

RECORDS

of the

INDIAN MUSEUM

(A JOURNAL OF INDIAN ZOOLOGY)

Vol. XIX, Part II.

JUNE, 1920.

	PAGE
VII. Notes on Indian Dragonflies. <i>F. C. Fraser</i>	31
VIII. On a new species of <i>Thalassema</i> from the Gulf of Manaar with notes on Thurston's species <i>T. formulosum</i> . <i>B. Prashad</i> ..	35
IX. On the occurrence of <i>Placocephalus javanus</i> (Lomah) in Siam. <i>T. Kaburaki</i>	39
X. Indian Freshwater Molluscs assigned to the genus <i>Bithynia</i> . <i>N. Annandale</i>	41
XI. Taxonomic Studies on the soft parts of the Solenidae. <i>E. Ghosh</i> ..	47

Calcutta :

PUBLISHED BY THE DIRECTOR, ZOOLOGICAL SURVEY OF INDIA.
PRINTED AT THE BAPTIST MISSION PRESS.

1920.

Price Two Rupees.

VII NOTES ON INDIAN DRAGONFLIES

By MAJOR F. C. FRASER, I.M.S.

I. A DESCRIPTION OF THE DIMORPHIC FEMALES OF *RHODISCHNURA NURSEI*, MORTON.

Rhodischnura nursei, Morton.

Ischnura nursei, Morton, *Trans. Ent. Soc. Lond.*, 1907, pp. 306-307, pl. xxiv, figs. 4, 5, 6.

Dr. Laidlaw in *Rec. Ind. Mus.*, Vol. XVI (1919), has described a female of *Rhodischnura nursei*, Morton, which differs entirely from those which I have seen myself and which may therefore be dimorphic forms.

Dr. Laidlaw's female is of the normal type with enclosed humeral bands, whilst the new females are firstly one of the normal type with unenclosed bands, and secondly an andromorph and a heteromorph.

(i) Normal type with unenclosed humeral bands.

Head.—Labrum pale green with the base finely black; post-clypeus bronzed black; frons pale green to just beyond the level of the origin of the antennae. Vertex black bronze, no postocular spots present.

Prothorax black with a narrow collar anteriorly and the sides low down, pale green.

Thorax pale green with a broad, dorsal, black bronze fascia. No humeral bands but the sides of the thorax at this level with a reddish brown tinge which fades imperceptibly into the pale green.

Legs pale greenish yellow with black stripes on the extensor surfaces of the femora.

Abdomen pale greenish yellow, deepening to a brighter yellow on the dorsum. Each segment with a very broad, dorsal, black bronzed stripe with the exception of the first where the band is a warm brown. On the 10th the band does not reach the apical end of the segment and there are pale green, apical rings to the 8th and 9th.

Length of abdomen 16 mm., of the hind-wing 13 mm.

Two specimens taken *in cop* at the Sewage Farm, Karachi, Sind, 18-9-19.

(ii) Andromorph form.

Almost exactly similar to the male, differing in the following particulars:—The black band crossing the vertex is narrower and therefore displays a postocular space coloured yellow. The black tends to encroach on this to partly enclose a spot externally, which is ochreous in colour.

The black on the dorsum of thorax external to the humeral bands is incomplete posteriorly where it changes to ochreous.

The black on the abdomen is more diffuse and is set in a background of reddish orange. Lastly, the stigma has not the reddish tinge.

One specimen taken by Dr. N. Annandale on Barkuda Island, Chilka Lake, Ganjam District, Madras Presidency, among herbage, 20-8-1919.

(iii) Heteromorph form.

Very similar to the foregoing from which it differs in the following particulars:—The postocular space is bright ochreous, the eyes are greenish, the humeral bands are unenclosed but as the sides of the thorax are ochreous, the yellow of the humeral bands is well displayed. The abdomen of the same ground colouring as in the male but the black marks differing considerably. The black marking on the first segment in the form of a V with its apex at the base of the segment, that on the 2nd segment, wedge-shaped with its broadest part at the base of the segment; the bands on the last four segments narrow, incomplete basally on the 7th and 8th and apically on the 9th and 10th, the sides of these four segments being reddish. A very fine, black, mid-dorsal line runs from the 2nd to the 6th segment and this is crossed on each segment, near the apex, by another fine, black line, the points of intersection defined as tiny, black spots, largest on the 6th segment.

This last form is of interest in that it closely resembles *Ischnura rufostigma*, Selys, and thus forms a connecting link between the genus and the true *Ischnuras*. Were it not for the great disparity in the size of this single specimen, it might easily be taken to belong to the above-mentioned species.

The specimen mentioned by Dr. Laidlaw as taken by Dr. N. Annandale on the Cooum River, Madras, is, I believe, a female of *Agriocnemis pygmaea*, dimorphism in this species being almost infinite. I have collected in the neighbourhood mentioned almost continuously for four years and have never once come across *R. nursei*, which I believe to be a purely Northern species. I have seen a painting of a male specimen taken at Pusa by Mr. T. Bainbrigge Fletcher, 26-3-19, and another specimen from Nagpur, so that the distribution, as at present known, stretches as a belt across Northern India, from Karachi to the Chilka Lake, *via* Nagpur, Deesa, Pusa, Agra, and Dehra Dun.

II. DESCRIPTION OF A NEW INDIAN ODONATE.

Enallagma insula, sp. nov.

I ♀ Barkuda Island, Chilka Lake, Ganjam District, Madras Presidency, 5-10-19. Coll. N. Annandale.

Head.—Labrum whitish green, the base finely black; frons and clypeus a whitish green, with a black streak across the anteclypeus; a broad, black streak across the vertex; the postocular

and included spaces pale blue. A small, black projection into this latter, almost enclosing a blue spot.

Prothorax black with a narrow, anterior collar and two fine, mesial points blue. The free border of the posterior lobe finely blue.

Thorax black on the dorsum, blue at the sides. A narrow, blue humeral line on both sides.

Legs whitish, the distal ends of the femora black.

Abdomen greenish blue, the last three segments sky blue. Marked on the dorsum with black as follows:—A subquadrate spot on the 1st segment connected to a black apical ring, broad streaks on all segments from 2 to 8 which are incomplete basally and connected apically with black annules. The streaks dilated near the apical end on segments 2 to 6. Two small, tongue-like spots at the base of the 9th segment which are situated subdorsally and extend for about half the length of the segment. The 10th segment immaculate. A spine on the ventral surface of the 8th segment.

Wings.—Petiolation ceases before the level of *Ac*; *arc* at the 2nd antenodal nervure; postnodals 10 in the forewing, 9 in the hind.

Length of hind-wing 17 mm., of abdomen 24 mm.



VIII. ON A NEW SPECIES OF *THALASSEMA*
FROM THE GULF OF MANAAR WITH
NOTES ON THURSTON'S SPECIES
T. FORMULOSUM.

By B. PRASHAD, D.Sc., Offg. Director of Fisheries,
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Thurston in his account of the Fauna of the Gulf of Manaar¹ records the occurrence of a species of the genus *Thalassema*, Lamarck,² as the only representative of the Gephyrea Chaetifera in this region. Regarding the exact locality from which the specimens were obtained, he adds the following note—"Of the four species dredged off Raméshwaram Island, only *Dendrostoma signifer* was abundant."

On the authority of Dr. Selenka, who identified the collection of Gephyrea, the name of the species in the Bulletin is given as *Thalassema formulosum*. Curiously enough, though the authorities for the other names are cited in all cases, the name of the author of *T formulosum* is omitted. Selenka, so far as I have been able to ascertain, did not describe any species as *T formulosum*, nor has any other author described one of this name. Probably the species was *T formosulum*, Lampert,³ and the name in Thurston's work is only a *lapsus calami*, or Selenka meant to describe a new species under this name, though he never did so. In his revision of the genus *Thalassema*,⁴ Shipley does not make any reference to Thurston's record and was probably not acquainted with it. According to him *T. formosulum* had been obtained from Cavitte near Manila and Shanghai. Sluiter⁵ has since recorded the same species from Labuan Tring and Sapeh-Bai, Sumbawa, from the material collected by the Siboga Expedition in the Dutch East Indies. If my interpretation regarding the name of the species recorded by Thurston is correct, then the species *T formosulum* has a very wide range of distribution in the Pacific and the Indian Ocean. No specimens of the genus *Thalassema* were obtained during Herdman's investigations⁶ of the Fauna of

¹ *Bull. Madras Mus.*, III, p. 116 (1895).

² In my previous papers I followed Annandale and Kemp (*Mem. Ind. Mus.*, V, p. 58 and *Rec. Ind. Mus.* XVI, pp. 399-402) in assigning the authorship of *Thalassema* to Gaertner; this, however, as Shipley had pointed out, was not quite correct, as the real author is Lamarck.

³ *Zeitschr. Wiss. Zool.*, XXXIX, p. 339 (1883).

⁴ Willey's *Zool. Results*, p. 348 (Cambridge, 1889).

⁵ *Siboga-Expeditie*, XXV, p. 48 (1902).

⁶ *Rept. Ceylon Pearl Fisheries and Marine Biology*, pt. 1, p. 169 (1903).

the Pearl-banks round Ceylon. During the past few years the Madras Fisheries Department has been making extensive collections of the marine animals occurring on the chank-beds at Tuticorin, in the Gulf of Manaar, but no specimens of Echiuroids had ever been obtained. Recently (November, 1918) while on deputation to the Madras Fisheries for a short time, I was fortunate enough in obtaining two specimens of *Thalassema*. The specimens were brought up from the bottom by a chank-diver, who found them crawling round the burrows of the chank—*Turbinella pirum*, Lam., about five miles from the mainland. The bottom of the sea in these parts consists of fine sand mixed with some mud and large quantities of dead shells, coral pieces and tubes of Polychaete worms.

The specimens belong to a very interesting new species, which I propose to describe as *Thalassema hornelli*, associating it with the name of Mr. J. Hornell, F.L.S., Director of Fisheries, Madras, to whom I am greatly obliged for making my short stay in the Madras Presidency both interesting and useful.

Thalassema hornelli, sp. nov.

The body in this species is elongate, cylindrical; in one of the specimens, owing to contraction at the time of preservation, the posterior end appears of a much less diameter than it actually is in the living specimens. The living individuals showed great powers of expansion and contraction; in spirit the larger of the two specimens is 8.2 cm. long, while its maximum breadth is 2.1 cm. The proboscis is very short compared to the length of the body, and measures 1.1 cm. in length. The ventral margins of the proboscis are not united with one another even at its base. The whole of the surface of the body is covered over by minute irregularly arranged papillae; the papillae near the two ends of the body are larger than those in the middle, while the proboscis papillae are very minute.

Two rather small hooks of a pale yellow colour are present in the normal situation on the ventral surface. The musculature of the body is broken up into nineteen bundles in the middle of the body, but higher up and lower down the muscle-bands become more or less contiguous, and it is not possible to count the bundles. There are five pairs of segmental organs with large funnels; the lateral margins of the funnels are produced into very long spirally coiled lobes. Of the five pairs of segmental organs the three anterior pairs are rather poorly developed structures, and are situated in front of the insertion of the ventral hooks, while the two posterior pairs are very well-developed with elongated, ovoid vesicles and very long spiral lobes for the funnels. The anal vesicles are well-developed tubular structures reaching to a little more than half the length of the body; each of the vesicles has three rows of rather large funnels extending over a little more than half the length of the vesicles. The body-wall is very thick at the two ends of the body but much thinner in the middle.

The living specimens were of a pale pinkish colour due largely to the pinkish coelomic fluid which could be seen shining through. The proboscis and the two ends of the body were light yellow with a tinge of green here and there. Specimens preserved in spirit after fixation in 10% Formalin are of a deep yellowish colour.

The two type-specimens, since the description was written, have unfortunately been lost and are not available for future reference. I have, however, requested Mr. R. H. Whitehouse, Marine Biologist of the Madras Fisheries, to kindly procure some more specimens from the original locality.

Relationships:—The species described in the previous pages differs from the other known species of the genus in having five pairs of segmental organs and the musculature divided into nineteen bundles. It shows a distinct advance on the condition described by me in *T kempi*¹ in having five pairs of segmental organs, even though the number of muscle-bands has become reduced to nineteen.

Remarks:—As has been noted above, the animals showed great powers of extension and contraction of the body. One of the specimens also showed the phenomenon of the autotomy of the proboscis, as it threw off the proboscis on being taken out of sea water. This latter peculiarity has been observed in the case of other marine species, but the group of the essentially brackish water Asiatic species (*loc. cit.*) of the genus differs very markedly in this respect from the marine species.

¹ *Mem. As. Soc. Bengal*, VI, pp. 321-338, pl. xi (1919).

IX ON THE OCCURRENCE OF *PLACOCEPHALUS JAVANUS* (LOMAN) IN SIAM.

By TOKIO KABURAKI, *Zoological Laboratory, the Museums, Cambridge.*

Owing to Loman¹ and v. Graff's² works, it was made out clearly that *Placocephalus javanus* (Loman) is fairly common in the Malay Archipelago. It has hitherto been recorded from Java, Sumatra and Singapore. This fact is of some interest from the point of view of geographical distribution, though its distribution might have been brought about through the agency of man.

The purpose of the present report is to record the occurrence of the species, which I identify with *Plac. javanus*, in Siam. Owing to the kindness of Dr. N. Annandale of the Indian Museum, I was able to observe one individual only of this species, which was obtained by Mr. W. N. Dunn in a certain garden in the town of Singgora, Siam. To the gentlemen named I beg to express my thanks for the opportunity of observing the planarian.

The specimen was preserved in planarian fixitive³ and was in fairly good condition, except that it was torn near the middle of the body. In shape the animal conforms to the typical *Placocephalus* outline, with the head, which is of a semi-lunar shape, not a great deal wider than the trunk, and only marked off from the trunk by a constriction. The greater part of the trunk, rather stoutly built, is of almost similar breadth, though the body tapers extremely gradually to a rather pointed posterior end. The dorsal surface is slightly convex and the ventral nearly flat; the ambulacral surface forms a scarcely raised ridge, rather less than one eighth the width of the body, and extending the whole length.

¹ Loman, J. C. C., Zwei neue Arten von Bipalium. *Zool. Anz.*, VI Jahrg. 1883, p. 168. Über den Bau von Bipalium Stimpson, nebst Beschreibung neuer Arten aus dem indischen Archipel. *Bijdragen tot de Dierkunde*, 14 Afl., 1888, pp. 64-85. Über neue Landplanarien von den Sunda-Inseln. *Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien* herausgeg. von M. Weber, I Heft, 1890, pp. 138, 145, 151. On some Landplanarians of the genus Bipalium from the Leyden Museum of Natural History. *Notes from the Leyden Museum*, Vol. XVII, 1895, p. 30. Hallez, P., Catalogue des Turbellariés du Nord de la France et de la côte Boulonnaise. *Revue biol du Nord de la France*, T. II, 1889-90 (1893), p. 110. Bleeker, P., Bijdrage tot de geneeskundige topographie van Batavia. *Natuur- en Geneeskundig Archief voor Nederlandsch Indië*, I, 1844, p. 523.

