

ON A NEW SPECIES OF THE GENUS *THALASSEMA* FROM BOMBAY.

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(Plate XII.)

In this paper we give the description of a new species of the genus *Thalassema* Lamarck which is fairly common in the intertidal zone in certain areas near Bombay and discuss its relationship with the other known Indian species.

***Thalassema bombayensis*, sp. nov.**

The shape of the body is variable, in a well preserved specimen, such as is figured on plate xii, fig. 1, it is elongate, cylindrical, gradually tapering posteriorly to a subtruncate tip and rounded anteriorly to where the proboscis is attached. The length of the body in the holotype preserved in 90 per cent. alcohol after fixation in formalin is 10·8 cm., but other specimens, depending on the state of preservation, vary from 7 to 12 cm. in length. The maximum breadth of the body is 2·5 cm. The proboscis, like the body, is capable of a great deal of contraction and expansion; in a well preserved specimen, such as the one selected as the holotype, it is elongated, somewhat tubular and is broadly truncated at its free anterior end; it is 2·4 cm. long, and its maximum breadth is ·9 cm.; its form in a contracted condition is shown in the specimen illustrated in fig. 2. The ventral margins of the proboscis are free from one another almost to the point of attachment to the body, and unlike the condition in most of the estuarine Asiatic species of the genus, the margins are not united ventrally at the base to form a tube. The entire surface of the body is covered over by papillae, those in the middle region are minute (fig. 5, *p*), conical and hardly visible to the naked eye; along the two ends, however, there are a large number of fairly large somewhat raised ovoidal tubercle-like structures (fig. 6, *p'*) interspersed with the microscopic papillae of the same type as are found in the middle region of the body. Some large papillae (fig. 5, *p'*) are also to be seen in the middle region of the body. The tubercles, as is clear on examination with a lens, are formed by the union of groups of 4-5 small papillae. The arrangement of the papillae and tubercles is irregular over the greater part of the body but near the two ends they appear to be arranged in regular rings. The surface of the proboscis is quite smooth.

At a distance of about a centimetre from the anterior end in the mid-ventral line there are the usual two-hooked setae of a golden-yellow colour. Lying slightly externally to the hooks are the narrow, somewhat slit-like openings of the segmental organs. In a well preserved specimen two pairs of these openings were clearly visible anterior to

the hooks and 3 on the right and 2 on the left side posterior to the hooks ; in other specimens the openings could not be clearly distinguished. The longitudinal muscular layer of the body-wall is not continuous, but in the middle region of the body it is broken up into bundles. Normally the number of bundles is 10, and these are separated by interspaces almost as broad as the bundles themselves, but in some specimens one or another of the bundles is divided into two distinct bundles and as a result 11 bundles are present. Along the ends of the body, however, the longitudinal muscles form a continuous sheath. The number of segmental organs (fig. 3, *s.o.*) is variable, usually there are 5 pairs, 2 pairs lying anterior to and 3 posterior to the setal hooks, but in some specimens only 4 pairs of well developed segmental organs were found ; of the posteriormost fifth pair a vestigial one was developed on the right or left side and the corresponding organ of the opposite side was altogether absent (fig. 3). In one specimen there was no trace of the fifth pair. The vesicles of the segmental organs are drawn out into almost whip-like structures at their free ends, while the lateral margins of the funnels are provided with very long spirally-coiled lobes. The spiral lobes are only the lateral prolongations of the margins of the funnel, and are in normal specimens only two in number, but in one case the spiral structures by irregular dichotomous branching had developed into a bunch-like structure (fig. 4). The anal vesicles, which are greatly elongated structures, are of almost the same length as the body of the animal ; from a little in front of the middle they narrow gradually to almost thread-like structures ; the funnels are arranged irregularly on the anterior one-third of their length. No caecum could be distinguished in the specimens dissected by us.

The colour of the specimens preserved in formalin is light salmon-red, but owing to the blackish mud shining through the interspaces between the muscle bands these areas appear to be rather darker in colour.

Locality.—As is noted in the introduction the species has been found only in certain areas near Bombay in the intertidal zone of the beaches, specially at Chowpatty, Worli and Colaba. So far as is known the species is not widely distributed all along the coast. The bottom in the intertidal areas at these places consists of a blackish sandy mud.

Holotype.—No. W $\frac{1525}{1}$ in the collections of the Zoological Survey of India (Indian Museum), Calcutta.

Remarks.—This animal is gregarious and is found in colonies living in muddy ooze containing a large quantity of fine sand grains ; each animal occupies a separate burrow in the colony. The burrows are easily recognised by the presence of small elliptical pellets of excreta lying in the depressions of the burrows. The number of individuals in the colonies is very large, as many as forty specimens were found on one occasion in a single colony.

The animal is very slippery owing to the presence of large quantities of mucus all over the body and especially on its posterior part.

It is found all the year round, and its breeding season is from July to September, though sometimes specimens with ripe ova and sperms are found as late as October and November.

There are no external sexual differences, but in the breeding season males can generally be recognized from the females. In the males the segmental organs, which are distended with ripe sperms, are seen through the more or less transparent skin as shining milky-white structures; while in the female these organs containing the ripe ova are dull grey. In some cases the males are bright red, while the females are usually of a dull colour.

Relationships.—Leaving out of consideration the species ¹ of the genus *Thalassema* Lamarck, which have been found in estuarine areas, the first essentially marine species of this genus from along the Indian coasts was recorded from the Gulf of Manaar off Rameshwaram Island along the coast of Peninsular India, on the authority of the late Dr. Selenka, by Thurston ² under the name *Thalassema formulosum*; this name, however, as was shown by one of us ³ is only a *nomen nudum*, and unless the suggestion made in the paper cited of *T. formulosum* being a *lapsus calami* for *T. formosulum* Lampert is correct, the identity of the species from off Rameshwaram Island must remain doubtful. In 1919 a second marine species from the mud-flats at Chandipore, Orissa, was described by Prashad ⁴ under the name *T. microrhynchus*, but this species and *T. branchiorhynchus* Annandale and Kemp, which was also found in association with it in the same locality, appear to belong to the group of estuarine species ⁵ referred to above and need not be considered here. A second truly marine species from the chank-beds at Tuticorin in the Gulf of Manaar was, however, described by Prashad in 1920 in the paper cited under the name *T. hornelli*, ⁶ and this completes the records of the species which are known from along the coasts of India.

T. bombayensis differs from all other extra-Indian species in having 4-5 pairs of segmental organs. In this respect it is allied to *T. hornelli*, which also has 5 pairs of segmental organs, but differs from it in general form and in having 10-11 instead of 19 longitudinal muscle bands. The variable number of both the muscle bands and the segmental organs in *T. bombayensis* suggests that the species is still in the process of evolution in these respects. The greatly divided condition of the spiral lobes of the funnels of the segmental organs, which was found in one specimen, is also of special interest.

¹ Annandale, N. & Kemp, S. W., *Mem. Ind. Mus.*, V, pp. 58-63, text-figs. 1-3 (1915). See also Prashad, B., *Mem. As. Soc. Bengal*, VI, pp. 323-338, pl. xi (1919).

² Thurston, E., *Bull. Madras Mus.*, III, p. 116 (1895).

³ Prashad, B., *Rec. Ind. Mus.*, XIX, p. 35 (1920).

⁴ Prashad, B., *Rec. Ind. Mus.*, XVI, pp. 399-401, text-fig. (1919).

