *Bullinus contortus*, Leiper, *Journ. R. A. M. C.* XXVII, p. 117, fig. 66.

Jickeli has discussed the synonomy and Leiper proved the sanitary importance of this species, which, with two closely allied forms, is the intermediate host of the human parasite, *Bilharzia haematobium.* The shell is extremely variable (see figs. 6—11, pl. XX) and it is possible that further study will extend the synonomy.

Specimens were obtained both in the swamp-deposit at Nasariyeh and at the edge of the Euphrates at the same place; also at Samara. The shells are small, rather thick, and extremely variable as regards both the form of the spire and the shape of the body-whorl. There are shells in the Indian Museum from Portugal, Corsica, Algeria, Egypt, Abyssinia, Natal and Palestine. The species is also known from tropical W. Africa, from the upper waters of the Euphrates, and from Syria.

PELECYPODA.

Family CYRENIDAE.

Genus **Corbicula,** Megerle.

A considerable number of species of this genus have been described from Western Asia, but the synonomy of these is obscure. I have distinguished two forms, which seem to be specifically distinct; others I have left unnamed.

Corbicula fluminalis (Müller).

1913. *Corbicula fluminalis*, Germain, *Bull. Mus. Hist. Nat. (Paris)*, p. 472.

This is perhaps the commonest species of the genus in Western Asia. It has a wide range in Asia and Africa. Specimens, both recent and subfossil, from Nasariyeh seem to be typical.

Corbicula cor, Lk.

1914. *Corbicula cor*, Preston, *Journ. As. Soc. Bengal* (n. s.) IX, p. 474.

Specimens from Nasariyeh seem to be intermediate between this form and *C. crassula*, Mousson, which is probably, as Preston points out, a variety of it. They differ very little from shells from the Lake of Tiberias identified by the latter conchologist as *C. crassula.* The species, if the two be united, is common in Syria and there are specimens from Persia

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[1] See Annandale, *Rec. Ind. Mus.* XIV, pl. xi, fig. 1 (1918)

in the collection of the Indian Museum. These are perhaps more like the typical *cor.* Germain (*loc. cit.*) treats *C. crassula* as a variety of *C. fluminalis.*

Family UNIONIDAE.

The Western Asiatic species of this family are described and figured piecemeal by Kobelt in the new edition of Rossmässler's " Iconographie," on which I have relied mainly in the following identifications. Volumes XVIII and XIX (1912-1913) contain most of the descriptions. There seems to be much confusion among the named shells from Mesopotamia in the Indian Museum.

Unio calliopsis (Bourg.), Kobelt.

1913. *Unio calliopsis,* Kobelt in Rossmässler's *Icon. Land-u. Süssw. Moll.* (n. f.) XIX, p. 15, pl. dxix, fig. 2703.

There are a number of fresh shells in Mr. Hodgart's collection from the banks of the Euphrates at Nasariyeh. Most of them are rather smaller than Kobelt's figure, but a single worn valve which has the characteristic hinge is larger : 62 mm. × 31 mm. The shell is thinner than the other Unionid shells in the collection and its epidermis is paler than that of other fresh specimens.

The species was described from Baghdad.

Unio tigridis, Bourguignat.

1912. *Unio tigridis,* Kobelt, *op. cit.*, XVIII, p. 62, pl. dx, figs. 2683, 2684.

Fresh shells from the same collection as the last species show considerable variation in outline and have the epidermis darker than it is shown in Kobelt's figures.

The species occurs in both the Tigris and the Euphrates.

Unio dignatus var. **semiramidis,** Kobelt.

1913. *Unio dignatus semiramidis,* Kobelt, *op. cit.*, XIX, p. 11, pl. dviii, fig. 2698.

Dead shells from Samara agree with Kobelt's figures. The variety was described from " the Euphrates near Baghdad."

Unio ciconius (Bourg.), Kobelt.

1913. *Unio ciconius,* Kobelt, *tom. cit.*, p. 11, pl. dvii, fig. 2697.

Shells were found, with those of the last species, at Samara by Colonel Lane. The type-specimens were collected near Mossul.

Gabillotia euphratica (Bourguignat).

1886. *Margaritana euphratica,* Kobelt, *op. cit.*, II, p. 26, pl. xlv, fig. 266.

A single fresh valve from the Euphrates at Nasariyeh agrees well with Kobelt's figure. The species has been found in the Tigris as well as the Euphrates.

Family CORBULIDAE.

Genus **Corbula,** Brugière.

The majority of the species of this family are marine, but a few make their way up the larger rivers of South America and southern Asia into water that is nearly if not quite fresh. Their range, however, never extends much beyond the limits of tidal influence. The shells of these brackish water forms are small, fragile and colourless, with prominent single hinge-teeth. The Asiatic and American species are probably convergent, but it may be convenient to group all the characteristic estuarine forms under the subgeneric name *Erodona*, Daudin. Preston[1] has described several species from the delta of the Ganges.

Corbula (Erodona) mesopotamica, sp. nov.

(Plate XX, figs. 12, 13.)

Shell small, thin, inaequivalve, inaequilateral, about 1½ times as long as high, rounded in front, subtruncate and produced behind, moderately swollen in the central region; umbones pointed, small, slightly prominent, not at all introverted, situated slightly nearer the anterior than the posterior extremity; dorsal margin from umbo to upper end of anterior margin slightly convex, not interrupted, from umbo to posterior margin straight, sloping, hardly at all concave; lower margin convex, evenly curved; surface of upper part of shell with fine irregular transverse concentric striae; striae coarser near lower margin; no sloping ridges on posterior region. The form of the hinge is shown in figs. 12*a*, 13*a*, plate XX

Measurements of shells (*in millimetres*).

	Right valve.	Left valve.
Breadth	8·5	8
Height	5·5	5·4

Type specimen.—No. 11404/2M, *Zoological Survey of India* (*Ind. Mus.*).

Locality.—Nasariyeh, Mesopotamia; subfossil in sandy beds of lacustrine deposit near the Euphrates.

The fresh shell was probably translucent, but a thin brownish epidermis, of which traces possibly persist, may have been present. The species comes nearest among described forms to *C. pfefferi*, Preston, from the Gangetic delta, but the shell is larger, proportionately broader and more produced posteriorly; the umbo is also more acute.

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[1] *Ann. Mag. Nat. Hist.* (7) XIX, p. 215 (1907).