² Graff, L. v., Bestimmungsschlüssel für die Indo-Malayischen Landplanarien. *Annales du Jardin Botanique de Buitenzorg*, Suppl. II, 1898, p. 124. Monographie der Turbellarien. II. Tricladida terricola (Landplanarien), 1899, pp. 465-467.

³ 30 c.c. Nitric acid, 30 c.c. Corrosive sublimate and 40 c.c. Distilled water.

This specimen attains in the preserved state a length of 87.5 mm. and the greatest breadth, a little behind the neck, of 4 mm.

According to Dr. Annandale's note, taken while the worm was living, the dorsal surface of the body is of a blackish colour with a broad brown median dorsal band, which is divided longitudinally by a fine black line, and is bounded on either side by a black line of about twice the width of the fine one. These three lines extend from the head to the caudal extremity, much as in the form reported from Singapore. The mid-dorsal line widens quite extraordinarily above the pharyngeal region, revealing a spindle-like marking, and as it approaches the hind end becomes gradually indistinct. The present specimen varies in the colouration of the broad dorsal band from the examples previously recorded. According to v. Graff, however, this, not being constant, must be regarded as a variation. Further, in the present worm there exists just a suspicion of a lateral dark line at the edge of the body, as has been described by v. Graff in some forms from Java as well as from Singapore. The head is almost uniformly blackish, without any sign of marking, but gets slightly lighter towards the frontal margin. Ventrally, the ambulacral surface is as usual of a much paler colour than the rest of the surface. On either side the colour may be described as a dark grey shade, getting much lighter laterally.

It is not easy to assign the distribution of the eyes in the head, but they surround as usual its entire fringe and are continued round to the sides of the neck.

The mouth is placed slightly in front of the commencement of the middle third of the body. I could make out its position by a slight protrusion of the pharynx.

According to Loman,¹ *Plac. javanus* is protandrous, the male genital organs being mature in July and August, and the egg-cocoons not being deposited till October or November. In the present specimen, secured on the 24th of January, 1916, the genital organs were not developed. Like other forms, this species may to some extent reproduce asexually by transverse fission, as mentioned by v. Graff.

¹ Loman, J. C. C., Over den bouw van de Land-Planariën. *Tijdschr. Nederl. Dierk. Ver.*, Deel I, p. 130. Shipley, A. E., On the Occurrence of *Bipalium kewense*, Moseley, in a new Locality; with a Note upon the Urticating Organs. *Proc. of the Camb. Philos. Soc.*, Vol. VII, Pt. IV, 1891, p. 144.

X INDIAN FRESHWATER MOLLUSCS ASSIGNED TO THE GENUS *BITHYNIA*

By N. ANNANDALE, D.Sc., F.A.S.B., Director, Zoological
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In Mr. H. B. Preston's volume on the Freshwater Molluscs in the *Fauna of British India* series, eighteen species are assigned to the genus *Bithynia*, Leach (with the two subgenera *Hydrobioides*, Nevill and (?) *Fossarulus*, Neumayr) and several allied forms have since been described from Burma and Assam. All of these (22 species) I have examined, so far at any rate as the shell and operculum are concerned. I find no less than five distinct genera included among Mr. Preston's eighteen species. It is unfortunate that in the official account of an important section of the fauna of India no attempt seems to have been made to examine these species critically. Some of them, probably the majority, must be represented in English collections.

I shall not attempt at present to revise these species, but merely to assign them to their proper genera and sub-genera, to point out the characteristic features of these, and to describe a new genus and a new subgenus that seem to be necessary.

Of the five genera here discussed, four are closely related and must be included in the subfamily Bithyniinae. The fifth, however, which has recently been described by Col. Godwin-Austen, is so distinct that it may be accepted as the type of a new subfamily, the Mysorellinae. The external anatomy of the two subfamilies is identical, but there are important differences in the radula as well as the shell. The subfamilies may be briefly described as follows:—

BITHYNIINAE. Shell never very thick, smooth to the naked eye or with spiral ridges, ovate or globose, with the peristome continuous and the columellar fold ridge-like. Operculum calcareous, concentric or spiral. The central tooth of the radula usually bearing a series of latero-basal denticulations on each side. The external male organ with a well-developed lateral process.

MYSORELLINAE. Shell rather thick, with strong spiral ridges, turbinate, with the peristome continuous and prominent. Operculum thick, calcareous, concentric. The central tooth of the radula without latero-basal denticulations but bearing a single downwardly-directed blunt process on either side. The external male organ as in the Bithyniinae.

Key to the Indian Genera, species of which have been assigned to
Bithynia, Leach.

1. Operculum spiral on *both surfaces*, with the nucleus eccentric. Whorls of shell more or less tumid and body-whorl very large; umbilicus closed or rimate; columellar fold ridge-like but by no means prominent; central tooth of radula with latero-basal denticulations in a series on either side *Amnicola*
(*Alocinma*).
2. Operculum concentric, or mainly so externally, with the nucleus central or sub-central, almost smooth internally.
 - A. Shell conspicuously perforate, turbinate, ornamented with strong spiral ridges; peristome continuous, prominent, uniform; central tooth of radula with a single blunt, downwardly-directed lateral process at each side *Mysorella*.¹
 - B. Shell broadly but shallowly umbilicate, with a broad oblique groove proceeding downwards from the umbilicus to the lower margin of the mouth; sculpture consisting of fine spiral grooves; central tooth of radula as in *Amnicola* *Sataria*, nov.
 - C. Shell narrowly umbilicate or subumbilicate, with a narrow groove descending obliquely from umbilicus but not reaching margin of mouth; columellar fold forming a sharp, prominent ridge continuous with outer lip; outer lip hardly thickened; central tooth of radula as in *Amnicola* *Bithynia*.
 - D. Shell resembling that of *Bithynia*, but with the columellar fold greatly thickened and the whole outer lip more or less incrassate; a varix often present on the body-whorl; central tooth of radula as in *Amnicola* *Hydrobioides*.

Two genera in this key (*Mysorella* and *Sataria*) are, so far as we know, monotypic. *Mysorella* has recently been described by Col. Godwin-Austen,² while *Sataria* is here described as new; but the type-species of both have long been known. *Hydrobioides* was first erected as a subgenus of *Bithynia* by the late Mr. G. Nevill.³ I have recently discussed it at some length.⁴ Dr. Baini Prashad⁵ and I have also, still more recently, proposed a new subgenus (*Alocinma*) of *Amnicola*, Gould and Haldeman, to contain certain Indian and Persian species. A large proportion of the Indian species hitherto assigned to *Bithynia* belong to this subgenus, more in fact than can be retained in the former genus. The species described by Mr. Preston, with those recently described by myself, may now be identified generically as follows:—

To the genus *Amnicola* and the subgenus *Alocinma* I attribute the following:—

Bithynia travancorica, Benson; *B. subpulchella*, Nevill; *B. inconspicua*, Dohrn; *B. orcula*, Frauenfeld; *B. laevis*,

¹ Godwin-Austen, *Rec. Ind. Mus.* XVI, p. 431 (1919).

² Godwin-Austen, *Rec. Ind. Mus.* XVI, pp. 211, 431 (1919).

³ Nevill, *Hand List Moll. Ind. Mus.* II, p. 42 (1884).

⁴ Annandale, *Rec. Ind. Mus.* XIV, p. 117 (1918).

⁵ Annandale and Prashad, *Rec. Ind. Mus.* XVIII, p. 23 (1919).

Morelet; *B. stenothyroides*, Dohrn; *B. dibrugarhensis*, Preston; *Amnicola alticola*, Annandale.

To *Bithynia*, Leach, the following:—

B. tentaculata (Linné), the type-species; *B. cerameopoma* (Benson); *B. pulchella* (Benson); *B. lutea*, Gray; *B. pygmaea*, Preston; *B. troscheli* (Paasch).

To *Hydrobioides*, Nevill:—

B. turrita, Blanford, the type-species; *B. nassa*, Theobald; *B. moreletiana*, Nevill; *Hydrobioides nana*, Annandale; *H. avarix*, Annandale.

To *Salaria*, gen. nov.:—

Bithynia evezardi, Blanford, the only known species.

To *Mysorella*, Godwin-Austen:—

Bithynia costigera (Küster) with its race *curta*, Nevill, which is the type of the genus.

All these species occur within the limits of the Indian Empire, but *B. tentaculata* and *B. troscheli* are Palaearctic and are only found, so far as India is concerned, in Kashmir and the neighbouring country, while *Hydrobioides* seems to be exclusively Burmese; *Mysorella* is confined to the southern part of Peninsular India (plains and Mysore Plateau) and Ceylon, and *Salaria* to the Bombay section of the Western Ghats. The range of *Alocinma* extends from Mesopotamia to Upper Burma, and the south of the Indian Peninsula, but the subgenus is closely allied to the Palaearctic *Pseudamnicola*, which may also be regarded as a subgenus of *Amnicola*. *Amnicola* (s.s.) is American. *Bithynia* is found all over Europe and Asia, but is perhaps mainly Palaearctic.

Subfamily BITHYNIINAE.

Genus *Amnicola*, Gould and Haldeman (1841).

1865. *Amnicola*, Simpson, *Smiths. Misc. Coll.* 201, p. 12.

This genus, as has been pointed out recently, can be divided into three subgenera, *Amnicola*, s.s. (American), *Pseudamnicola* (Palaearctic) and *Alocinma* (Indian, Persian and Mesopotamian). All the Indian species of the genus I have examined belong to it.

Subgenus *Alocinma*, Annand. and Prashad (1919).

1919. *Alocinma*, Annandale and Prashad, *Rec. Ind. Mus.* XVIII, p. 23.

The shells of this subgenus are more or less globose, with the whorls somewhat tumid, the body-whorl very large and the suture rather wide. The umbilicus is almost or entirely closed and the columellar fold is never prominent though always ridge-like. There is no well-defined groove proceeding downwards from the umbilicus outside the fold. The shell-sculpture is microscopic. The

structure of the operculum is distinctive when it can be seen, but is often obscured by deposits of algae or mineral substances on the surface. These should always be cleared away before the operculum is examined. It fits precisely into the mouth of the shell. The radula differs from that of *Bithynia* in the following points:— (1) the central tooth has a distinct quadrate projection on its disc and is produced in the middle on the basal margin; (2) the latero-basal denticulations on this tooth are very few and are situated at some distance from the lateral margins; (3) none of the denticulations of the lateral teeth are greatly enlarged; (4) those of both marginals are minute and sharp. The soft parts seem to be very similar in the two genera.

TYPE-SPECIES, *Amnicola sistanica*, Annandale and Prashad.

Mousson's ¹ *Bithynia ejecta* from Mesopotamia belongs to this subgenus, as well as the type-species and the Indian and Burmese forms listed above.

Genus *Bithynia*, Leach (1818).

1919. *Bithynia*, Godwin-Austen, *Rec. Ind. Mus.* XVI, p. 213.

The shell of this genus is as a rule more elongate, more acuminate and more conical than that of *Amnicola*. The umbilicus is usually perforate but constricted and even when it is completely closed a well-defined groove can be distinguished proceeding obliquely downwards from it but not meeting the margin of the lip. The columellar fold is a sharp and prominent ridge, forming a wall along the inner margin of the groove. The shell-sculpture in the Indian forms is microscopic. The operculum is never very thick. It is marked externally with coarse concentric ridges, encircling a central or subcentral nucleus. The internal surface is nearly smooth. In young specimens traces of a spiral structure can sometimes be detected on the external surface. The radula differs from that of *Alocinma* in the points noted in discussing the latter genus.

TYPE-SPECIES, *Helix tentaculata*, Linné.

Hydrobioïdes, Blanford (1869).

1918. *Hydrobioïdes*, Annandale, *Rec. Ind. Mus.* XIV, p. 117.

This genus is closely related to *Bithynia* but may be distinguished by the structure of the lower part of the shell and of the radula. Although the spire and the upper part of the body-whorl are thin the lower part of the latter, or rather the lower and outer part, is considerably thickened and has a more or less porcellaneous appearance. The columellar callus is also much broader and flatter. In several species a prominent varix on the body-whorl is a conspicuous feature. The shell varies in shape so greatly that two subgenera may be distinguished. The operculum is like that of *Bithynia*, but is relatively smaller ² and the concentric lines

¹ Mousson, *Journ. Conchyl.* XXII, p. 46 (1874).

² It is sometimes withdrawn into the shell in highly contracted specimens.

penetrate to the internal surface. The radula closely resembles that of *Alocinma*; but the laterals have the central denticulation much enlarged and bear a distinct prominence on their disc.

The two subgenera may be distinguished as follows:—

1. Shell more or less elongate, acuminate, with the main axis of the spire and that of the body-whorl in the same straight line and the mouth vertical ... *Hydrobioides* (s.s.)
2. Shell globose, with the spire short and oblique, almost neritiform, with the mouth very oblique ... *Paranerita*, nov.

The type-species of *Hydrobioides* (s.s.) is *Bithynia turrita*, Blanford; that of *Paranerita*, *Hydrobioides physcus*, Annandale, the only known species. I can find no structural difference between the animals of the two subgenera.

The peculiarities of the lower part of the shell in both subgenera seem to be correlated with a very definite, probably seasonal and recurring period of arrested growth. The varix in those species in which it persists represents the last period of rest, after which there is apparently only one more growth-period. In several shells in Nevill's series of his *Bithynia moreletiana*, which must be referred to this genus, a well-defined varix is present at some distance from the mouth, but beyond this point the shell is very thin and the outer lip is sharp, proving that the animals were killed during a period of active growth.

The porcellaneous appearance of the mouth and the outlines of the shell give the species of *Hydrobioides* (s.s.) a superficial resemblance to those of *Pachydrobia*, Crosse and Fischer, an Indo-Chinese genus; but the structure of the operculum is very different and the male organ of *Pachydrobia* differs in being simple and without a lateral process. The shell of *H. (Paranerita) physcus*, on the other hand, resembles that of *Julliena* of the same authors and from the same region, but here again there are the same structural differences in the animal.

Genus *Sataria*, nov.

The shell is moderately small and thick, almost trochiform, with swollen whorls. The umbilicus is patent but not deep and is approached from the anterior border of the mouth by a broad, deep, oblique groove. The peristome is continuous, uniformly thickened internally, prominent and produced to a point both above and below. The sculpture of the shell consists of fine but distinct spiral grooves. The operculum is calcareous, of ovate outline and rather smaller than the mouth of the shell. The operculum is stout and marked with strong concentric ridges externally, the nucleus being central; internally it is convex and without sculpture. The radula resembles that of *Bithynia* but the denticulations of the teeth are blunter and there is a quadrate process on the disc of the central tooth. Nothing is known of the soft parts.