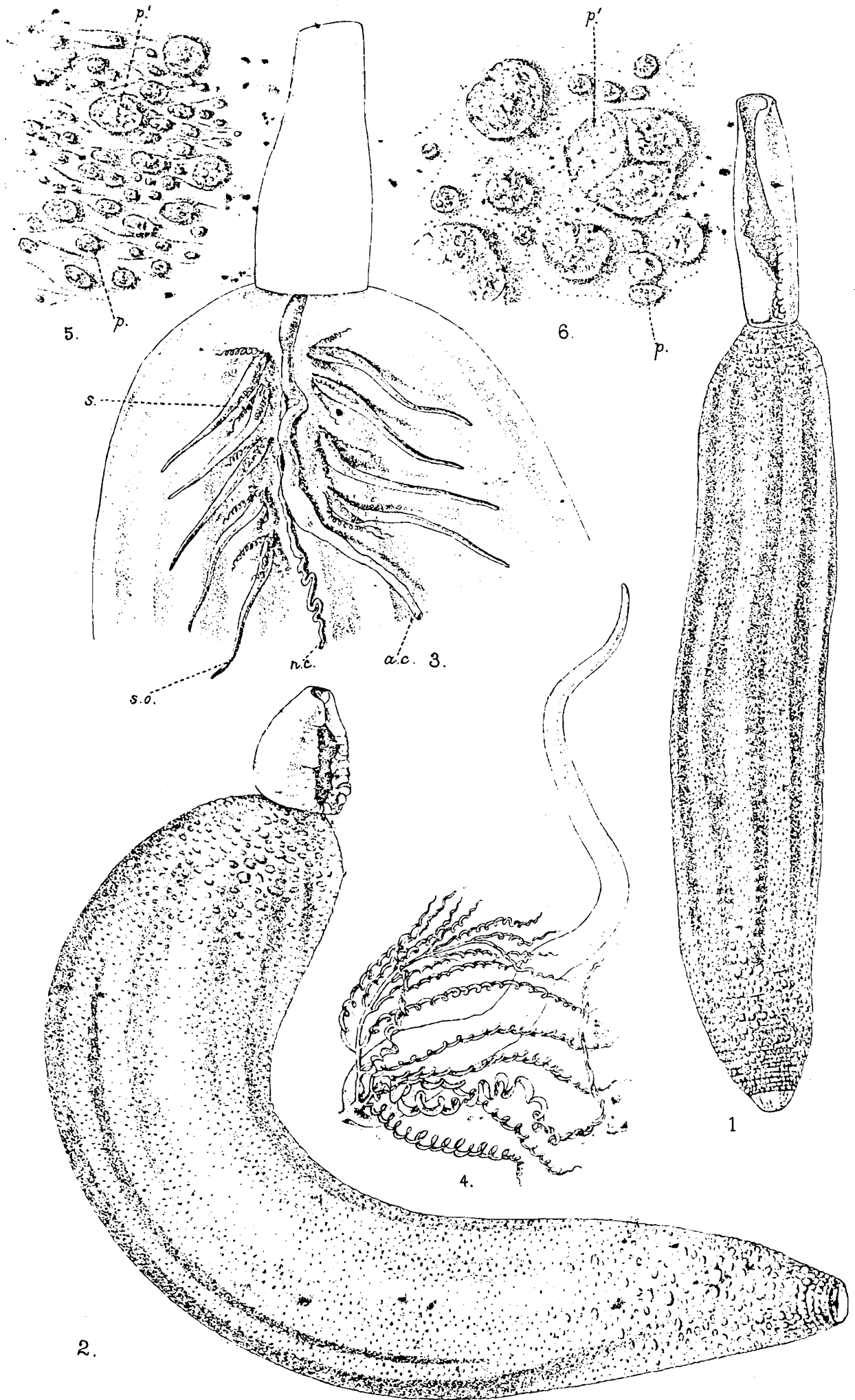
⁵ Annandale in *Bijdrag. Tot. d. Dierkunde* (Max Weber Feest-Numer), p. 148 (1922) separated this interesting group of estuarine species together with *T. sabinum* Lankester from Siam into a distinct genus for which he proposed the name *Anelassorhynchus*. Anatomically, however, these forms do not differ in any respect from the other marine species of the genus *Thalassema* Lam., and it is very doubtful whether the slight differences in the "structure, function and physiology of the proboscis" are enough for separating them into a distinct genus. It may also be noted here that no species had ever been described by Annandale & Kemp under the name *Thalassema gangetica* and apparently this name is synonymous with *Thalassema branchiorhynchus* Annandale & Kemp which was originally described from the Gangetic Delta. The page reference to this species in the *Mem. Ind. Mus.* should be 61 and not 56 as given by Annandale in the paper cited.

⁶ Prashad, B., *Rec. Ind. Mus.*, XIX, pp. 36, 37 (1920).

EXPLANATION OF PLATE XII.

Thalassema bombayensis, sp. nov.

- FIG. 1. Holotype with the expanded proboscies as seen from the ventral surface. Natural size.
- FIG. 2. Another specimen preserved in 10 per cent. formalin, showing the contracted proboscis, arrangement of tubercles and papillae. Natural size.
- FIG. 3. Anterior part of a dissected specimen showing the arrangement of the segmental organs. In this specimen there are 5 segmental organs on the left and only 4 on the right side; slightly enlarged. *a. c.* alimentary canal; *n. c.* nerve cord; *s.* inner end of seta; *s. o.* segmental organ.
- FIG. 4. A segmental organ, as seen from the ventral side, showing the vesicle and the much divided spiral lobes of the funnels, $\times 16$.
- FIG. 5. Papillated area of the skin from the middle of the body, $\times 16$. *p'* small papilla; *p* larger tubercle formed by the union of small papillae.
- FIG. 6. Tuberculated area of the skin from near the posterior end of the body, $\times 16$. Reference lettering same as fig. 5.



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THALASSEMA BOMBAYENSIS, sp. nov.

DESCRIPTION OF A NEW GENUS AND SPECIES OF GEOPHILIDAE (MYRIAPODA, CHILOPODA) FROM MADRAS (INDIA).

By F. SILVESTRI.

Gen. **Mixophilus**, nov.

Body anteriorly and posteriorly slightly narrowed. Head small, not completely covering the lateral part of first segment of the maxillipedes, with the sides converging a little anteriorly. Antennae somewhat attenuate, sparse, setose. Labrum very small, provided with four teeth medially; mandibles with one pectinate lamella, the teeth of which are very short and similar; first maxillae with the entire coxosternum provided with a submedian triangular, tapering process, which has a seta at its base internally and inferiorly; maxillary palp biarticulated; its second article longer than the first, bearing a seta on its lower surface; second maxillae with an entire coxosternum and a 3-jointed palp provided with a distinct subconical claw.

Frontal lamina coalesced; prebasal lamina scarcely distinct, basal lamina broad, trapezoidal. Maxillipedes separated from the frontal margin of head by a long distance; first joint long and strong, second and third very short, all unarmed, claw long, somewhat curved, and at base armed with a small tooth, subcoxosternum with entire chitinous lines, anterior margin unarmed and medially very faintly sinuate.

Segments provided with short and trapezoidal pretergites; tergite transversely subrectangular; pleurae with prescutellum somewhat larger than the spiracular scutellum; sternites with presternum in the middle faintly and incompletely divided, sternum provided (last pediferous excepted) with glandular pores disposed in a posteriorly situated entire area on a number of segments in the anterior part of the body and in two posteriorly situated areas on the remaining segments.