The only known species is Blanford's *Bithynia evezardi*¹ from Mahableshtar in the Satara district and Khandalla in the Poona district of the Bombay Presidency. Both places are situated at moderate altitudes in the Western Ghats and the range of the genus seems to be coterminous with that of the remarkable Littorinid genus *Cremanoconchus*, Blanford, which lives in the spray of waterfalls. Nothing is known of the habits of *Sataria* and very few specimens have been collected.

Subfamily *MYSORELLINAE*, nov.

Genus *Mysorella*, Godwin-Austen (1919).

1919. *Mysoria*, Godwin-Austen, *Rec. Ind. Mus.* XVI, p. 211.

1919. *Mysorella*, *id. ibid.*, p. 431.

1919. *Mysoria*, Annandale, *Rec. Geol. Surv. Ind.* L, p. 211.

In describing this genus (under the name *Mysoria*) Col. Godwin-Austen drew attention to the remarkable difference between its radula and that of *Bithynia* and suggested that they might be placed in different families. The external anatomy, however, is so similar in the two genera that this course seems unnecessary, and the recognition of a special subfamily will meet the case, unless some conspicuous difference can be found in the internal anatomy. The original name, which was preoccupied in Insecta, was subsequently changed to *Mysorella*.

TYPE-SPECIES, *Paludina costigera*, Küster.

Two local races are distinguished, the typical form from the southern part of the Madras Presidency and Ceylon and the var. *curta*, Nevill² from the Mysore plateau. The former is a mollusc of the plains and is common in the neighbourhood of the town of Madras, while the latter has been found only at an elevation of about 3,000 feet above sea-level.

It is noteworthy that while the shell has a very close external resemblance to that of the Littorinid *Cremanoconchus syhadrensis* (Bfd.) and both genera are highly modified, their habits are quite unlike. *Cremanoconchus* lives on vertical rocks kept wet by the spray of waterfalls, while *Mysorella* frequents the edge of ponds and flooded rice-fields. In the latter it burrows into the mud when desiccation takes place, and it is completely aquatic. The shorter-shelled form (*curta*) is found among stones, while the *forma typica* usually frequents a muddy bottom.

¹ See Blanford, *Fourn. As. Soc. Bengal* XLIX (2), p. 220; Nevill, *ibid.*, XLX (2), p. 157, pl. vi, fig. 13.

² Nevill, *Hand List Moll. Ind. Mus.* II, p. 42 (1884).

XI. TAXONOMIC STUDIES ON THE SOFT PARTS OF THE SOLENIDAE

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(Plates II, III.)

INTRODUCTION.

The anatomy of nearly all the known genera of Solenidae has been described by Bloomer (5-17) in a series of papers published in the *Journal of Malacology*, and in the *Proceedings of the Malacological Society*. The animal of *Solen sloanii*, Gray, has been briefly described by Hedley (31) in 1899. Drew (25), in the year 1907, noted the anatomy of *Ensis directus*, Conrad, along with its habits and especially its movements. In the year 1916, Annandale and Kemp (*Mem. Ind. Mus.* V, p. 354) added a short note on what was then doubtfully considered to be a dwarfed form of *Solen fonesi*, Dunker, and I described the anatomy (28) in an appendix to the same paper. No stress has been put upon the taxonomic importance of the soft parts, however, in any of these publications with the exception of a single one of them titled "Classification of the British species of the genus *Solen*, Linné" by Bloomer (5) and scattered notes in his other papers. The present paper aims at treating the subject with a view to define the subfamilies and genera from the soft parts, including their gross internal anatomy. It is also intended to append an account of the gross anatomy of species, the soft parts of which are still unknown.

I should specially mention that I have received all the specimens from the Zoological Survey of India through the kindness of Dr. N. Annandale. Lastly, I heartily thank Prof. H. H. Bloomer for his kindness in sending his papers to me at my request.

GENERAL NOTES ON THE SOFT PARTS.

The animals are either narrow and elongated with more or less straight and parallel margins or short and broad (deep) with rounded margins.

MANTLE LOBES. The mantle lobes are fused with each other in various degrees in the different genera. The fusion, being incomplete, has left a number of gaps bounded laterally by free mantle margins and described as *apertures*. An anterior aperture for the protrusion of the foot is formed by the separation of the anterior margins of the mantle lobes. This is known as the *pedal*

aperture. It may extend posteriorly both along the dorsal and ventral margins but specially along the latter. In two species, so far studied, the free anterior margins of the mantle lobes have given rise to two muscular flaps from their inner surfaces which serve to close the pedal aperture when the foot is withdrawn into the mantle chamber. The flaps may be named the *pedal valves*. The outer surface of the thick muscular anterior margin of each mantle lobe sometimes presents a groove parallel to and slightly behind the free margin which receives a ridge from the valve. Posteriorly, the mantle lobes leave two apertures one above the other and placed at the end of two tubes formed from the mantle lobes. They are known as the anal and branchial siphon. The two siphonal tubes are either constricted completely in a single piece as in the typical genera, or completely or partially separate from each other in others. A fourth aperture has been described in the ventral margin of the fused mantle lobes. Bloomer (8, pp. 43-45) has conclusively shown that this aperture in the Solenidae is not homologous with a similar one in other Pelecypoda and is derived secondarily from the posterior end of the pedal aperture. The degree of fusion of the mantle lobes appears to have some distinct bearing on the assortment of the genera. Lastly, from the union of the mantle lobes with each other or with the walls of the siphons, spaces may be formed either demarcated or completely separated from the general mantle chamber. Thus a space has been described by Bloomer (7) in *Cultellus pellucidus* formed in the dorsal aspect anteriorly by the mantle lobes being joined together a little below their margins. This chamber does not communicate with the mantle cavity and is known as the *suprapedal chamber* [Bloomer (8), p. 41]. Another chamber may be formed by the union of the dorsal margins of the mantle lobes in front of the anterior adductor muscle and lying above the foot. In some genera a space is enclosed posteriorly by the mantle lobes (which are free at their posterior margins), and limited in front by the union of the siphonal tubes at their anterior margins with the mantle lobes, either directly along their inner side in front of their free posterior margins (*Solecurtus*, *Azor*), or through the intervention of narrow (*Novaculina*) or wide lateral processes (*Tagelus*), extending from the free posterior margins of the mantle lobes to the base of the siphonal tubes. Further, in *Tagelus* and *Azor*, the dorsal wall of the upper siphonal tube is connected with the ventral aspect of the posterior adductor muscle. This space contains the siphonal tubes (which may be completely retractile within the chamber) and may be designated as the *siphonal space*.

PALLIAL MUSCULATURE. A *cruciform muscle* is found in some genera, showing their relation to the fam. Psammobiidae.

FOOT. The foot is an elongated organ more or less cylindrical in typical forms but somewhat flattened in others. It arises from the anterior or antero-ventral aspect of the visceral mass. The shape of the foot, specially its anterior portion, is so variable in different degrees of retraction that it is difficult to form an idea

of its exact shape in preserved specimens in which the organ may be fixed in any degree of contraction. The foot of *Cuttellus javanicus* has been figured by Weber (50), who showed the different shapes it can assume in different degrees of extension.

The intrinsic pedal musculature as described by Bloomer (5), and followed by me in my specimens, requires a brief notice in order to understand the differences in the arrangement of the muscles in the different genera. The pedal musculature consists of (1) two layers of longitudinal muscles on each side (an outer, and an inner abutting on the pedal cavity) separated by (2) a dorso-ventral semi-circular band; (3) two rows of transverse muscle bands extending across the pedal cavity along its dorsal and ventral surfaces, and passing to the inner side of the semi-circular layers; (4) a thin layer of circular muscles just beneath the epithelial covering of the foot (the *pedal integument* of Bloomer); (5) lastly, a set of oblique muscles extending from the pedal integument between the outer longitudinal muscles to the outer side of the semi-circular bands.

The *protractor pedis* muscle is well developed in some genera (*Solecurtus*, etc.) but rudimentary or absent in others (*Solen*, etc.).

The *retractor pedis anterior* muscle, one on each side, consists of one or two bands which pass upwards to be attached to the valve. The pedal portion of the muscle consists of radiating fibres which spread out in the foot either on the inner side of or superficially to the longitudinal muscles of the foot. They are of some taxonomic importance in the differentiation of some genera.

The *retractor pedis posterior* muscle bifurcates into right and left portions which are attached to the corresponding valves. It does not bifurcate in *Cuttellus cultellus*, Dunker. The muscle at its insertion may either remain separate from or merge into the fibres of the posterior adductor muscle. The impression of the muscle on the valve may be of different sizes in comparison with that of the posterior adductor muscle.

LABIAL PALPS. The palps are wide and short, or narrow and elongated. The anterior lips formed by the union of the outer labial palps are either placed immediately behind the anterior adductor muscle, or are removed posteriorly from the muscle. A *labial groove* has been described by Bloomer (3) on the inside of each mantle lobe passing dorsally from the fourth aperture towards the foot. The distal portions of the labial palps are placed in the groove.

GILLS. The gills are generally narrow (in depth), elongated, and are often prolonged into the siphon. The outer lamella of the outer gill (demibranch) is generally attached to the mantle lobe along its dorsal margin. The inner lamella of the inner gill is divisible into visceral and cloacal portions in consideration of its attachment along its dorsal margin. The visceral portion is generally free (except in *Ensis*), whereas the cloacal portion is either free or joined to its fellow of the opposite side. *Branchial*

retractor muscles are developed in some genera along the axis of the gills. They serve to throw the gills into folds when the siphons are retracted and withdrawn between the valves.

The gills are of synoptorhabdic type, *i.e.* the filaments are connected by interfilamentar tissues. They are either simple and homorhabdic, or plicate (*i.e.* thrown into vertical folds) and heterorhabdic (sometimes very indistinctly).

ALIMENTARY CANAL. The *oesophagus* may vary in its course. The *stomach* has been divided by Bloomer (5) into four portions. The antero-ventral (*oesophageal*) is continuous with the oesophagus in front and separated from the antero-dorsal portion (*cardiac*) by a muscular ridge. The middle portion (*central*) is ventro-lateral in position adjoining the oesophageal portion. The posterior portion (*pyloric*) is separated from the central portion by a ridge passing ventrally, and from the cardiac portion by another passing to the dorsal aspect.

The pyloric stomach gives off the *coecum* of the crystalline style either from its ventral aspect or from its posterior end. The course of the coecum is somewhat different in the different genera.

The origin and course of the *intestine* may be thus considered in a tabular form:—

I. *Solen* type. The intestine arises directly from the ventral aspect of the pyloric chamber independently of the coecum. It consists of two limbs which pass along the dorsal and ventral aspects of the coecum respectively. The type may show the following variations:—

- (a) The two limbs of the intestine simple (not folded) (*Ceratisolen*, *Subcullellus*).
- (b) The anterior limb forming a number of large folds (*Pharella*).
- (c) The anterior limb with closely placed coils and posterior limb simple (*Siliqua*).
- (d) The anterior limb with closely placed coils and posterior limb with one or more folds (*Solen*).
- (e) The anterior limb with closely lying coils and posterior limb with a number of large loops (*Ensis*).

II. *Novaculina* type. The intestine arises directly from the pyloric stomach and forms several long loops traversing the entire length of the visceral mass.

III. *Solecurtus* type. The intestine arises in connection with the coecum as a common tube and is only separated from it outwardly by two lateral grooves. It forms a separate tube near the distal end of the coecum and then passes along the ventral aspect of the coecum (corresponding to the second limb of the first type). The course is either simple or is attended with loose or close coils. This type of intestine is also found in members of the fam. Psammobiidae to which some of the genera of the Solenidae are undoubtedly closely related. This point has already been emphasized by Dall (23) and Bloomer (16).

VASCULAR SYSTEM. The position of the heart varies somewhat in different genera. It may occupy the anterior, middle or posterior portion of the pericardial chamber.

NERVOUS SYSTEM. Some difference has been noted in the position of the *viscero-parietal ganglia* varying from beneath the bifurcation of the retractor pedis posterior muscle to the antero-ventral aspect of the posterior adductor muscle. There are also some minor differences in the origin, number and distribution of the nerves from the various ganglia.

CLASSIFICATION.

The family Solenidae may be divided into three subfamilies, two of which form natural assemblages of genera having a number of important characters in common. The genus *Novaculina*, Benson, differs so much from either of the two other subfamilies that it is best placed in a subfamily of its own.

Subfam. SOLENINAE.

1858. Subfam. Soleninae, subfam. Pharinae (pars), Adams and Adams, *Gen. Recent Mollusca*, pp. 340, 342.
 1862. Solenaria, Siliquaria (pars) Bronn, *Thier-Reichs. Malacozoa Acephala*, III (2), p. 476.

The present subfamily includes the typical genera of the family, presenting a narrow, elongated body, compressed from side to side, and a *Solen* type of intestine. It may be diagnosed as follows:—

Animal. Body elongated, narrow in depth and compressed laterally. Pedal aperture variable in extent. United ventral margins of the mantle lobes forming a very narrow elongated surface. No cruciform muscle. Siphons either fused in a single piece with two siphonal canals, or completely free from each other. No siphonal space (p. 48) posteriorly. A narrow, elongated cylindrical foot extending horizontally forward through the pedal aperture. Retractor pedis anterior muscle bifurcated or not (*Solena*, *Pharella*, *Cultellus*) and generally directed upwards and forwards. Protractor pedis muscle rudimentary or absent. Gills simple or plicate. Intestine arising directly from the pyloric stomach and consisting of two limbs. Viscero-parietal ganglia beneath the bifurcation of the retractor pedis posterior muscle or under the posterior adductor muscle (*Pharella*).

The subfamily forms a natural group by itself. Further study of the soft parts of the animals of the present subfamily will perhaps raise it to the rank of a distinct family.

Gen. *Solen*, Linné.

- 1782-93. *Solen* (pars), Linné, *Syst. Nat.*, ed. XIII (edited by Gmelin), p. 3223 (pars VI).
 1858. *Solen*, Adams and Adams, *Gen. Recent Mollusca*, II, p. 340; III, pl. xcii, fig. 1.
 1874. *Solen* (pars), Reeve, *Conch. Icon.*, XIX.

1887. *Solen*, Fischer, *Man. de Conch.*, p. 1110.

1889. *Solen* (pars), Clessin in Martini-Chemnitz, *Syst. Conch.-Cab.*, XI (*Solanacea*), p. 2.

The original genus *Solen*, Linné, has been split up by Schumacher (45) into three, viz., *Solen*, *Ensis* and *Cultellus*, the distinction of which has been confirmed by the anatomical researches of Bloomer (8, pp. 43-45). He described and compared a large number of species of *Solen* in a series of papers. I have three species of *Solen* at my disposal, viz., *S. kempi*, Preston, *S. sp.* from Japan and another species which appears to be new (*S. gravelyi*, sp. n.), the anatomy of which I have been able to study.

The following diagnosis has been drawn up from the work of Bloomer as well as from my study of the above species:—

Animal. Body elongated, and narrow, dorsal and ventral margins very nearly parallel to each other, anterior and posterior margins straight and sloping. Pedal aperture generally confined to the anterior margin, sometimes extending posteriorly. No fourth aperture. Siphon a single piece with the distal end fringed with tentacles. Anterior adductor muscle narrow and elongated. Posterior adductor muscle oval. Foot cylindrical, somewhat flattened laterally with the anterior end more or less dilated. Radiating fibres of the retractor pedis anterior muscle passing outside the longitudinal muscle of foot. Labial palps elongated and narrow ending in a point generally. Anterior lip of the mouth separated from the posterior end of the anterior adductor muscle by a distinct interval. Gills narrow and elongated, prolonged into the proximal end of the branchial siphonal canal; plicate and heterorhabdic, the plicae being free from one another. Visceral portion of the gills forming less than half their entire lengths. Inner lamella of the inner gill free in the visceral portion, but united with its fellow of the opposite side behind (except in *S. gravelyi*, sp. n.). Coecum arising from the ventral aspect of pylorus and passing forward. Intestine generally of *Solen* subtype (p. 50). Heart generally placed in the middle of the pericardial chamber. Liver not extending anteriorly over the anterior adductor muscle. A single anterior pallial nerve from each cerebro-pleural ganglion. Viscero-parietal ganglia placed beneath the bifurcation of the retractor pedis posterior muscle. A single circumpallial nerve.

Solen kempi, Preston.

1915. *Solen kempi*, Preston, *Rec. Ind. Mus.* XI, p. 305, figs. 18, 18a.

1916. *Solen kempi*, Annandale and Kemp, *Mem. Ind. Mus.* V, p. 355.

1916. *Solen annandalei*, *id.*, *ibid.*, pl. xvi, fig. 8.¹

Animal (pl. II, figs. 1-5). The body is five times longer than broad, being deepest somewhat behind the anterior end. The anterior margin is curved above and straight below. The posterior

¹ Dr. Annandale informs me that the figures on the plate have been accidentally transposed owing to incorrect labels received from the author of the species.

margin is straight. The dorsal margin is slightly concave in front and slightly convex behind. The siphon is long and segmented, but missing in the specimen as "it threw it off when captured" (Dr. N. Annandale's note). The surface of the distal end of the branchial siphon presents six small prominences. The pedal aperture is confined to the anterior margin and the antero-ventral notch. It is bounded by the pedal valves, with a small tentacle-like process from the dorsal aspect where the pedal valves meet.

The foot is long, somewhat flattened, and is shaped like the blade of a scalpel from the side; it is about half the body in length, and is more thickened in the middle than at either end.

The anterior adductor muscle is very long, five times as long as deep. The posterior adductor muscle is wide and slightly elongated.

The labial palps are narrow and greatly elongated, being somewhat wide posteriorly and tapering to a curved point behind.

The gills are elongated, about five times as long as broad, and more than one-third the body in length. The visceral portion of the gills is very small.

The oesophagus is fairly long and curved. The stomach has a well developed cardiac and pyloric portion, the latter forming a distinct cul-de-sac beyond the crystalline style. The intestine arising from the anterior end of the pyloric chamber soon forms a number of close coils and then passes round the long coecum forming loose folds in its posterior limb. It forms a round loop before ending in the rectum. The digestive gland surrounds the stomach and the beginning of the intestine.

The heart is placed in the middle of the pericardial chamber.

Considering the general structure of the body, the animal is evidently more elongated in its anterior than in its posterior portion, the effect being impressed upon all the organs in that part of the body.

Solen sp.

A single specimen was received from the Zoological Survey of India. It was brought by Dr. N. Annandale from Moji, Japan.

Animal. The body is about five times as long as broad (6.4 cm. long), with the posterior end slightly deeper than the anterior. Both the anterior and posterior margins are straight, the anterior sloping forwards. The pedal aperture is confined to the anterior margin. The siphon is very short and completely retractile inside the shell. The branchial aperture is much wider than the anal, and presents a pair of small valves at its proximal end. A longitudinal ridge extends from the ventral aspect of the proximal portion of the branchial siphon to the fused ventral margin of the mantle, with a second smaller one beneath and parallel to it.

The anterior adductor muscle is elongated, but not so narrow. The posterior adductor muscle is small and oval. The retractor pedis posterior muscle is elongated and larger than the posterior adductor muscle at its insertion.

The foot is comparatively short but wide with a free anterior oblique surface presenting a vertical ridge; it is flattened from side to side and is widest at the junction of the anterior and middle thirds of its length; lastly, it presents an oval patch of transverse folds on its ventral surface posteriorly.

The labial palps are triangular, being about one-fourth the body in length. The gap between the anterior lip and the anterior adductor muscle is comparatively short.

The gills are about half the body in length, and are about five times as long as broad; they are prolonged to the base of the labial palps; the visceral portions of the gills are about as long as the cloacal portion. The lamellae are separated by long interlamellar septa extending alternately between the principal filaments, and the plicae of both the lamellae are free from one another.

The oesophagus is short and nearly horizontal. The oesophageal stomach is narrow and elongated, and separated from the flattened cardiac chamber by a prominent muscular ridge. The pyloric chamber is wide and extends posteriorly beyond the coecum as a rounded sac. The coecum of the crystalline style is long and extends forwards along the ventral aspect of the visceral mass. The intestine begins close to the pyloric coecum and passes along the anterior aspect of the coecum forming loosely coiled folds. Without reaching the anterior end of the coecum, the intestine turns back and passes along the right side of the coecum to end in the rectum with a sharp bend.

Shell. Thick, strong, epidermis yellowish, with wide vertical flesh-coloured stripes above and long indistinct horizontal stripes of the same colour below the diagonal line from the antero-superior to the posterior inferior corner. Epidermis slightly corroded in its posterior upper quadrant. Length 4 to $4\frac{1}{2}$ times as long as broad. Greatest width near the posterior end. Anterior margin straight, sloping forwards from above, with the antero-superior angle obliquely truncate, and the antero-inferior angle slightly rounded. Posterior margin nearly straight, sloping backwards from above, and strongly rounded above and below. Umbonal teeth anterior, one in each valve, left tooth slightly stouter than the right.

Anterior adductor impression wide, elongated. Anterior retractor at a short distance behind and above the level of the anterior adductor. Posterior adductor impression small and oval. Posterior retractor triangular, smaller than posterior adductor. Retractor siphonis impression elongately oval.

Length 64 mm. Breadth 15 mm.

Solen gravelyi, sp. nov.

(Pl. II, figs. 6-9).

Three specimens of this species were collected by Dr. F. H. Gravely at Chandipore, Balasore (Orissa).¹ They seem to form a

¹ See Gravely, *Rec. Ind. Mus.*, XVI, p. 395 (1919).

new species which is named in honour of the collector. The description of the shell will follow the notes on the animal.

Animal. The body is 5 to 6 times as long as broad, nearly straight both anteriorly and posteriorly, being somewhat sloping in front. The anterior free margins of the mantle lobes bounding the pedal aperture are thick and muscular, and present a groove on their outer surface which receives a constriction of the valve just behind the anterior margin. The pedal aperture extends to the antero-ventral corner, and is slightly dorsal to the anterior end of the anterior adductor muscle. The ventral surface of the mantle is elongated and very narrow; it presents a median band along the middle line. The siphon is short and presents a longitudinal ribbing on the surface.

The anterior adductor muscle is long and narrow, and is slightly curved. The posterior adductor muscle is small and oval. The retractor pedis posterior muscle is smaller than the posterior adductor muscle at its insertion. There is a well-developed retractor siphonis muscle. The foot is a comparatively short cylindrical organ slightly flattened laterally and presents a knob-like swelling which ends in a blunt point at the free extremity.

The labial palps are narrow and elongated, less than one-fourth the body length.

The gills are very long and narrow, 9 to 10 times as long as broad. They are half as long as the body, and are prolonged over the dorsal aspect of the labial palps; the visceral portion of the gills is less than half their entire lengths. The inner lamella of the inner gill is free in the visceral portion. In the cloacal portion the inner lamella of the inner gills are free from each other—differing in this respect from the other species of *Solen* and resembling those of *Ensis*.

The oesophagus is long. The anterior limb of the intestine is simple, but the posterior limb presents loose folds posteriorly before it forms a loop for ending in the rectum.

Shell. The shell is very thin, translucent, very brittle, with a whitish epidermis somewhat corroded in its upper anterior quadrant; length about 4 to 5 times the breadth; anterior margin nearly straight and directed from above a little forward with a rounded antero-superior and antero-inferior corner; a strongly marked constriction just behind and parallel to the anterior margin; posterior margin straight or slightly convex, nearly vertical. Umbonal teeth anterior, one in each valve.

Anterior adductor impression narrow and elongated, with tapering ends. Anterior retractor impression very small, behind the anterior adductor. Posterior adductor impression small and oval, at a distance from the postero-superior angle. Posterior retractor impression rounded in front of the posterior adductor and smaller than the latter.

Length 16 mm. Breadth about 4 mm.

Type-specimen : M. 11658 Z.S.I. (*Ind. Mus.*).

Comparing the general conformation of the body of the three species under consideration we find that in *S. kempi*, Preston, the elongation has far more affected the anterior than the posterior portion of the body, and that in *S. gravelyi* the anterior and the posterior portions are perhaps equally affected in the process. In *S. sp.* from Japan the posterior portion of the body is comparatively more elongated than the anterior.

Although a large number of species of *Solen* have been described from their shells, only a few are known by their animals.

Considering the few species described by Bloomer and three species of mine, it is premature, at the present moment, to attempt to group the various species of *Solen* into sections according to the conformation of their soft parts. And the anatomical conditions may, if possible, be further co-related with the peculiarities of the shells. For the present, a division of the above species into sections may be provisionally suggested as follows:—

Section I. Body elongated equally both anteriorly and posteriorly.

Types: *S. vagina*, *S. gravelyi*.

Section II. Body elongated more anteriorly than posteriorly.

Type: *S. kempi*.

Section III. Body elongated more posteriorly than anteriorly.

Types: *S. sp.* from Japan, *S. dolerscoti*.

Subgen. *Solena*, Browne (1756).

1854. *Hypogella*, Gray, *Ann. Mag. Nat. Hist.* (2) XIV, p. 23.

1858. Subgen. *Solena*, Browne, Adams, *Gen. Recent Mollusca*, II, p. 342.

1887. Sect. *Hypogella*, Gray in Fischer, *Man. de Conch.* p. 1110.

The anatomy of *Solena rudis*, Adams, has been studied by Bloomer (11). The anatomical peculiarities in which it differs from the species of *Solen* have sufficient grounds for ranking the present animal as the type of a subgenus already erected for it. The following diagnosis has been drawn from Bloomer's anatomical work on *S. rudis*:—

Animal. Body elongated with rounded anterior and posterior margins. Pedal aperture confined to the anterior margin and guarded by pedal valves. Siphon a single piece. A pair of valves in the proximal portion of the siphon in both the apertures. Anterior adductor muscle broad and deep (more or less oval in shape). Posterior adductor muscle of the same size, being much larger than the retractor pedis posterior muscle at its insertion. Foot more or less flattened, but somewhat swollen towards the distal end. Fibres of the retractor pedis anterior muscle passing between the longitudinal muscles and the pedal integument. Labial palps relatively short and wide, the anterior lip being separated from the posterior end of the anterior adductor muscle by a short interval. Gills heterorhabdic and plicate, alternate inter-

lamellar septa extending half way up the gill. Coecum of the crystalline style arising as a posterior continuation of the pylorus, large in size, very curved and comparatively short in its course. Intestine like that of *Solen* with an additional large loop before it ends in the rectum. Heart posterior. The general conformation of the body distinctly shows that the body has been elongated in its posterior portion, perhaps beyond the posterior end of the visceral mass, the remaining anterior portion being affected to a minimum. The maximum of elongation has taken place in that portion of the body which lies behind the posterior adductor muscle.

Gen. *Neosolen*, gen. nov.

1916. *Solen*? *fonesi*, Annandale and Kemp, *Mem. Ind. Mus.* V, p. 354, fig. 5, pl. xvi, fig. 7.

1916. *Solen*? *fonesi*, Ghosh, *ibid.* p. 368, figs. 1-3.

The present genus is erected for the reception of a species which was doubtfully thought to be a dwarfed form of *Solen fonesi*, Dunker. The fairly complete literature at my disposal shows that it ought to be referred to a genus of its own. I propose for the species the name *Neosolen aquae-dulcioris*. The following diagnosis is drawn from my anatomical notes (28) and from a further examination of spirit specimens:—

Animal. Body 3 to $3\frac{1}{2}$ times as long as broad, sloping anteriorly at both the anterior and posterior margins; anterior margin slightly curved. Pedal aperture confined to the anterior margin and antero-ventral corner. Thick anterior margins of the mantle lobes extending beyond the anterior margin of the valves. Concreted ventral margins of the mantle lobes forming a narrow surface. Siphon a long segmented piece, each segment with a tentacular fringe round its distal margin. Anterior adductor muscle elongated and narrow, with a short space between it and the upper end of the pedal aperture. Posterior adductor muscle oval, of smaller size than the retractor pedis posterior muscle at its insertion. Foot elongated, cylindrical, slightly flattened laterally; it is stouter towards the apex, where it forms a distinct rounded annular swelling and still further a conical process at the tip. Fibres of the retractor pedis anterior muscle passing between the longitudinal muscles and the pedal cavity. Labial palps short and broad, subtrigonal, and about one-fourth the body length. Anterior lip immediately behind the anterior adductor muscle, with no interval between the two. Gills short and deep, $3\frac{1}{2}$ to 4 times as long as broad and more than half the body in length, just continued into the proximal portion of the branchial canal; visceral portion nearly as long as the cloacal; gills broadly plicate and sub-heterorhabdic, with inter-plical junctions. Attachment of gills similar to those in *Solen*. Coecum from the postero-ventral aspect of pylorus and passing forward in its long course. Heart pushed forward into the anterior portion of the pericardial chamber by the outgrowths of the kidneys which constrict the middle portion of the pericardium.

Viscero-parietal ganglia placed beneath the bifurcation of the retractor pedis posterior muscle.

The general conformation of the body shows that the present animal is considerably abbreviated antero-posteriorly in comparison with that of the species of *Solen*. The process of elongation has mainly affected the posterior region of the body behind the posterior adductor muscle and a small anterior region including the anterior adductor muscle. The animal is evidently more primitive than the species of *Solen*. It is quite suggestive that the type of body in *Solen* might have passed in evolution through a stage more or less resembling the present genus in descending from a still more abbreviated type of ancestor.

Type-specimen: No. M. $\frac{2981}{2}$ Z.S.I. (*Ind. Mus.*).

FURTHER NOTES ON THE ANATOMY OF *N AQUAE-DULCIORIS*,
sp. nov.

Gills. The gills are plicate and heterorhabdic. The principal filament is somewhat flattened laterally and is slightly different from the ordinary filaments. The interlamellar septa extending between the principal filaments are very short bringing the lamellar closer to each other. The plicae themselves are also connected with one another antero-posteriorly by interplicar tissues.