Legs short, provided with an unguiform terminal joint, strong, bearing basally a seta a little shorter than the claw.

Last pediferous segment provided with an obtrapezoidal sternum and with numerous glandular pores, which open in a large common pit as shown in fig. 3, *a*; legs 7-jointed including the last claw, little longer than the preceding legs, and in female very little more attenuate than in male.

Anal pores present.

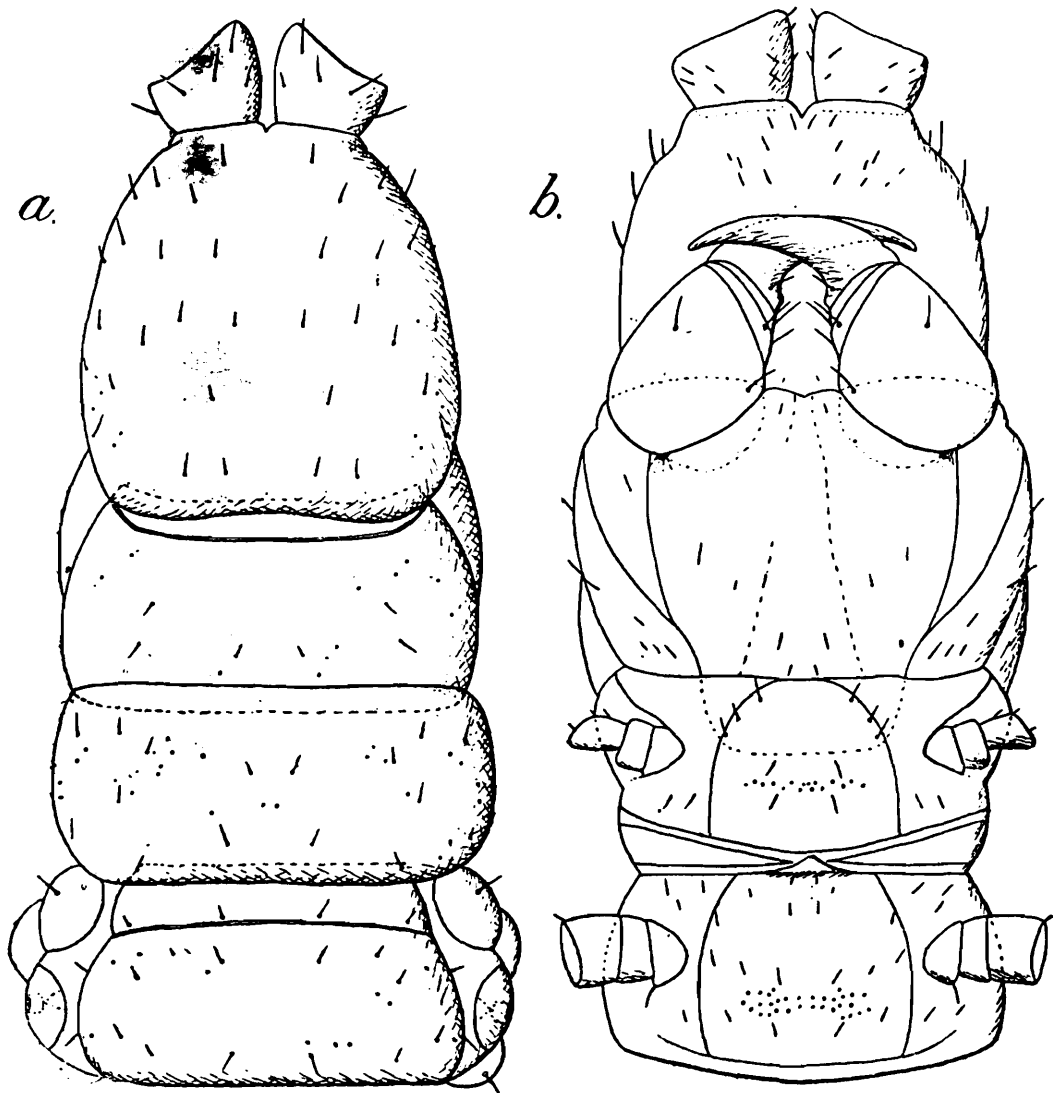
Genotype: *Mixophilus indicus*, sp. nov.

Remarks: This genus is related to *Henia* C. L. Koch and to *Chaetochelyne* Mein., but it differs from both in the form of the labrum, in the distribution of sternal pores, and from the first in the legs of the last pediferous segment being provided with an unguiform joint (claw) and from the second in the basal laminae being very much longer.

Mixophilus indicus, sp. nov.

Body light leather-coloured, with head and maxillipedes, except for the black claw, of an ochre-amber colour.

Sterna sparsely and shortly setose and provided with a posterior entire area of glandular pores up to segment xvii, which in the xviii segment are about 70 in number; the glandular areas become medially interrupted from segment xviii onwards and the lateral groups become gradually less numerous; in the last ambulatorial segment each lateral group is composed of about 9 pores only.



TEXT-FIG. 1.—*Mixophilus indicus*: a, b. Dorsal and ventral aspect of anterior part of body.

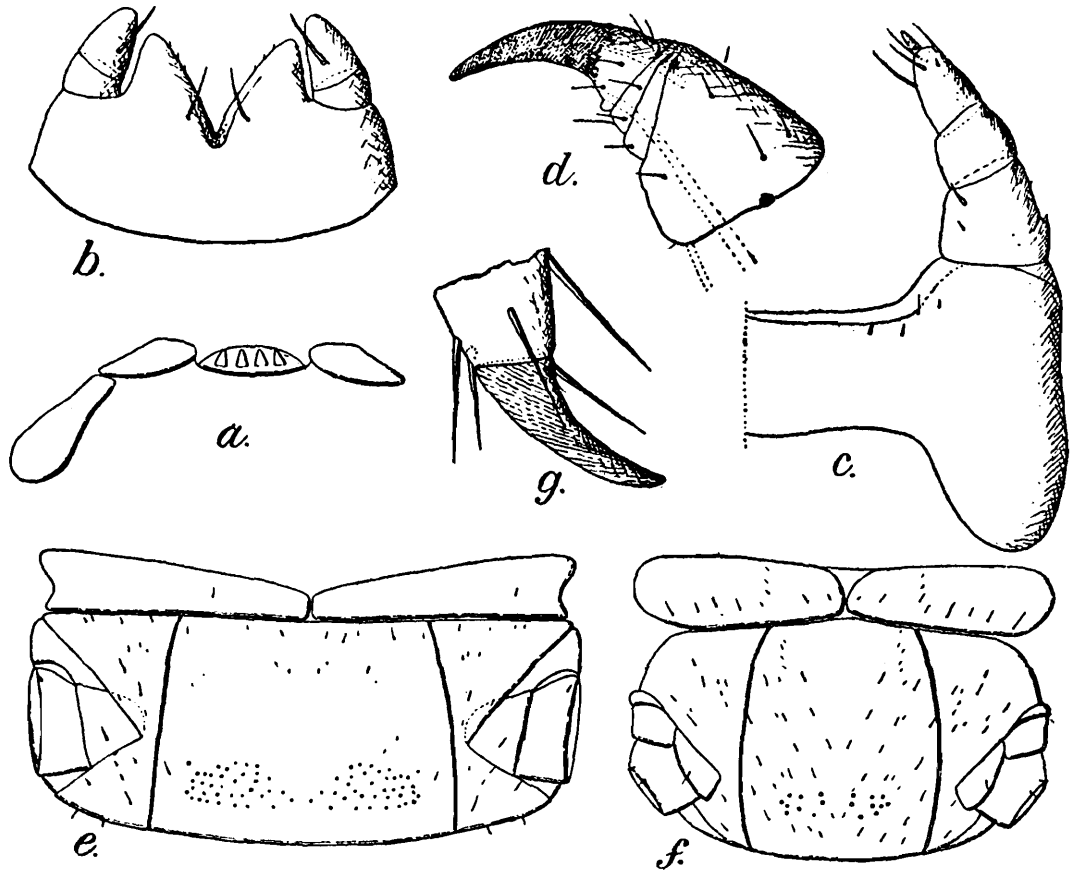
Pairs of legs in the female 57, in the males 55-57.