The oesophagus is nearly horizontal with a slight curve having its convexity directed upwards. The wide oesophageal stomach is separated from the cardiac stomach, extending beyond the former in front by a thick prominent horizontal fold. The pyloric stomach does not extend beyond the coecum of the crystalline style posteriorly. The central stomach is triangular in shape and is separated from the cardiac and pyloric chambers by a ridge continuous with that in front.

The shell was described and figured in the paper cited above.

Gen. *Ensis*, Schumacher.

- 1782-93. *Solen* (pars), Linné, *Syst. Nat.* ed XIII, edited by Gmelin.
1817. *Ensis*, Schumacher, *Essai d'un. Nov. Syst. des Habit. des vers Testacé*, pp. 47, 143, pl. xiv, fig. 1.
1840. *Ensatella*, Swainson, *Tr. Malac.* p. 365.
1858. *Ensis*, Schumacher in Adams, *Gen. Recent Mollusca*, II, p. 342 ; III, pl. xcii, figs. 2, 2a, 2b.
1887. *Ensis*, Schumacher in Fischer, *Man. Conch.*, p. 1110.
1889. *Solen* (pars), Clessin in Martini and Chemnitz, *Conch-Cab.*, pp. 10, 14, pl.

The genus has been studied by Bloomer (5) who described the anatomy of *Ensis ensis* with full details and later on compared it with several other species (11, 12, 13). Drew (25) briefly noticed the animal of *E. directus*. He figured the siphon and the ventral aspect of the animal and gave a schematic transverse section of the body showing the attachments of the gills not fully dealt with by Bloomer. The following diagnosis is drawn from the researches of Bloomer and Drew :—

Animal. Body narrow and greatly elongated. Pedal aperture either confined to the anterior margin, or extending posteriorly

along the ventral margin for a short distance. A fourth aperture and labial grooves present. Siphon of a single piece, comparatively short, and with a tentacular fringe. Anterior adductor muscle elongated, but not very narrow. Posterior adductor muscle less elongated. Retractor pedis posterior muscle much smaller than the posterior adductor muscle at its insertion. Foot narrow and elongated, somewhat flattened laterally and swollen and keeled at the anterior extremity. Fibres of the retractor pedis anterior muscle spread on the inner side of the longitudinal muscle. Anterior lip separated from the anterior adductor muscle by a long interval. Gills elongated, heterorhabdic and plicate, the plicae being free from one another; gills extending into the siphon. Outer lamella of the outer gill attached to the mantle lobe along their dorsal margin. Inner lamella of the inner gill attached to the side of the foot along its dorsal margin, but free behind in the cloacal region. Coecum of the crystalline style short and extending postero-ventrally from the posterior end of the pyloric chamber. Intestine of *Ensis* sub-type. Digestive gland extending over the anterior adductor muscle. Heart in the middle of the pericardial chamber. Viscero-parietal ganglia beneath the bifurcation of the retractor pedis posterior muscle. Two nerves from each cerebo-pleural ganglion. Two circumpallial nerves.

The structure and general conformation of the animal distinctly show that the members of the present genus have attained the greatest degree of elongation and are greatly removed from the ancestral stock.

Gen. *Ceratisolen*, Forbes.

1847. *Pharus*, Leach, *Ann Mag. Nat. Hist.* XX, p. 272.
 1848. *Ceratisolen*, Forbes and Hanley, *A History of British Mollusca and their shells*, p. 259.
 1858. *Pharus*, Leach in Adams, *Gen. Recent Mollusca*, II, p. 343; III, pl. 92, fig. 3, 3a, 3b.
 1874. *Pharus*, Leach in Reeve, *Conch. Icon.*, XIX, fig. 1.
 1887. *Pharus*, Leach in Fischer, *Man. Conch.*, p. 1108.

The anatomy of *C. legumen* L. has been studied by Bloomer (8, pp. 31-40). The following diagnosis has been drawn up from his work:—

Animal. Body moderately elongated (comparatively shorter than that of *Solen* or *Ensis*), nearly straight along the anterior and posterior margins. Pedal aperture extending a short distance along both the ventral and dorsal aspects. A chamber above the anterior adductor muscle opening in front and continuous with the pedal aperture. A fourth aperture at the postero-ventral end of the pedal aperture continuous with it and fringed with tentacles. Siphon of two long and narrow separate tubes. Anterior adductor muscle elongated. Posterior adductor muscle placed rather posteriorly and comparatively small. Retractor pedis posterior muscle much smaller than the posterior adductor muscle at its insertion; bifurcated portions long. Foot large, conical or club-shaped, truncate. Fibres of the retractor pedis anterior muscle passing outside the longitudinal muscle. Labial palps short and wide.

Anterior lip close behind the anterior adductor muscle. Gills small and narrow, non-plicate and homorhabdic. Attachments of gills similar to those in *Solen*. No division into oesophageal and cardiac chambers. Coecum of the crystalline style from the anterior portion of the ventral aspect of the pyloric chamber. Intestine of two simple limbs. Digestive gland passing over the anterior adductor muscle. Heart placed in the middle of the pericardial chamber, blood red. A single circumpallial nerve.

The anatomical researches of Bloomer on *Ceratisolen* has disclosed some facts which help to determine the relation of *Ceratisolen* with other genera of the family. The general conformation of the body shows that the animal is less elongated than *Ensis* and *Solen* but more so than *Neosolen*, *Subcultellus* and *Cultellus*; the position of the posterior adductor muscle near the hinder end of the body is certainly compatible with the view that the posterior end has not elongated behind the attachment of the muscle. The genus, however, resembles the genus *Subcultellus* (*Cultellus pellucidus*) most closely in having a fourth aperture in continuation of the pedal aperture (a condition of great morphological importance), and in several other points, viz. in the separation of siphonal tubes, attachments of gills, relation of the pedal fibres of retractor pedis anterior muscle with the longitudinal layer of muscles, and in the direction of the coecum of the crystalline style, but differs from the latter in having simple, non-plicate gills, in the position of the heart and digestive gland. Differing from *Ensis* in the attachments of the gills, arrangement of the pedal fibres of the retractor pedis anterior muscle, direction of the coecum and its mode of origin, and in the presence of a single circumpallial nerve, the genus cannot be assigned an intermediate stage between *Ensis* and *Subcultellus*, giving origin to the former genus by the fusion of the siphonal tubes and separation of the fourth aperture. It, however, resembles the genus *Ensis* in the extension of the digestive gland over the anterior adductor muscle, a character absent in *Subcultellus* but present in *Cultellus*. Thus it obviously follows that although the genera *Ceratisolen* and *Subcultellus* are more or less related to each other and to *Ensis* on the one hand and *Cultellus* on the other, they cannot be considered to form a connecting link between the above genera in the direct line of ancestry but to represent diverging offshoots from the same stock.

Gen. *Subcultellus*, gen. nov.

- 1810. *Cultellus* (pars), Schumacher, *Essai Nouv. Syst. Habit. des Vers. Testacé*, pp. 43, 130, pl. vii, fig. 4.
- 1835. *Solen pellucidus*, Pennant, Lamarck, *Hist. Nat. Anim. Sans Vert.*, VI, p. 56.
- 1851. *Ensis pellucidus*, Pennant in Gray, *Cat. Brit. Mus.*, VII, p. 60.
- 1858. *Ensis* (pars), Adams, *Gen. Recent Moll.*, II, p. 342.
- 1874. *C. pellucidus*, Pennant in Reeve, *Conch. Icon.*, fig. 4.
- 1887. *Cultellus*, Schum. (pars), Fischer, *Man. Conch.*, p. 1, 109.
- 1889. *Cultellus*, Schum. (pars), Clessin in Martini-Chamnitz, *Conch. Cab. (Solanacea)*, XI, p. 38.

The present genus is erected for the reception of *Solen pellucidus*, Pennant (*Zool. Brit.* IV, pl. 46, fig. 23). The anatomy of *Solen (Cultellus) pellucidus* (7) and of two species of *Cultellus* [*C. javanicus* (11), *C. cultellus* (16)] has been described by Bloomer (7, 11, 16). I have been able to study the animal of *C. subellipticus*, Dunker. The animal of *C. pellucidus* differs from those of the other three species in having a fourth aperture, a suprapedal chamber, an elongated anterior adductor muscle, very small posterior adductor muscle, a wedge-shaped foot, a large coecum with a long course, and lastly in having no fringe of long tentacles round the distal margin of the siphonal tubes. These features, along with an elongated body, are sufficient to split the genus *Cultellus* into two, and I suggest to form a new genus *Subcultellus* for *Cultellus pellucidus*. The relation of *Subcultellus* with *Ceratisolen* has already been dealt with. The present diagnosis is drawn from Bloomer's work.

Animal. Body somewhat elongated (more than *Cultellus*). Pedal aperture large, extending both dorsally and ventrally to some distance posteriorly. Margins of pedal aperture crenulate. A chamber formed dorsally by the union of the mantle lobes a little below their margins. A fourth aperture at the postero-ventral end of the pedal aperture. Siphons separate, with very short anal and branchial tubes. Anterior adductor muscle elongated, wider posteriorly than anteriorly. Posterior adductor muscle very smooth, but larger than retractor pedis posterior muscle at its insertion. Foot large, wide anteriorly and terminating in a deep obliquely truncate extremity. Fibres of the retractor pedis anterior muscle passing outside the longitudinal layers of muscles. Gills similar to those in *Solen*. Anterior lip of mouth immediately behind the anterior adductor muscle. Pyloric chamber very large, coecum of the crystalline style very wide proximally and arising from the ventral aspect of the pylorus; it is of considerable length extending along the greater portion of the visceral mass. Intestine of two simple limbs. Digestive gland not extending over the anterior adductor muscle. Heart at the anterior end of the pericardial chamber.

Gen. *Cultellus*, Schumacher.

- 1782-93. *Solen* (pars), C. A. Linné, *Syst. Nat.*, ed. XIII, pp. 3223, 3224.
 1817. *Cultellus*, Schumacher, *Essai Nouv. Syst. Habit. des Vers Testacé*, pp. 43, 130, pl. vii, fig. 4.
 1835. *Solen Cultellus*, Lin. and *S. javanicus*, Lamk., Lamarck, *Hist. Nat. Anim. Sans. Vert.*, VI, pp. 56, 58.
 1858. *Cultellus*, Schum., Adams, *Gen. Recent Moll.*, II, p. 344; III, pl. xciii, figs. 2, 2a.
 1858. *Pharella*, Gray (pars), (*Solen javanicus*, Lamarck) *id.*, *ibid.*, II, p. 344, pl. xciii, figs. 1, 1a, 1b.
 1887. *Cultellus*, Schum., Fischer, *Man. Conch.*, p. 1109.
 1889. *Cultellus*, Schum., Clessin, Martini-Chernitz, *Conch. Cab.*, XI (*Solenacea*), p. 36.

Animal. Body comparatively short. Anterior and posterior ends tapering and rounded. Pedal aperture extending beyond the anterior margin both dorsally and ventrally (nearly to half the ventral margin). No fourth aperture. Siphons separate, very short, fringed with long tentacles which extend to the adjacent fused mantle margins. Anterior adductor muscle slightly elongated. Posterior adductor muscle rounded or oval, placed backward due to the elongation of the retractor pedis posterior muscle. Retractor pedis posterior muscle very small at its insertion. Foot elongated, compressed laterally and of uniform depth; free anterior end truncate obliquely. Retractor pedis anterior muscle not bifurcated. Fibres of retractor pedis anterior muscle spreading irregularly both inside and outside the longitudinal muscles. Labial palps short, wide and triangular. Anterior lip immediately behind the anterior adductor muscle. Gills heterorhabdic and broadly plicate, plicae connected by interplicar tissues; gills short and wide, visceral portions much shorter than the cloacal. Outer lamella of the outer gills free dorsally. Inner lamella of the inner gill free dorsally in the visceral portion, but united with its fellow of the opposite side below the cloacal chamber. Pyloric stomach very large. Coecum arising from the postero-ventral aspect of the pylorus, very short and passing ventrally and slightly anteriorly with a curve. Limbs of the intestine with closely formed folds at their junction. Digestive gland passing to the anterior adductor muscle. Heart occupying nearly the entire length of the short pericardial chamber.

Cultellus subellipticus, Dunker.

1861. *C. subellipticus*, Dunker, *Proc. Zool. Soc.*, p. 421.
 1874. *C. subellipticus*, Dunker, Reeve, *Conch. Icon.*, XIX, fig. 9.
 1889. *C. subellipticus*, Dunker, Clessin, Martini-Chemnitz, *Conch. Cab.*, XI (*Solenacea*), p. 43.

Animal. The body is comparatively short, about twice as long as broad, rounded at both ends, and somewhat tapering anteriorly. The pedal aperture extends anteriorly to the antero-dorsal aspect of the anterior adductor muscle and ventrally beyond the antero-ventral corner to the level of the posterior end of the anterior adductor muscle. The siphons are very short and separate; there is a row of small tentacles round the anal and branchial apertures and a row of large tentacles round them. The anterior adductor muscle is broadly oval and comparatively small. The posterior adductor muscle is slightly elongated. The labial palps are short, triangular and tapering to a point postero-ventrally. They are about one-fourth the body in length. The foot is slightly longer than half the body and about twice as long as broad. The retractor pedis anterior muscle is short and is directed upwards and slightly forwards.

The gills are broad, about half the body in length and $2\frac{1}{2}$ to $2\frac{1}{4}$ times as long as broad. They are broadly plicate. The lamellae are closely applied to each other and are connected by extensive

interlamellar tissue only leaving spaces inside the plications. The plicae are connected with one another by interplicar tissues and the surface of the gills is covered over by a thin membrane.

The oesophagus is horizontal and short. Cardiac stomach extending slightly in front beyond the oesophageal portion. Pyloric stomach not protruding posteriorly beyond the origin of the coecum. Coecum of the crystalline style short and tapering at the distal extremity. The anterior limb of the intestine forming a few closely placed coils near the junction with the posterior limb which is simple and presents a wide loop above before it ends in the rectum.

Genus *Pharella*, Gray.

1854. *Pharella*, Gray, *Ann. Mag. Nat. Hist.* (2) XIV, p. 24.
 1858. *Pharella*, Gray, Adams, *Gen. Recent Moll.*, II, p. 343.
 1887. *Pharella*, Gray, Fischer, *Man. Conch.*, p. 1108.

The animal of a single species of *Pharella* (*P. orientalis*, Dunker)¹ is known through the researches of Bloomer (10). The following diagnosis is drawn from his paper:—

Animal. Body somewhat elongated. Pedal aperture extending over the anterior adductor muscle dorsally and along the ventral margin still further posteriorly. No fourth aperture. Siphons separate, consisting of short anal and branchial tubes, fringed with tentacles. Anterior adductor muscle large and nearly rounded. Posterior adductor muscle large and rounded. Foot large, compressed and abruptly truncate in front. Retractor pedis anterior muscle not bifurcated; its fibres passing inside the longitudinal muscles of the foot. Retractor pedis posterior muscle connected with the posterior adductor muscle. Labial palps short, wide and angular. Anterior lip separated from the anterior adductor muscle by a short interval. Gills elongated, narrow, heterorhabdic and plicate. Coecum of the crystalline style directed forward from the ventral aspect of the pylorus. Intestine of two simple limbs. A single nerve from each cerebro-pleural ganglion. Viscero-parietal ganglia under the posterior adductor muscle, each giving off a branchial and a pallial nerve. Heart towards the anterior end of the pericardial chamber.

The anatomical features of the present animal distinctly show that it is elongated in the middle region of the body between the two adductor muscles. Allowing for the necessary changes consequent upon this elongation, this genus is related to *Cultellus* which seems to be more primitive than the present one in many respects.

Genus *Siliqua*, Mühlfeldt.

1811. *Siliqua*, Mühlfeldt, *Magazin d. Ges. naturf. Fr. Berlin*, V (1), p. 38.
 1817. *Leguminaria*, Schumacher, *Essai Nouv. Syst. Habit. des Vers Testacé*, pp. 42, 126, pl. vii, fig. 1.

¹ *Solen orientalis*, Dunker, *Proc. Zool. Soc. Lond.*, p. 423 (1861). *Cultellus orientalis*, Clessin in Martini-Chemnitz, *Conch. Cab.*, XI, p. 46.

1858. *Siliqua*, Mühlf., Adams, *Gen. Recent Moll.*, II, p. 345.
 1870. *Manchaera*, Gould, *Report on the Invertebrata of Mass.* (2nd Edition), p. 46, fig. 369.
 1887. *Siliqua*, Mühlf., Fischer, *Man. Conch.*, p. 1109.
 1889. *Manchaera*, Gould, Clessin in Martini-Chemnitz, *Conch. Cab.*, XI (*Solenacea*), p. 57.

The anatomy of two species of *Siliqua* has been studied by Bloomer (13). The following diagnosis is drawn from his researches:—

Animal. Body elongated (but shorter than *Solen* and *Ensis*), 2 to 3 times as long as broad. Anterior and posterior margins more or less rounded. Entire margin of each mantle lobe fringed with a thin narrow membrane. Pedal aperture extending above to the anterior end of the adductor muscle, and below about half-way along the ventral margin. Siphon a single piece, wide and comparatively short. A muscular ridge inside each mantle lobe a short distance dorsal to the fused ventral margins. A strong siphonal retractor muscle. No fourth aperture. Anterior adductor muscle short and deep. Posterior adductor muscle slightly elongated and deep. Retractor pedis posterior muscle very small in comparison with the posterior adductor muscle at its insertion. Foot elongated and cylindrical, dilate and truncate obliquely at the extremity. Fibres of the retractor pedis anterior muscle passing partly into the pedal integument and partly inside the longitudinal muscle. Labial palps elongated and tapering. Anterior lip placed immediately behind the anterior adductor muscle. Gills broad and comparatively short, homorhabdic and non-plicate, reaching the wall dividing the siphonal chambers. Attachments of gills like *Solen*. Pyloric stomach very large. Coecum of the crystalline style arising from the ventral side of the pyloric chamber at its posterior end, large and directed towards the front. Intestine like *Solen*. Digestive gland not reaching the anterior adductor muscle. Heart in the middle of the pericardial chamber. A single nerve from each cerebro-pleural ganglion. Viscero-parietal ganglia situated between the bifurcation of the retractor pedis posterior muscle, with a branchial and a posterior pallial nerve from each ganglion.

The anatomical peculiarities of the present genus tend to show that the animals are in many respects more primitive than the other members of the subfamily.

Subfam. *NOVACULININAE*, nov.

The present subfamily is made to include the single genus *Novaculina*, Benson. It seems to be greatly removed from and more primitive than the other two subfamilies.

Animal. Body comparatively short and deep, widened out laterally, about twice as long as broad, straight anteriorly, and concave posteriorly. Pedal aperture extending ventrally as a deep wide notch at the antero-ventral corner, not extending dorsally. Fused ventral margins of the mantle lobes forming a very wide

surface and traversed by numerous transverse bands of muscle. No cruciform muscle. Siphonal tubes completely separate from each other. A wide siphonal space posteriorly. A very short stout foot with a disc-like anterior end projecting forwards and downwards. Retractor pedis anterior muscle bifurcated with the bands passing upward and backward. Gills simple, homorhabdic and non-plicate. Outer lamella of the outer gill attached dorsally to the mantle lobe. Intestine of several long loops. Heart in the middle of the pericardial chamber. Viscero-parietal ganglia beneath the bifurcation of the retractor pedis posterior muscle.

Novaculina gangetica, Benson.

(Pl. III, fig. 20-23).

1830. *Novaculina*, Benson, *Glean. Science, Calcutta*, II.
 1858. Subgen. *Novaculina*, Benson (Gen. *Siliquaria*, Schumacher), Adams, *Gen. Recent. Moll.*, II, p. 347.
 1874. *Solecurtus novaculina*, Benson sp., Reeve, *Conch. Icon.*, XIX, fig. 31 a, b.
 1887. Subgen. *Novaculina* (Gen. *Solecurtus*), Fischer, *Man. Conch.*, p. 1, 107.
 1889. *Tagelus gangeticus* (pars), Benson sp., Clessin, Martini-Chemnitz, *Conch. Cab.*, XI (*Solenacea*), p. 81.

Animal. The body is about three times as long as broad, widest in the vertical line of the antero-ventral notch. The anterior margin is nearly vertical with a deep notch at the antero-ventral corner; it does not project beyond the anterior margin of the shell. The pedal aperture is somewhat oblique and extends to the antero-ventral corner. The dorsal margin is convex in front and concave behind. The fused ventral margins form a wide surface, in breadth about one-third the body length; the surface is slightly convex in front and concave behind. The siphons consist of two separate anal and branchial tubes connected proximally with the posterior margins of the mantle lobes, through the intervention of lateral flaps. The branchial siphon is longer and stouter than the anal, being one-half to one-third the body length; the surface of both the siphons is finely ribbed, but not segmented. The apertures are constricted and without tentacular fringe. A circular space is formed round the base of the siphonal tubes and enclosed by the mantle lobes and the lateral flaps from them. This space, named the *siphonal space*, is mentioned by Weber (50, p. 280) to extend halfway between the base of the upper siphonal tube and the posterior adductor muscle. The siphons do not seem to be completely retractile inside the shell.

The anterior adductor muscle is elongated and obliquely pyriform. The anterior limb of the retractor pedis anterior muscle is placed behind the anterior adductor muscle. The posterior adductor muscle is elongated with a notch on the postero-dorsal aspect in which is lodged the retractor pedis posterior muscle. The siphonal muscle is a thick sheet, elongated and trapezoidal in shape.

The labial palps are shaped like an equilateral triangle, the outer one extending slightly more ventralwise than the inner. A

side of the palp is five times smaller than the body length. The anterior and posterior lips are comparatively wide (deep).

The gills are elongated, about half the body in length and thrice as long as broad. The inner gill extends a little further forward beneath the labial palps and slightly below the outer one along the antero-ventral margin. The gills do not extend into the branchial siphon. The visceral portion of the gills is of the same length as the portion behind. Owing to the widening out of the body from side to side, and along with it the visceral mass, the gills are directed more or less outward from their dorsal attachments. The visceral portion of the inner gill is free along its dorsal margin. The gills are simple and non-plicate, but they are capable of much folding posteriorly owing to the presence of well-developed branchial retractor muscles.

The foot is short and stout, slightly flattened from side to side and is about one-fifth the body in length. The free end is somewhat dilated to form a disc-like expansion more or less concave on the surface which presents a vertical ridge. The plane of the surface is oblique to the long axis of the foot [at right angles according to Preston (40)], which is directed forward and slightly downward from the visceral mass. The retractor pedis anterior muscle has a short and slender anterior and a stout long posterior limb, both passing upward and backward. The fibres form a thick strand in the dorso-lateral aspect of the foot posteriorly, but spread out anteriorly on the inner side of the inner longitudinal muscle-layer. The bifurcations of the retractor pedis posterior muscle are rather short. The protractor pedis muscle is wanting. The inner longitudinal layer is much thicker than the outer. The semi-circular layers are not so thick. The muscles of the pedal integument are well-developed with numerous strands of oblique muscles passing inward from the layer. Transverse muscle strands extend through the entire depth of the foot, passing to the semi-circular layers. At the distal end of the foot the longitudinal muscles are separated into distinct bundles by the branching of the semi-circular muscles and by the transverse muscles thus forming a close network.

The oesophagus is short, flattened dorso-ventrally, and is horizontal in its course. The stomach is a wide irregular cavity and differs greatly from that of the other members of the family. The oesophageal stomach is a wide cavity receiving the oesophagus on its dorsal aspect and extending in front beyond the opening of the oesophagus. It is placed towards the right side of the body. The cardiac stomach is smaller than the oesophageal chamber lying towards the left side of the visceral mass and pushing the oesophageal stomach to the right. The central cavity is a small chamber on the left side, separated by a vertical ridge from the cardiac stomach in front and by a curved ridge from the pyloric chamber behind. The pyloric stomach is a large rounded sac extending posteriorly behind the origin of the coecum. The coecum of the crystalline style arises from the antero-ventral aspect of the pyloric

chamber on the left side and passes forward and downward to reach the base of the foot, gradually shifting to the middle line in its course. The intestine begins from the right side of the pylorus close to the origin of the coecum of the crystalline style. The intestine immediately after its origin forms a number of closely placed coils and then passes forward along the dorsal aspect of the coecum to the base of the foot. It then turns backwards and passes in the same direction along the left side of the dorsal aspect of the coecum to the dorsal aspect of the visceral mass between its left wall and the stomach, where it sharply bends downward and forward to pass along the left side of the coecum to reach the base of the foot again. Lastly, it curves backward and passes along the right side to reach the posterior and dorsal aspect of the visceral mass, where it forms a broad loop to end in the rectum. The rectum has its usual course. The digestive gland surrounds the stomach but does not reach the anterior adductor muscle.

The glandular sac of the kidney is placed on the ventral aspect and then on the outer side of the non-glandular sac, extending backward to the posterior adductor muscle and lying beneath the retractor pedis posterior muscle and its bifurcation. Posteriorly from the glandular sac a big diverticulum is given off, which in its forward course gives origin to another small sac interpolated between itself and the glandular sac. The non-glandular sac in its backward course lies at first between the venacava and the pericardium in contact with its fellow of the opposite side, but separated from it in its further course by the venacava coming in contact with the pericardium. There is an interrenal aperture between the two non-glandular sacs.

The visceroparietal ganglia are placed beneath the bifurcation of the retractor pedis posterior muscle. The pedal ganglia are placed in the visceral mass just above the junction of the dorsal and ventral halves and at a distance from the base of the foot nearly equalling its long axis.

The gonads extend along the side of the stomach to the dorsal aspect of the oesophagus.

The anatomical study of the animal distinctly shows that the genus is more primitive than the members of the other two subfamilies. Further, the animal seems to be secondarily modified as shown from its flattening in the dorso-ventral direction. The short stumpy foot with a disc-like flattened surface is certainly an indication of its primitive nature.

Subfam. SOLECURTINAE.

1858. Subfam. Pharinae (pars), Adams, *Gen. Recent Moll.*, II, p. 342.
 1862. Siliquaria (pars), Bronn, *Thier-Reichs, Malacozoa Acephala*, III (2), p. 476.

The present subfamily include the rest of the genera. Forming a natural group, they are more primitive than the members of the Soleninae, but are greatly specialised and less primitive than *Novaculina*. In the presence of a cruciform muscle and in the con-

nection between the coecum and intestine, they closely resemble the members of the fam. Psammobiidae to which the genera have been referred by Dall (23) and Bloomer (16). For the present they are considered to form the present subfamily, which will have to be raised to a family when the animals will be further known to us. They are undoubtedly more related to Psammobiidae than to the other two subfamilies.

The subfamily may be diagnosed as follows:—

Animal. Body comparatively short, but deep and widened out laterally. Pedal aperture extending along the entire ventral margin or a portion of it, sometimes along a small portion of the dorsal margin. United ventral margins of the mantle lobes short and comparatively wide (from side to side). A cruciform muscle in the ventral surface. Siphonal tubes either completely separate from each other or with a fused proximal portion. A large deep, linguiform foot generally protruding obliquely forward and downward from the pedal aperture. A siphonal space present or absent. Retractor pedis anterior muscle not bifurcated, and directed vertically upward. Labial palps comparatively short, generally triangular. Anterior lip close behind the anterior adductor muscle. Gills heterorhabdic, plicate, with the plicae free and flattened out antero-posteriorly. Intestine fused with the coecum and consisting of a single limb (corresponding to the second limb of Soleninae). Viscero-parietal ganglia variously placed.

Gen. *Solecurtus*, Blainville.

- 1782-93. *Solen* (pars), Linné, *Syst. Nat.*, ed. XII, p. 3225.
 1825. *Solecurtus*, Blainville, *Man. Malac. Conch.*, p. 568.
 1826. *Psammobia*, Risso, *Hist. Nat. princip. prod.* etc., IV p. 375 ;
Psammosolen, *Ibid.*, V (Index).
 1839. *Solenocurtus*, Sowerby, *Man. Conch.*, p. 99.
 1842. *Solenocurtus*, *id.*; 2nd edition, p. 262.
 1840. *Solenocurtus*, Swainson, *Tr. Malac.*, p. 366.
 1847. *Cyrtosolen*, Herrmannsen, *Indicis Gen. Malac. prim.*, p. 468.
 1858. *Macha*, Oken, Adams, *Gen. Recent Moll.*, II, p. 346; III, pl. xciii, figs. 4, 4a, 4b.
 1874. *Solecurtus*, Reeve, *Conch. Icon.*, XIX.
 1887. *Solecurtus*, Blainville, Fischer, *Man. Conch.*, p. 1, 107.
 1889. *Solecurtus*, Blainville, Clessin, Martini-Chemnitz, *Conch. Cab.*, XI (*Solenacea*), p. 84.

The anatomy of three species of *Solecurtus* has been studied by Bloomer (8, 11), viz. *S. strigillatus*, L., *S. candidus*, and *S. dombeyi*, Lam. The anatomy of the latter differs in so many points from that of the other two, that it is necessary to separate it and place in a distinct subgenus if not in a genus of its own.