Length of body 20 millimetres, breadth 1 millimetre.

Described from one female and 5 males collected by Prof. Bonavis Bonnell at Madras.

[*Mixophilus indicus* here described by Prof. Silvestri was secured for the first time about the end of July, 1928 from a piece of land in the bed of the Cooum River at Madras, surrounded by water not less than $2\frac{1}{2}$ feet deep, to a distance of about 10 to 12 feet on all sides. This bit of land, which is situated in the southern arm of the Cooum between the Gymkhana and Government House, is frequented by fishermen who collect Polychaete worms of the genera *Marphysa* and *Lycastis*. The forms were obtained when search was made for *Lycastis* and the extremely fine specimens lay coiled within loose soft mud just as these

Polychaetes do. These forms of a pale brownish yellow tint differed in colour from *Lycastis*, which is of a fleshy red colour, and were thought to be young forms of *Lycastis*. One fact, however, noticed at the time was the quickness with which they took cover, and on careful examination in the laboratory they were found to be centipedes belonging to the Geophilomorpha.

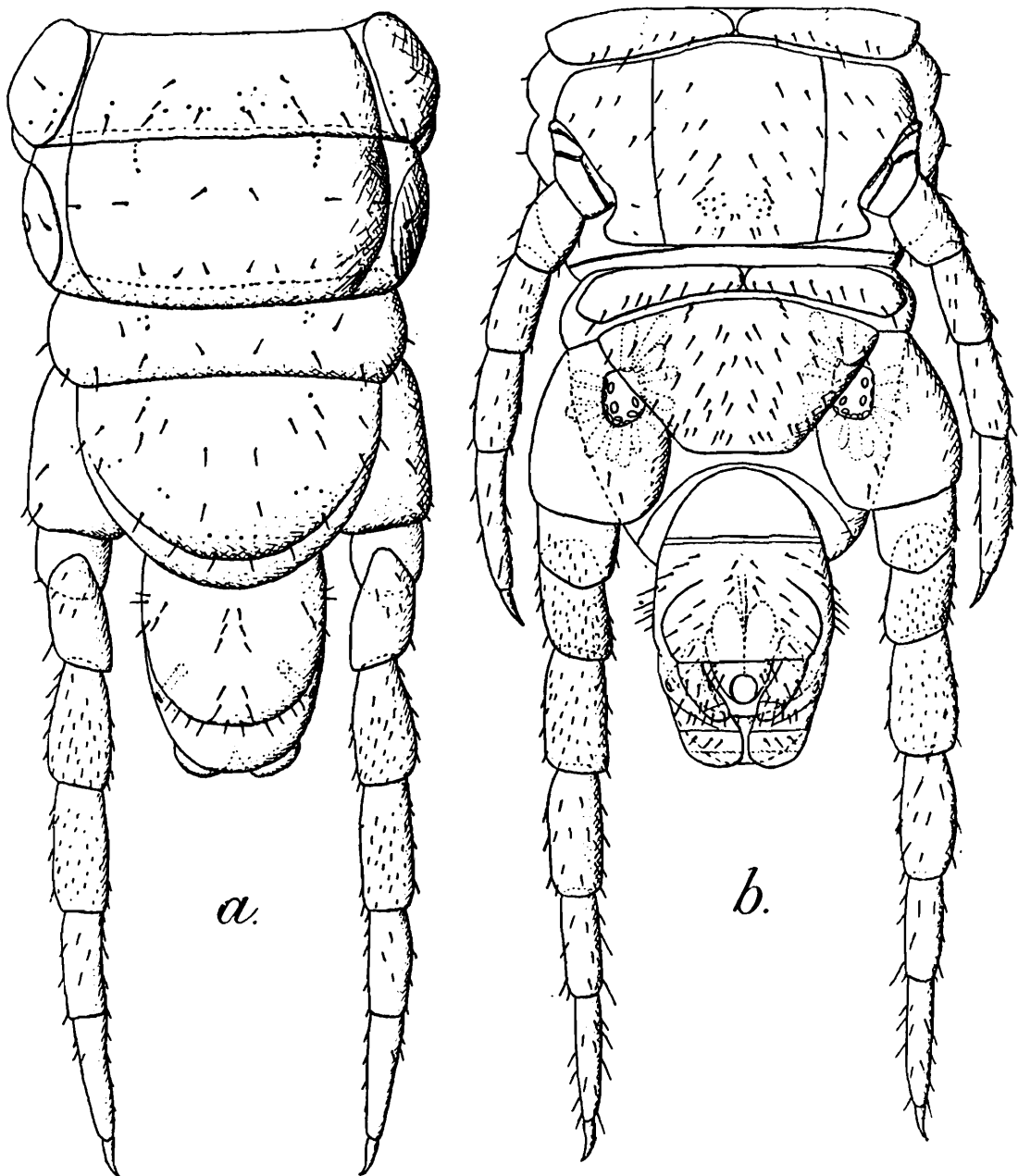


TEXT-FIG. 2.—*Mixophilus indicus*: a. Labrum, ventral view; b. First maxillae; c. Half part of second maxillae; d. One of the prehensile feet; e. Ventral aspect of xviii segment; f. Ventral aspect of last ambulatorial segment; g. Distal part of tarsus and pretarsus.

On subsequent occasions they were obtained from heaps of soil sticking out of the water from the bed of the Cooum at a point east of the Island ground and towards the Napier bridge. The heaps were piled up by fishermen while digging for *Marphysa*. That nearest to the shore was about three feet away and the others were separated by intervals of two to three feet. In the superficial layers of these heaps the centipedes were found coiled up and making practically no attempt to escape or leave the place. Along with these certain Forficulids, which were seen to run on the water and cross from one mound to another, were also obtained.

It had recently been decided by the Corporation of Madras to flood the Cooum periodically with water pumped in from the sea. The operation began for the first time in the end of July and since then the mounds and the piece of land in the bed of the Cooum have been submerged, becoming visible only occasionally for a few hours at a stretch. When the mounds are thus exposed to view no trace of these centipedes can

be found. On the assumption that they had migrated to the shore excavations were made between the maximum and minimum water levels. At first this search appeared unsuccessful, but later it was discovered that they lived in the very loose sand of crab-burrows along with Amphipods and Isopods. The burrows were a few days old. It is probable that these Geophilids move about during the night in search of food and occupy the heaps at the mouth of crab-burrows expecting to find food from the remains of the food of the crabs and also shelter. Pocock mentions that *Linotenia maritima* was found with hosts of scuttling woodlice and hopping sand-shrimps (*Zoologist* (Ser. 4) IV, p. 484, 1900) similar to what was observed in the present case.