The following diagnosis is drawn from Bloomer's description:—

Animal. Body short and wide with the anterior margin rounded. Pedal aperture extending above to the anterior end of the anterior adductor muscle and below nearly to the middle of the ventral margin. A wide ventral surface. Cruciform muscle typical, shaped like a cross. Siphon with a fused proximal portion, considerably wide and long and distally with separate anal and

branchial tubes with transverse ribbing. Large siphonal muscle. A siphonal space bounded in front by the fusion of the proximal portion of the siphon with the inner surface of the mantle lobes someway anterior to their posterior margins. Anterior adductor muscle narrow and elongated. Posterior adductor muscle narrow and small. Foot very large, wide and linguiform. Fibres of the retractor pedis anterior muscle passing to the pedal integument. No protractor pedis muscle. Retractor pedis posterior muscle very small at its insertion. Labial palps narrow and triangular. Anterior lip placed beneath the posterior portion of the anterior adductor muscle. Gills narrow and elongated, extending into the branchial siphon. Inner gills united dorsally in the cloacal region. Well-developed branchial retractor muscles. Pyloric stomach not produced posteriorly beyond the coecum. Coecum of the crystalline style a long and wide tube extending in front to the antero-dorsal end of the visceral mass in a curve. Intestine fused with the coecum to the distal end of the latter. Posterior limb of the intestine with a large number of irregular folds. Rectum passing closely round the posterior adductor muscle to end in the anus after bending forward along the ventral aspect. Heart placed at the anterior end of the pericardial chamber. A bulbous arteriosus in the posterior aorta. Viscero-parietal ganglia placed beneath the bifurcation of the retractor pedis posterior muscle.

Subgen. *Solecurtellus*, nov.

1818. *Solen Dombeyi*, Lamarck, *Hist. Nat. Anim. Sans. Vert.*, VI, p. 58.
 1874. *Solecurtus Dombeyi*, Reeve, *Conch. Icon.*, XI, fig. 30 a, b.
 1889. *Tagelus Dombeyi*, Lamarck, Clessin, Martini-Chemnitz, *Conch. Cab.*, XI (*Solenacea*), p. 72.

The present subgenus is erected for the reception of *Solecurtus dombeyi*, Lamarck. The following diagnosis is drawn from Bloomer's anatomical note:—

Animal. Body comparatively elongated and somewhat narrow. Pedal aperture occupying the anterior margin and nearly the entire length of the ventral aspect of the body. Cruciform muscle typically cross-shaped and placed at the posterior end of the ventral surface close to the proximal end of the siphon. Siphonal space as in *Solecurtus*. Siphon with a short proximal portion and with separate anal and branchial tubes distally. Anterior adductor muscle elongated and deep. Posterior adductor muscle oval, of the same size as the anterior adductor muscle. Foot as in *Solecurtus*. Retractor pedis anterior fibres passing inside the longitudinal muscles. Retractor pedis posterior muscle very small at its insertion. Coecum of the crystalline style large and passing forward along the ventral side of the visceral mass. Posterior limb of the intestine forming a loose fold.

Gen. *Azor*, Gray.

- 1782-93. *Solen* (pars), Linné, *Syst. Nat.*, ed. XII, pp. 3223, 3227.
 1835. *Solen* (pars), Lamarck, *Hist. Nat. Anim. Sans. Vert.*, VI, pp. 51, 59.
 1847. *Azor*, Leach, *Ann. Mag. Nat. Hist.* XX, p. 272.
 1851. *Azor*, Leach, Gray, *Cat. Brit. Mus.*, VII, p. 62.
 1858. Subgen. *Azor*, Gray (Gen. *Macha*), Adams, *Gen. Recent Moll.*, II, p. 347.
 1874. *Solecurtus coarctatus*, Reeve, *Conch. Icon.*, XIX, fig 8.
 1887. Subgen. *Azor*, Gray (Gen. *Solecurtus*), Fischer, *Man. Conch.*, p. 1107.
 1889. *Solecurtus* (pars), Clessin, Martini-Chemnitz, *Conch. Cab.*, XI, (*Solenacea*), p. 85.

The anatomy of two species of *Azor* (*A. antiquatus* and *A. coarctatus*) has been described by Bloomer (16). I have a specimen of *A. coarctatus*, Gmel. from the Persian Gulf. The present diagnosis is drawn from the animal in my possession as well as from Bloomer's descriptions.

Animal. Body comparatively short, deep, and strongly constricted laterally near the centre of the ventral surface. Pedal aperture occupying the anterior margin and nearly half the ventral margin of the mantle lobes. Posterior half of the ventral margins of the mantle lobes fused to form a wide surface. Cruciform muscle typically cross-shaped. Siphonal tubes long and separate, with a very short fused proximal portion prolonged backwards. Strongly developed retractor siphonal muscles. Two longitudinal folds on the inner surface of each mantle lobe, which terminate in the pedal aperture anteriorly, and enclose a portion of the mantle cavity behind by their united posterior end, continuous with the ventral wall of the siphon. A tentacular fringe all round the anterior, ventral and posterior margins of the mantle from the anterior to the posterior adductor muscle.

Anterior adductor muscle deep and elongated, placed obliquely, much longer (from side to side) ventrally than dorsally. Posterior adductor muscle large and nearly rounded. Foot large, short and deep. Labial palps small, somewhat elongated and triangular in shape. Gills much elongated, narrow and prolonged into the branchial siphon; cloacal portion forming half the entire length of the gill. Inner lamella of the inner gill attached to the side of the visceral mass in front and to its fellow of the opposite side behind. Well-developed branchial retractor muscles. Stomach without central portion. Pyloric stomach produced posteriorly as a blind sac beyond the origin of the coecum. Coecum of the crystalline style short and straight, passing downward and slightly forward to the ventral aspect. Intestine with closely placed folds in the upper portion of its posterior limb. Viscero-parietal ganglia placed at the antero-ventral edge of the posterior adductor muscle.

The specimen of *A. coarctatus* at my disposal differs from Bloomer's specimen in the following points. The animal is somewhat smaller in size, both the siphonal tubes are shorter and the posterior end of the body is more tapering than in Bloomer's specimen.

Gen. *Tagelus*, Gray.

1817. *Siliquaria*, Schumacher, *Essai Nouv. Syst. Habit. des Vers Testacee*, pp. 43, 129, pl vii, figs. 2, 3.
 1851. *Macha*, Gray, *Cat. Brit. Mus.*, VII, p. 61.
 1854. *Tagelus*, Gray, *Ann. Mag. Nat. Hist.* (2) XIV, p. 24.
 1858. *Siliquaria*, Schum., Adams, *Gen. Recent Moll.*, II, p. 347.
 1887. Subgen. *Tagelus*, Gray, Fischer, *Man. Conch.*, p. 1107.
 1889. *Tagelus*, Gray, Clessin, Martini-Chemnitz, *Conch., Cab.*, XI (*Solenacea*), p. 68.

The anatomy of three species of *Tagelus*, Gray (*T. rufus*, Spengler, *T. gibbus*, Spengler, and *T. divisus*, Spengler) has been described by Bloomer (10, 15) in full detail. His researches clearly point out that the two former species are closely related to each other but differ a good deal from the last one (*T. divisus*), which is somewhat related to *Solecurtellus*. A separate subgenus (*Subtagelus*) is suggested for this species in the present paper.

Animal. Body somewhat elongated and rounded anteriorly. Pedal aperture very long and wide, extending from the antero-dorsal aspect of the anterior adductor muscle, through the anterior margin, to the posterior end of the ventral margin in a vertical line with the posterior adductor muscle. Ventral margins of the mantle lobes united at a single spot with the cruciform muscle placed in it. Cruciform muscle typically cross-shaped with the posterior or both pairs of the limbs short. The mantle lobes are free at their posterior margins from the point of concrescence to the posterior end of the posterior adductor muscle. Siphon consisting of two long separate anal and branchial tubes. Siphonal space separated from the general pallial chamber by two lateral processes extending from the posterior margins of the mantle lobes to the proximal end of the siphon. Retractor siphonis muscle well-developed. Anterior adductor muscle unequally divided into two portions. Posterior adductor muscle irregularly oval or triangular, and united posteriorly with the mantle lobes and the proximal portion of the siphon. Retractor pedis posterior muscle connected with the posterior adductor muscle by its long bifurcated portions. Foot large, comparatively short and very deep. Retractor pedis anterior fibres passing inside the longitudinal muscles. Gills united dorsally at their margins beyond the foot. Anterior lip beneath the posterior division of the anterior adductor muscle. Pyloric stomach produced posteriorly beyond the origin of the coecum. Coecum of the crystalline style long, wide and produced forward and upward in a curved course to the dorsal aspect of the visceral. Limb of the intestine forming closely placed folds above. Viscero-parietal ganglia placed underneath the bifurcation of the retractor pedis posterior muscle.

The anatomical study of the genus by Bloomer (15) distinctly shows that it is somewhat related to *Solecurtellus*. It has distinctly been shown by Bloomer [(15), p. 219; (12), p. 80] that *S. rufus* is anatomically more closely related to *S. dombeyi* than to *T. gibbus*, and that the two genera resemble each other in the structure of the gills.

Subgen. *Subtagelus*, nov.

1851. *Macha divisus*, Spengler, Gray, *Cat. Brit. Mus.*, VII, p. 160.
 1854. *Tagelus* (pars), Gray, *Ann. Mag. Nat. Hist.* (2) XIV p. 24.
 1874. *Solecurtus bideus*, Reeve, *Conch. Icon.*, XIX, fig. 35.
 1887. *Tagelus divisus*, Spengler, Clessin, Martini-Chemnitz, *Conch. Cab.*, XI (*Solenacea*), p. 79.

Animal. Body similar to *Tagelus*. Mantle lobes strongly muscular. Pedal aperture resembling that of *Tagelus*. Cruciform muscle a simple broad transverse band. Anterior adductor muscle large and simple (not divided). Posterior adductor muscle large and triangular. Foot comparatively large, deep and muscular, protruding obliquely downward and forward. Protractor pedis muscle well-developed. Retractor pedis anterior and posterior muscles short. Strongly developed elevator muscles. Pyloric stomach not produced posteriorly beyond the origin of the coecum.

The above diagnostic characters, drawn from the anatomical description of Bloomer (15), clearly shows that the present animal is more primitive than the members of the genus *Tagelus*. The undivided anterior adductor muscle and the simple band-like cruciform muscle may be cited as evidence for the above conclusion. It may also be suggested that the present subgenus (which might almost be considered a genus) is closely connected to the ancestral form which has given origin to *Tagelus* on the one hand and to the type of *Psammbiidae* on the other.

CONCLUSION.

Although the little knowledge we had on the soft parts of the members of the Solenidae has been greatly enhanced by the anatomical researches of Bloomer, supplemented by my own study on the small collection of the Zoological Survey of India, we are as yet not in a position to discuss and arrive at a definite conclusion regarding the phylogenetic question of the family, unless more material comes into the hands of malacologists to be worked out by them than is the case at present. The relation between the three subfamilies is still obscure, but they seem to form fairly natural and definite groups taken by themselves. The presence of a short stout foot with a flat disc-like anterior end, and the absence of a cruciform muscle in *Novaculina* point to the comparatively primitive nature of the animal; the non-plicate gills have no taxonomic value more than as specific or subgeneric characters as shown by Ridewood (pp. 161-2). The animal is, however, otherwise specialised, and might be considered to have early separated from the ancestral stock—perhaps earlier than the appearance of the ancestral forms of the other two subfamilies.

The great width of the body from side to side seen in *Novaculina*, certainly a primitive character again, has been retained in the ancestral forms of *Solecurtinae* and has been handed down to its members. This ancestral type of *Solecurtinae* must have acquired the peculiar connection between the intestine and coecum of the

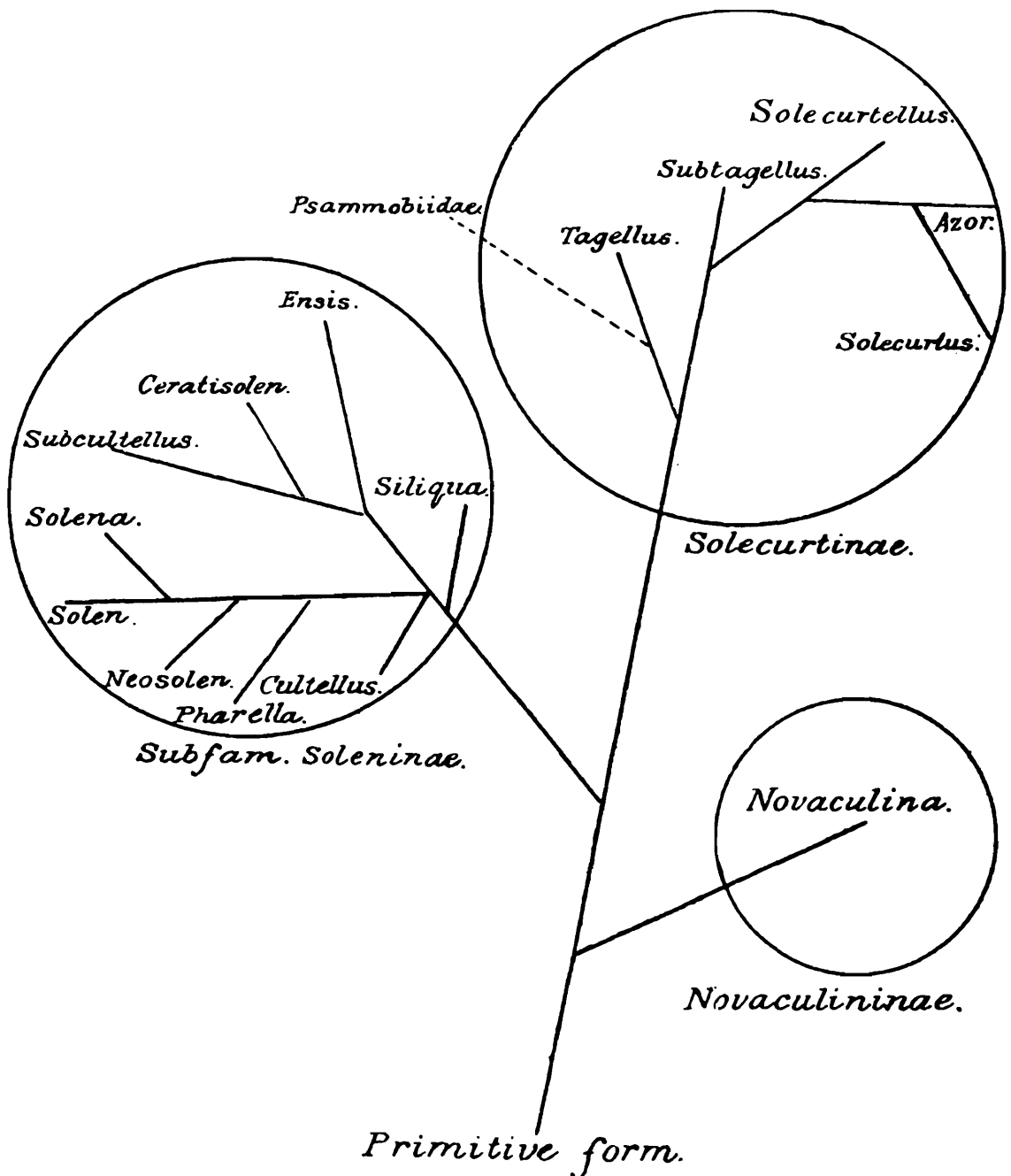
crystalline style. The question arises whether the coecum of the crystalline style has primarily originated from the side of the intestine as a side groove and has only secondarily separated from it to form a distinct and separate tube, or the coecum has primarily arisen as a ventral outgrowth of the stomach and has only secondarily acquired a connection with the intestine by the fusion of their walls. The researches of Barrois (2) have conclusively shown that the epithelial structure of the coecum of the crystalline style and intestine are quite different from each other whether they are fused together or not. Lately Bloomer has arrived at a similar conclusion, also corroborated by my own histological study on *Neosolen* and *Novaculina*.

M. Martin (*Jenaisch. für Naturwiss.* LII, 1914, pp. 363-444) has studied the relation of the crystalline style with the intestine and has found that the coecum of the crystalline style and the beginning of the intestine form together a single short wide tube in *Nucula* and in many Filibranchia. Hence, the condition found in one of the primitive types of Pelecypoda may be considered primarily at least in the present class. But it is quite probable that the condition might have arisen from one with a coecum distinct and separate from the intestine, as is still found in many Prosobranchia, and which was perhaps present in the ancestral forms before the evolution of the present class. The peculiar condition in the subfam. Solecurtinae may be easily derived from that found in *Nucula* simply by the elongation of the short conjoined portion into a long narrow tube, otherwise retaining the same primitive stage. The coeca of *Novaculina* and of the subfam. Soleninae differ from the above primitive type in being separate and distinct from the intestine. But the case of *Novaculina* seems to be different in origin from that of the members of the Soleninae. In *Novaculina*, the coecum seems to have separated at an early stage from the intestine, and in the process might have passed through a stage still found in *Modiolaria* (see Martin's paper). In the Soleninae, the condition has arisen at a later epoch secondarily from that of the Solecurtinae. The presence of connective tissue uniting the walls of the coecum and intestine, as distinctly shown by Bloomer, may be set forth as strong evidence for such a hypothesis, viz. the separation of the wall of the coecum from the intestine has taken place secondarily from a condition seen at present in the members of the Solecurtinae, the connective tissue being left as the last remnant of a former continuity of the two. Consequently it might be argued that the ancestral forms of the subfam. Soleninae have arisen from one with the intestine and coecum fused together (as in all Solecurtinae), but still without the development of a cruciform muscle, there being not a trace of it in the subfam. Soleninae; they then acquired the lateral flattening of the body and lost the connection between the coecum and intestine. It is also probable that the ancestral forms of both the subfamilies had their mantle lobes free along their ventral margins or just con-

crested at their posterior ends, as seen at present in *Tagellus*, and the fusion of the two mantle lobes gradually extended to the anterior end as the various genera originated from them. The fam. Psammobiidae, closely related to Solecurtinae, might have arisen from the same ancestral forms after the differentiation of a cruciform muscle in the fused ventral margins of the mantle lobes. The evolution of the muscle can at present be followed in the different genera of the subfam. Solecurtinae, the primitive condition as a simple transverse band being found in *Tagellus*.

Returning to the subfam. Soleninae, we find the genera *Siliqua* and *Ceratosolen* differing from the others in having simple non-plicate gills with irregular interlamellar junctions; but the plication of the gills has no taxonomic value more than as a sub-generic character as shown by Ridewood (26, pp. 161-2).

The relation between the genera of the three subfamilies may be thus provisionally represented:—



SYNOPSIS OF THE GENERA.

- a. Body flattened laterally with a narrow ventral surface ;
no cruciform muscle Subfam. Sole-
ninae.
- a¹. Gills plicate.
- a². Siphons fused to a single piece.
- a³. No fourth aperture.
- a⁴. Body and gills narrow and elongated.
- a⁵. Anterior adductor muscle nar-
row and elongated ... *Solen.*
- b⁵. Anterior adductor muscle
rounded *Solena.*
- b⁴. Body and gills short and deep ... *Neosolen.*
- b³. A fourth aperture *Ensis.*
- b². Siphons separate.
- a³. A fourth aperture continuous with pedal
aperture.
- a⁴. Body elongated ; two *long* siphonal
tubes *Ceratisolen.*
- b⁴. Body comparatively short ; two *short*
siphonal tubes *Subcultellus.*
- b³. No fourth aperture ; siphonal tubes short.
- a⁴. Gills short and deep ; anterior lip
immediately behind the anterior
adductor *Cultellus.*
- b⁴. Gills long and narrow ; anterior lip
separated from anterior adductor
muscles by an interval *Pharella.*
- b¹. Gills non-plicate *Siliqua.*
- b. Body widened laterally, with a wide ventral surface.
- a¹. Gills non-plicate ; no cruciform muscle ... Subfam Nova-
culininae
(*Novaculina*).
- b¹. Gills plicate ; a cruciform muscle Subfam Sole-
curtinae.
- a². Ventral margins of the mantle lobes fused to
form a surface ; cruciform muscle cross-
shaped.
- a³. Ventral surface long ; a long and wide
common proximal portion of the
siphon ; no tentacular fringe along the
mantle margin... .. *Solecurtus.*
- b³. Ventral surface short ; a short common
proximal portion of the siphon ; a ten-
tacular fringe along the mantle margin
Azor.
- b². Ventral margins of the mantle lobes not fused,
except at the posterior end.
- a³. A short common proximal portion of
the siphon ; anterior adductor muscle
simple ; cruciform muscle cross-shaped
Solecurtellus.
- b³. No common proximal portion of the
siphon.
- a⁴. Anterior adductor muscle simple ;
cruciform muscle band-like *Subtagelus.*
- b⁴. Anterior adductor muscle divided
into two portions ; cruciform muscle
cross-shaped *Tagelus.*

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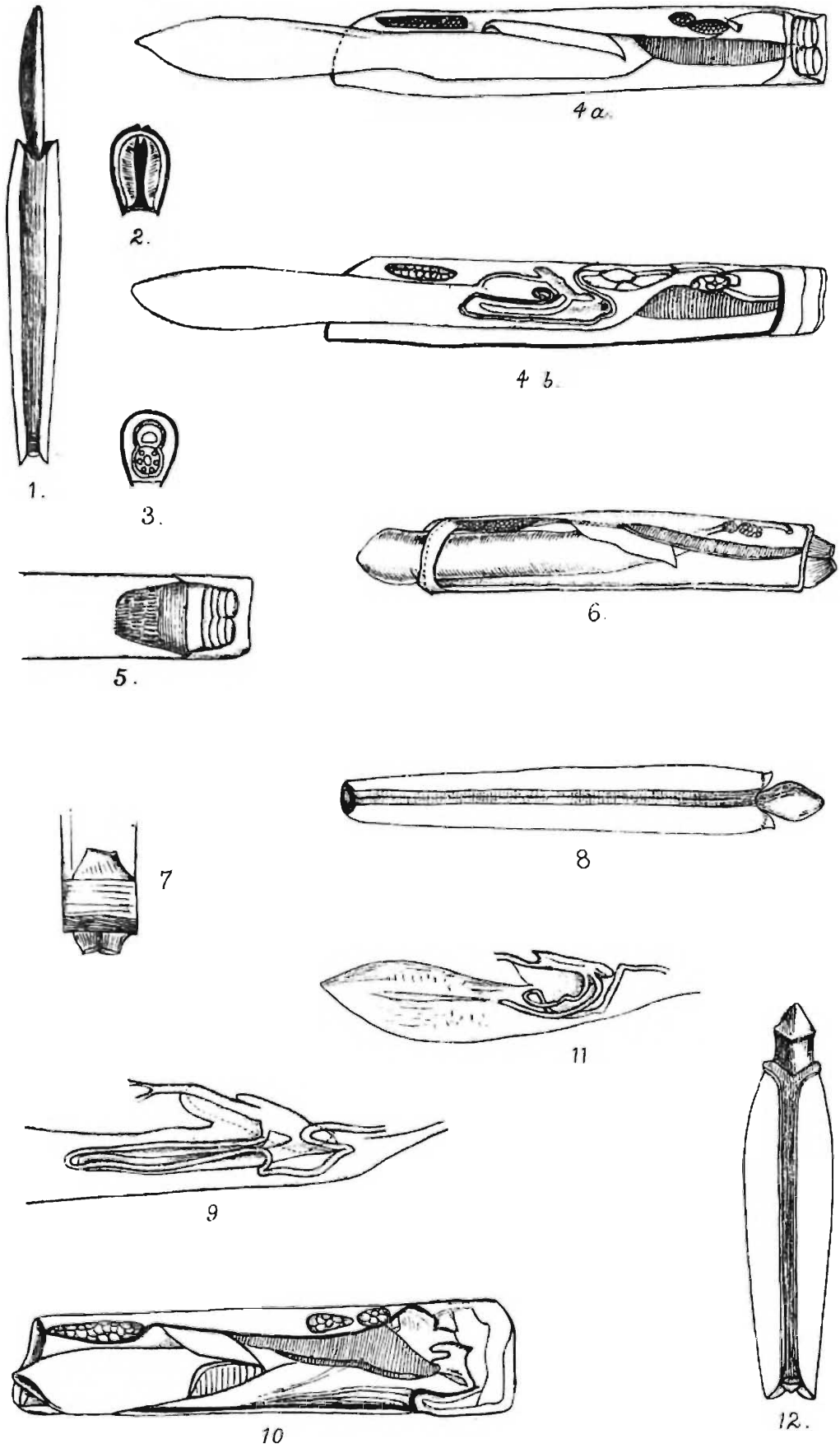
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EXPLANATION OF PLATE II.

- FIG. 1.—Animal of *Solen kempi*, Preston, ventral view, $\times 2$.
,, 2.—Animal of *S. kempi*, Preston, anterior view, $\times 3$.
,, 3.—Posterior view of *S. kempi*, Preston, $\times 3$.
,, 4.—Animal of *S. kempi*, side view (*a*) and (*b*), $\times 3$.
,, 5.—Posterior portion of *S. kempi*, showing retractor siphonis muscle, $\times 3$.
,, 6.—Animal of *S. gravelyi*, side view, $\times 3$.
,, 7.—Animal of *S. gravelyi*, posterior portion showing retractor siphonis muscle, $\times 3$.
,, 8.—Ventral view of *S. gravelyi*, $\times 3$.
,, 9.—Semi-diagrammatic section of the visceral mass of *S. gravelyi*.
,, 10.—Animal of *S. sp.* from Japan, side view, $\times 10$.
,, 11.—Section of visceral mass of *S. sp.* from Japan, showing the alimentary canal. Semi-diagrammatic.
,, 12.—*Neosolen aquae-dulcioris*, ventral view, $\times 2$.



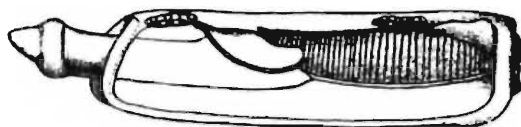
E. Ghosh del.

A. Chowdhary lith.

ANATOMY OF THE SOLENIDAE.

EXPLANATION OF PLATE III.

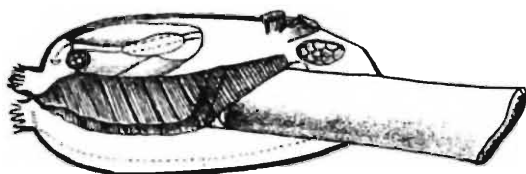
- FIG. 13.—*Neosolen aquae-dulcioris*, side view, × 2.
,, 14.—*N. aquae-dulcioris*, side view, × 2.
,, 15.—Animal of *Cultellus subellipticus*, Dunker, side view,
× 3.
,, 16.—Alimentary canal of *C. subellipticus*.
,, 17.—Ventral view of *Azor coarctatus*, × 2.
,, 18.—Animal of *A. coarctatus*, side view, × 1.
,, 19.—Animal of *A. coarctatus*, side view, × 2.
,, 20.—*Novaculina gangetica*, Benson, ventral view, × 2.
,, 21.—*N. gangetica*, Benson, side view (animal), × 2.
,, 22.—*N. gangetica*, Benson, side view (animal), × 2.
Mantle lobe of one side removed.
,, 23.—*N. gangetica*, Benson, alimentary canal (diagram-
matic).



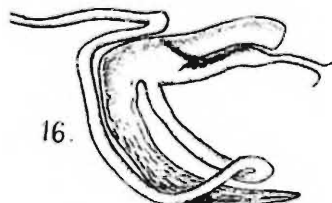
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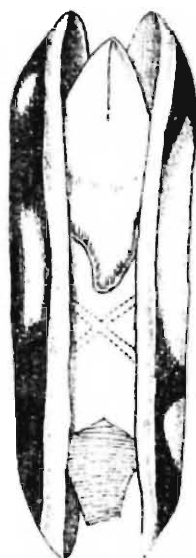
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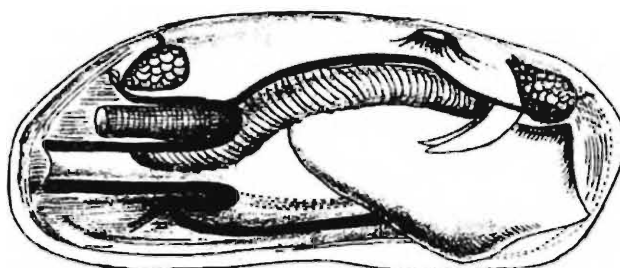
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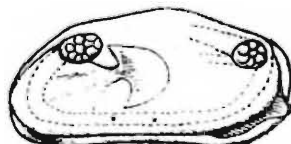
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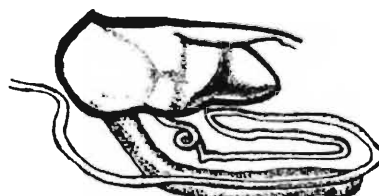
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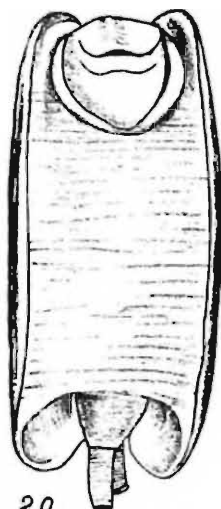
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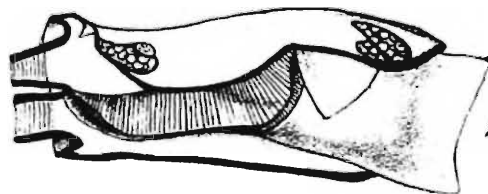
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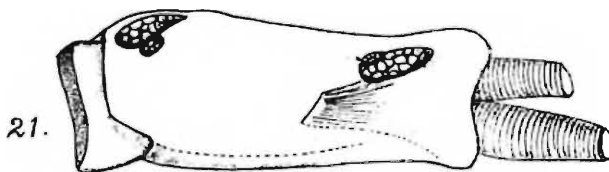
23.



20.



22.



21.

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A. Chowdhary lith.

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