TEXT-FIG. 3.—*Mixophilus indicus*: a, b. Dorsal and ventral aspect of posterior part of body.

The questions that arise now are whether these Geophilids were obtained from the first and second locality by mere accident or whether they represent their natural habitat. If the latter, whether there are

any peculiarities in structure which enable them to cross water and to withstand submergence for short periods. The accident theory does not seem to be tenable, for it fails to account for their occurrence in large numbers in these places, or to explain why out of several forms found on land this particular form alone should be unfortunate enough to be stranded.

The new species *Mixophilus indicus* here described is also interesting in that it has succeeded in the struggle for existence by adapting itself to a new kind of diet, namely the flesh of the polychaetes. *Mecistocephalus*, a common Geophilid, though distributed in almost every garden in Madras and even in the Island ground itself has not yet been found in places where *M. indicus* was collected.

The Polychaete *Lycastis* is regarded as an aquatic form tending towards life on land through the reduction of the parapodia and the simpler nature of the dorsal cirri which act as gills. In *Mixophilus indicus* we probably have a Geophilid in the process of changing its habitat in the reverse direction and it appears as if the two animals are adapting themselves in opposite directions. *B. Bonnell.*]

SPONGES AND POLYZOA OF THE INDAWGYI LAKE, BURMA.

By H. SRINIVASA RAO, M.A., D.Sc., Assistant Superintendent, Zoological Survey of India.

In the fauna of the lake the sponges and Polyzoa are very poorly represented. Only one species of sponge and three of Polyzoa were found in the marginal zone of the lake. The specimens were obtained on a species of stout reed common in the marginal area and on leaves of other aquatic plants. *Hislopia lacustris*, the commonest species of Polyzoa in the lake, was also found encrusted on the outer surface of the shells of *Viviparus indawgyiensis* Rao.¹

The species of sponges and Polyzoa living in the lake are common in most parts of India and Burma. Their range often extends beyond the Indian Empire to other outlying countries of Asia and to Africa.

The following species were found in the lake :—

SPONGES.

Trochospongilla latouchiana Annandale.

POLYZOA.

Hislopia lacustris Carter.

Plumatella (Afrindella) tanganyikae Rousselet.

Lophopodella carteri (Hyatt).

SPONGES.

***Trochospongilla latouchiana* Annandale.**

1907. *Trochospongilla latouchiana*, Annandale, *Journ. As. Soc. Bengal*, III, p. 21.

1911. *Trochospongilla latouchiana*, Annandale, *Faun. Brit. Ind. Freshwater Sponges*, etc., p. 115.

This sponge was found at the northern end of the lake near Nyaungbin growing on stout reeds, many of which bore colonies of *Hislopia lacustris*. It is very thinly encrusted and does not exceed more than two inches in length along the reed. In spirit it has a slaty gray colour. Gemmules were not very numerous, but the few present are found attached to the base of the sponge.

In Burma the species has been previously recorded from Tenasserim. It was curiously absent in the Inle Lake in the S. Shan States.

POLYZOA.

Suborder CTENOSTOMATA.

***Hislopia lacustris* Carter.**

1918. *Hislopia lacustris*, Annandale, *Rec. Ind. Mus.*, XIV, p. 78, pl. xxi, fig. 4.

The species occurs commonly on reeds and leaves of aquatic plants, and on shells of *Viviparus indawgyiensis* at the northern end of the lake

¹ The species is described on p. 279.

near Nyaungbin and at the southern end near Lonton. The aperture of the zooecia is square in outline and bears at each corner a well-developed spine. The spines have apparently dropped in some parts of the zooaria.

The species is probably widely distributed in the Indian Empire, but the typical form has been recorded mostly from N. India and Lower Burma.

Order PHYLACTOLAEMATA.

Plumatella (Afrindella) tanganyikae Rousselet.

1912. *Plumatella (Afrindella) tanganyikae*, Annandale, *Rec. Ind. Mus.*, VII, p. 142. ¹

With some hesitation I refer to this species a small colony found growing on a blade of grass at the north end of the lake near Nyaungbin. None of the polypides is expanded. Owing to the opaque nature of the ectocyst the form of the lophophore is difficult to make out. No statoblasts are present in any part of the colony. The stiff ectocyst and the truncated and minutely roughened zooecia, and the branching of the zooaria give the colony a close resemblance to this species, and in several respects it agrees with the original description of the species.¹

The colour of the zooaria in spirit is dark brown, but the ventral surface of the colony and the terminal parts of individual zooecia are paler in colour. The surface of the zooaria is nearly smooth, especially the flat ventral portion, but the curved upper surface is covered chiefly with the remains of diatoms. A few minute sand grains and broken sponge spicules are also found amongst the diatoms. No furrows or annulations are present on any part of the zoecium. The edge of the zoarium at the junction of the flat and curved parts is produced into a narrow thin velum at the sides which also contains particles of sand and other debris. The distal part of each zoecium, particularly of the younger ones, projects more or less vertically in the form of a triangular spine. The aperture of the zoecium is elongate-oval and is closed by a pale membranous structure.² The lower extremity of the stomach is somewhat produced and mammiliform.

In the absence of statoblasts it is impossible to fix the identity of the species with certainty. The species, if not identical with *P. (Afrindella) tanganyikae*, is very closely related to it in the form and branching of the zooaria.

The ectocyst, which is densely covered mostly with the remains of diatoms, presents a noteworthy feature, and this is presumably to be associated with the fact that the lake teems with these organisms which on death settle on the bottom debris.

The distribution of *P. tanganyikae* is somewhat peculiar. It was first described from Lake Tanganyika in Central Africa, and has since been recorded in India from the W. Ghats in the Bombay Presidency, from the Kumaon Lakes in the lower ranges of the Western Himalayas and from Orissa in the Peninsular area. The discovery of the species

¹ Rousselet, *Proc. Zool. Soc. London*, (i), p. 252, pl. xiv, figs. 1-4 (1907).

² This structure is fully described and figured by Annandale in *Rec. Ind. Mus.* VII, pp. 140-142 (1912).

in Burma from which, so far as I am aware, there has been no previous record, is of some interest. Though from its known records the species seems to have a discontinuous distribution it is probable that on a careful and extended survey of freshwater areas in the Indian Empire the species will be found to have a much wider range.

***Lophopodella carteri* (Hyatt).**

1911. *Lophopodella carteri*, Annandale, *Faun. Brit. Ind. Freshwater Sponges, etc.*, p. 232.

1919. *Lophopodella carteri*, Annandale, *Rec. Ind. Mus.*, XVIII, p. 96.

A small young colony found on the thick leaf of a reed in the marginal zone of the lake near Nyaungbin is to be referred to this species. No statoblasts were found in any part of the colony, the polypides of which were preserved in a beautiful expanded condition. The ectocyst is hyaline and forms a trumpet-shaped structure, to the narrow end of which the polypide is attached. When fully expanded the polypide projects considerably above the flat side of the 'trumpet', its proximal part being protected by the entire ectocyst. In the contracted state the polypide lies well within the trumpet-shaped ectocyst. A thin membrane, having a cellular structure, seems to invest the ectocyst and the polypide. The cells are regularly arranged, and more or less spherical, and have their individual outline distinct over the whole membrane.

The distribution of the species in the Indian Empire is not fully known. The species has been recorded from Seistan in Eastern Persia, from the Bombay Presidency and the Central Provinces and from the Kumaon Lakes in the Western Himalayas. It is not known from other freshwater lakes, such as the Loktak Lake in the Manipur State of Assam or from the Inle Lake of the S. Shan States in Burma, the fauna of which has been investigated in recent years. The present record of the species from the Indawgyi Lake in Upper Burma is, therefore, of considerable interest. The range of the species extends from East Africa to Japan.

THE FRESHWATER AND AMPHIBIOUS GASTROPOD MOLLUSCS
OF THE INDAWGYI LAKE AND OF THE CONNECTED
FRESHWATER AREAS IN THE MYITKYINA
DISTRICT, BURMA.

By H. SRINIVASA RAO, M.A., D.Sc., Assistant Superintendent, Zoological
Survey of India.

The Gastropod molluscs dealt with in this paper were collected by Dr. B. Chopra during the cold weather of 1926 in the Indawgyi Lake and its environs, in the plains lying to the north of the lake, and in the freshwater areas round about Kamaing, all in the Myitkyina District, Upper Burma. The lake, as well as the various streams, channels and pools in the areas mentioned above, are indirectly connected with the Irrawady river system in Upper Burma.

The physical features of the lake and the adjoining country are briefly referred to by Dr. B. Prashad and Mr. D. D. Mukerji in their paper on the Fishes of the Indawgyi Lake,¹ and it would be enough to point out here that the physical conditions of the lake do not seem to be particularly conducive to the growth and differentiation of a varied molluscan life. Taking into consideration the size of the lake, its depth, and the suitability of the marginal areas as a zone for aquatic life, the Gastropod fauna actually found in the lake can by no means be said to be rich in species, though the number of individuals of certain species found living in the lake is large.

The fauna is represented by 7 families of Gastropod molluscs of which four belong to the order Pectinibranchiata, and three to the Order Pulmonata. Twenty-two species belonging to 14 genera were found in the areas surveyed. Six species and one form are new, but of these new species only two belong to the lake fauna proper; the remaining four are either inhabitants of streams and pools in the neighbourhood of the lake and closely connected with it, or of rocky or muddy streams in the vicinity of Kamaing, about 50 miles north of the lake. All the six species are presumably endemic in the Indawgyi Valley.² Of the remaining sixteen previously known species some are widely distributed in the Oriental Region, some are common to India and Burma, while a few are Burmese in origin and distribution.

In this paper I have also given descriptions of two new species of the Melaniid genus *Paludomus* from Lower Burma as they are very closely related to two other species, also new, which were found in the streams and pools in the plains north of the Indawgyi Lake.

In the preparation of this note the field-book of Dr. Chopra containing notes on the physical features and the fauna of the lake and the surrounding country has been of great help to me, and I take this

¹ Prashad, B. & Mukerji, D. D., *Rec. Ind. Mus.*, XXXI, pp. 161-223, pls. vii-x (1929).

² For the sake of convenience the words "Indawgyi Valley" are used in this and the following pages to indicate the entire area surveyed by Dr. Chopra from the southernmost point of the lake to the plains in the vicinity of Kamaing in the Myitkyina district.

opportunity to thank him for permitting me to make use of his copious notes.

The drawings illustrating this account have been made under my supervision by Babu A. C. Chowdhury, Senior Artist in the Zoological Survey, with his habitual skill.

Before discussing the general aspects of geographical and ecological distribution of the species of molluscs found in the Indawgyi Valley it will be convenient to enumerate the species occurring in that area.

PECTINIBRANCHIATA.

Viviparidae.

Viviparus bengalensis (Lam.).

* *Viviparus bengalensis* race *doliaris* (Gould).

† *Viviparus indawgyiensis*, sp. nov.

Ampullariidae.

† *Pila theobaldi* (Hanley).

Rissoidea.

Digoniostoma pulchellum (Benson).

* *Parafossarulus sulcatus*, sp. nov.

† *Bithynia (Alocinma) expansilabris*, sp. nov.

Tiaridae (Melaniidae).

* *Acrostoma baccata* f. *lirata* Rao.

Melanoides tuberculatus (Muller).

Melanoides scabra (Muller).

* *Paludomus regulata* Benson.

† *Paludomus crassicallosa*, sp. nov.

† *Paludomus kamaingia*, sp. nov.

PULMONATA.

Limnaeidae.

Limnaea acuminata f. *patula* Troschel.

† *Limnaea acuminata* f. *pseudohorae*, nov.

Limnaea luteola f. *australis* Annandale & Rao.

† *Limnaea decussatula*, sp. nov.

Planorbidae.

Indoplanorbis exustus (Deshayes).

Gyraulus convexiusculus (Hutton.)

Gyraulus rotula (Benson).

* *Gyraulus velifer* (Annandale).

* *Gyraulus velifer* var. *ciliata* (Annandale).

Segmentina calathus (Benson).

Hippeutis sp.

Succineidae.

Succinea gravelyi f. *deccanensis* Rao.

Species marked with an asterisk are essentially Burmese in origin and distribution, while those marked with a dagger are probably endemic in the Indawgyi Valley.

Most of the genera from the Indawgyi Valley are met with in most parts of the Indian Empire. Some are widely distributed in the Oriental

Region, while a few have a restricted distribution in India and Burma. The genus *Hippeutis* has so far been recorded from the Manipur Valley in Assam. In the Indawgyi Valley it is represented by a few dead shells, the specific identity of which is difficult to determine owing to poor preservation. The discovery of the genus, however, in the relatively contiguous valleys of Manipur and Indawgyi, both of which are indirectly connected with the Irrawady river system, seems to suggest the possibility of a wider distribution of the genus in the hill-tracts of Assam, Burma and China. *Parafossarulus* presumably represents the only distinct Chinese element in the Burmese Gastropod fauna, but its distribution in Burma appears to be restricted to the Shan plateau and to parts of Upper Burma. *Digoniostoma* has hitherto been known only from parts of Bengal and Assam, and from Peninsular India. The present record of its occurrence in Burma is, therefore, of some interest from the point of view of geographical distribution. From the Shan plateau, which lies east of the Irrawady basin and the mollusc fauna of which is now fairly well known, there is no record of this genus from as far as the Shively Valley on the Chinese Frontier in the north to the Inle Lake in the south. The subgenus *Alocinma* has a wide range extending from Mesopotamia through Peninsular India to Upper Burma. *Acrostoma* and *Paludomus* have a more or less restricted distribution in the eastern part of India, and in South India and Ceylon; in Burma, however, they are represented by a large number of species which are common in the river-systems of that province. Perhaps it may be said that they are two of the most dominant genera of the freshwater Pectinibranchs in Burma. The remaining genera are widely distributed in the Oriental Region, if not over the whole world.

With the exception of the six new species, which are probably endemic in the Indawgyi Valley, the distribution of all others is well known. *Indoplanorbis exustus*, *Melanoides tuberculatus*, *Melanoides scabra* and *Gyraulus convexiusculus* have a very wide distribution in the Oriental Region. Six species which may be ascribed to India proper are *Viviparus bengalensis*, *Digoniostoma pulchellum*, *Limnaea acuminata*, *Limnaea luteola*, *Segmentina calathus* and *Succinea graveleyi*, but their distribution within the Indian Empire is either very wide or apparently discontinuous as in the case of the last-named species, which has hitherto been recorded from Madras, the Deccan, the Andaman Islands and Burma.

The following species may well be regarded as Burmese in origin and distribution: *Pila theobaldi*, *Acrostoma baccata*, *Paludomus regulata*, and *Gyraulus velifer*. The last named species was first described from the Inle Valley, and is as yet known only from one other locality, e.g., the Indawgyi Lake. *Gyraulus rotula* must still be considered as a rare species. It was originally described from Moradabad in N. India, and was subsequently found in the same locality and in Ceylon. The discovery of this species in Burma is, therefore, of great interest.

It will thus be seen from the facts of distribution given above that the Gastropod fauna of the Indawgyi Valley consists of a large proportion of species having a wide distribution in the Oriental Region or in India proper, and of a comparatively small proportion of Burmese species if we exclude the new species described in this paper. It is clear,

at any rate, that the Gastropod fauna of the valley is of mixed origin, though it is not possible to be definite about the relative numbers of the species derived from the Indian and Burmese areas respectively.

In enumerating the facts of ecological distribution it will perhaps be of some value to arrange the species found in the Indawgyi Valley in accordance with their habitat, and in the following list the species occurring in the valley are distributed in three groups. A species occurring in one or more habitats is put down in as many groups.

Species from the marginal zone of the lake, and also from pools and streams near the shore.	Marginal or deeper parts of the lake only.	Streams and pools of the plains north of the lake not directly connected with it.
—	<i>Viviparus indawgyiensis.</i>	—
<i>Viviparus bengalensis</i>	—	—
<i>V. bengalensis</i> race <i>doliaris</i>	—	<i>V. bengalensis</i> race <i>doliaris</i>
<i>Pila theobaldi</i>	—	<i>P. theobaldi</i>
<i>Digoniostoma pulchellum</i>	<i>D. pulchellum</i>	<i>D. pulchellum</i>
<i>Bithynia (Alocinma) expansilabris</i>	—	—
<i>Parafossarulus sulcatus</i>	—	—
<i>Acrostoma baccata</i> f. <i>lirata</i>	—	—
<i>Melanooides tuberculatus</i>	—	<i>M. tuberculatus</i>
—	<i>Melanooides scabra</i>	—
<i>Paludomus regulata</i>	—	<i>P. regulata</i>
—	—	<i>P. crassicallosa</i>
<i>Limnaea acuminata</i> f. <i>patula</i>	—	—
—	—	<i>Paludomus kamaingia</i>
—	<i>L. acuminata</i> f. <i>pseudohorae</i>	—
<i>L. luteola</i> f. <i>australis</i>	—	—
—	<i>L. decussatula</i>	—
<i>Indoplanorbis exustus</i>	—	<i>I. exustus</i>
—	<i>Gyraulus velifer</i>	—
—	<i>G. velifer</i> var. <i>ciliata</i>	—
<i>Gyraulus convexiusculus</i>	—	—
<i>Gyraulus rotula</i>	—	—
<i>Segmentina calathus</i>	—	—
—	<i>Hippeutis</i> sp.	—
<i>Succinea graveleyi</i> f. <i>deccanensis</i>	—	—

It will be seen from this list that there are few species which exclusively inhabit the lake proper, and still fewer which are, in the strict sense of the term, fluviatile. On the other hand many species, which inhabit the streams and pools not in the immediate vicinity of the lake but also in the plains north of it, are actually found in the marginal zone as well. The species given in the second column of the list have, with one exception, *e.g.*, *Digoniostoma pulchellum*, all been found in the marginal zone of the lake, but nowhere else in the neighbourhood of the lake or in the plains near Kamaing. *D. pulchellum* usually inhabits sluggish streams with a muddy bottom and aquatic plants, and pools or swamps with some amount of weeds. In the lake and the connected waters in its vicinity the species appears to be stunted, whereas it attains its full development in size in the muddy streams and pools round about Kamaing. Specimens from the deeper parts of the lake were all dead. *Viviparus indawgyiensis* and *Limnaea decussatula* both seem to be lacustrine, and have not been found outside the marginal zone of the lake. The evidence for this statement with regard to the latter species (which has been described from a single specimen) is not conclusive, but with regard to the former it may be said that it is the only Gastropod which dominates the molluscan life in the lake. The deeper central parts of the Indawgyi Lake, which consists of soft sticky clay at the bottom and very little macroscopic vegetation, do not seem to support molluscan life, and it is not surprising that so few individuals of any species were found living in the central parts of the lake, and that there were few, if any, living species of Invertebrate animals in these parts. On the other hand Dr. Chopra found molluscs quite abundant in the marginal area, which is, as a rule, shallow in most parts of the lake, and has a fair quantity of aquatic weeds and an abundance of floating microscopic plant-life.

The aquatic species noted in the first column are generally inhabitants of ponds and swamps or sluggish streams, but *Acrostoma baccata* f. *lirata* and *Paludomus regulata* do not strictly belong to this habitat group, and their occurrence in the lake area is probably accidental. The occurrence of the remaining species (some of which are more or less paludine in habit) in the marginal zone of the lake is to be accounted for by the fact that during heavy rains the water brought down by the various hill-streams flowing into the lake swells its volume to such an extent that the swamps and pools on the shores of the lake in normal times are submerged and become part of the lake. Consequently the inhabitants of the swamps come to occupy the shallower regions of the lake where the conditions of life approximate to those of a swamp. Of the species enumerated in the third column the two new species of *Paludomus* from Kamaing are inhabitants of rocky streams, and are probably rupicolous; the remaining species are much at home in the marginal zone of the lake as in muddy streams and pools of the plains in the valley.

Family VIVIPARIDAE.

Viviparus Montfort.

1928. *Viviparus*, Rao, *Rec. Ind. Mus.*, XXX, p. 416.

This genus is represented in the fauna of the lake and of the surrounding country by only two species. One is the well known

V. bengalensis so common in most parts of India, and the other is a new species found only in the lake, and probably endemic in it. Of the former, the race *doliaris* seems to have a wide distribution in Burma, while the forma *typica* is represented by a dwarfed phase which is not common in Burma as it is in parts of India.

Viviparus bengalensis (Lamarck).

1921. *Vivipara bengalensis*, Annandale, *Rec. Ind. Mus.*, XXII, pp. 267-271, pl. i, figs. 1-3.

Individuals of this species belong to the forma *typica*. In form they are relatively dwarfed, and smaller than specimens taken in various parts of India. Presumably they never grow to a large size. The spiral bands on the shell are not usually conspicuous. The umbilicus is obsolete, but rarely takes the form of a small chink. In some young individuals the secondary spiral ridges of the embryo persist.

Specimens of this species were taken in small numbers from the shallower parts of the lake near the shore at Lonton, Loimon and Nyaungbin, small villages close to the lake.

There seem to be very few records of the forma *typica* from Burma. It is probable that this form was at one time dominant in Burma and that its place was later on taken by the race *doliaris*, which at present seems to be the commonest representative of *V. bengalensis* in that province.

Viviparus bengalensis race doliaris (Gould).

1928. *Viviparus bengalensis* race *doliaris*, Rao, *Rec. Ind. Mus.*, XXX, p. 416.

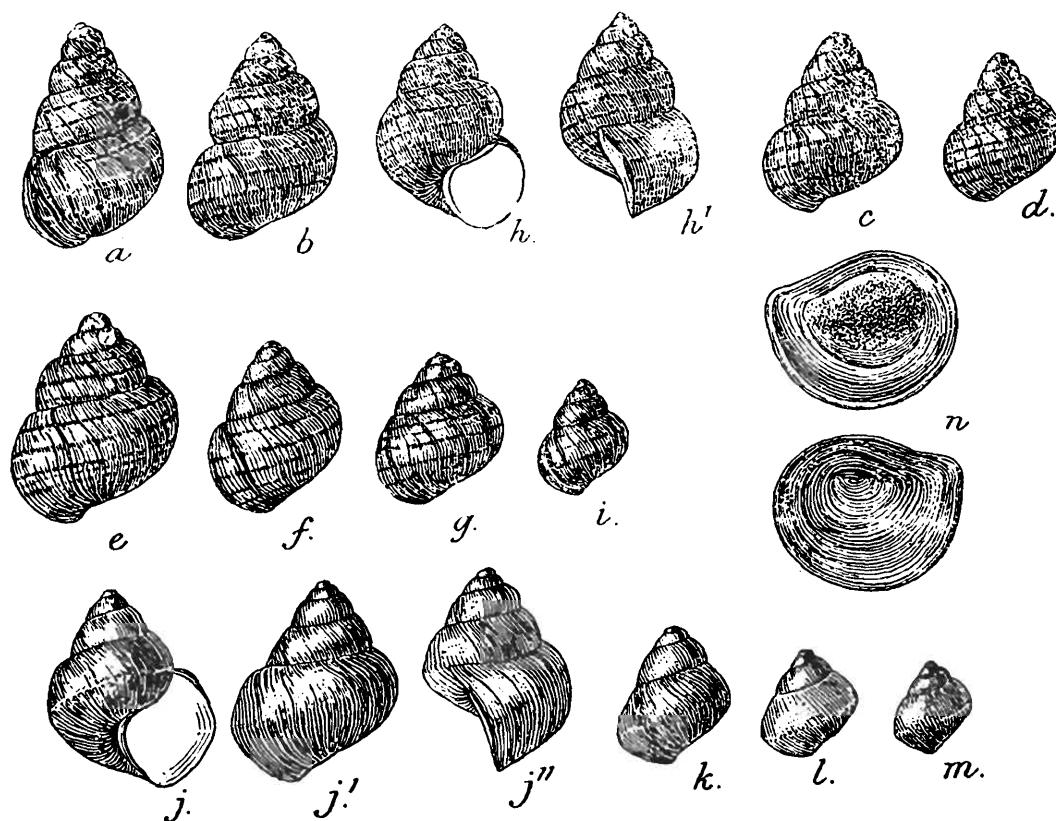
This is by far the commonest form in the ponds and sluggish streams in the country surrounding the lake, and in the shallower parts of the lake itself near the shore. Large numbers of shells and a few living specimens were dredged from the shallower regions of the lake in the vicinity of Loimon and Lonton; but some were found living on the submerged posts and stones forming the foundation of the Shwemyzu Pagoda, 3 miles south of Loimon. This form was also common in pools, near Lonton and Loimon, and in muddy or rocky streams in the vicinity of Kamaing, Hopin, Nyaungbin and Loimon.

This is apparently a well-established race in Burma. Its normal habitat is in muddy streams or pools. The occurrence of individuals of this race in large numbers in the shallower parts of the lake seems to be accidental. Owing to an exceptionally heavy rainfall in the year 1926 and the consequent flooding of the country round about the lake many of them had been washed down into the lake from the neighbouring pools and streams. Conditions of life in the shallower parts of the lake were presumably more or less similar to those obtaining in muddy ponds and streams, and the fact that a few continued to live in the lake seems to strengthen that presumption. Deep-water conditions in the lake are probably inimical to them, and it is not surprising, therefore, that a great proportion, if not all, of the specimens dredged from the deeper regions of the lake were dead.

Dr. Chopra informs me that the Shans break the shell partly and suck out the animal in the living condition.

***Viviparus indawgyiensis*, sp. nov.**

The shell is of moderate or small size, ovate to ovate-conical in outline and rather thick. The apex of the shell is usually blunt on account of its being worn. The colour of the shell varies from an olive-green to an olive-brown. There are usually eight well-defined but narrow brown spiral bands on the outside of the shell. There are 6-6½ gradually increasing convex whorls, and the suture is deeply impressed. There is very little flattening outside the suture, and the whorls present a telescoped appearance, the shells thus approaching a roughly scalariform condition. The sculpture consists of very minute spiral striae which are completely masked by the oblique, curved, longitudinal impressed lines which are well-marked on the last two whorls. These longitudinal lines give a characteristic appearance to the shell. On the body-whorl they are very prominent and often indistinguishable from the lines of growth found on the outer edge of the body-whorl. The number and prominence of the spiral bands on the body-whorl are subject to variability, but there are usually 8 bands, of which the third, fifth and sixth from above downwards are broader than the others. The body-whorl is slightly oblique. The aperture is broadly oval and never much longer than broad. Its anterior margin is broadly arched. The outer lip



TEXT-FIG. 1.—*Viviparus indawgyiensis*, [sp. nov. a-m, shells of different sizes; the three figures marked b, h, h' are of the holotype; n, outer and inner views of the operculum.

is somewhat dome-like in outline and often broadly sinuate in the middle. It is thin and joins the inner lip posteriorly forming an acuminate projection directed towards the columellar side. The inner lip is relatively thick and its margin is somewhat raised but never reflected. The

interior of the mouth is smooth, bluish in fresh specimens of moderate size, white owing to a deposit of calcareous matter in dead shells, and deep-brown in good-sized, comparatively thick, fresh shells. The umbilicus is open and more or less rounded, into which the impressed longitudinal lines on the body-whorl converge.

The operculum is thin, broadly ovate in outline and concave on the external surface. The sculpture consists of coarse concentric striae. The muscle-scar on the internal surface is close to the internal margin, *i.e.*, the columellar side of the operculum. It is thickened and raised into a boss and has a rough texture. Its colour is deeper than the rest of the operculum, and a faint whitish ring encircles the muscle-scar. The ground colour of the operculum varies from an yellowish-brown to claret, and in the centre the muscle-scar presents the appearance of a dark spot on the inner surface.

The measurements, in millimeters, given below are of a small series from various parts of the Indawgyi Lake :—

Locality.	Height of shell.	Maximum breadth of shell.	Height of aperture.	Maximum breadth of aperture.
Loimon .	21.5	17.5	10.5	9.2
	19.0	16.5	11.0	8.5
	19.5	16.0	10.0	8.0
Lonton	23.0	18.5	11.5	9.5
	23.0	16.0	11.5	8.5
	19.0	17.0	11.0	9.0
	19.0	15.5	10.0	8.0
Shwemyzu Pagoda	20.0	15.0	10.5	8.5
	18.0	15.0	9.5	8.0
Nyaungbin . .	21.0	17.0	11.0	9.0
	21.0	15.5	9.0	7.5
	17.5	15.5	10.0	8.0

The edge of the mantle is moderately thick with a fairly well-developed sphincter muscle. It bears on its free margin several minute triangular or finger-like processes which vary in number and prominence. Their appearance in the living condition is not known as the expanded animal in nature has not been closely observed, but in most preserved specimens two or three finger-shaped processes and several comparatively small triangular ones may be detected. The gill-lamella is elongate and its base is slightly broader than the free part of the lamella.

The radular teeth closely resemble those of *V. bengalensis* and are subject to the usual variation and abnormalities observed in many species of freshwater molluscs. The internal anatomy is very similar to that of *V. bengalensis*. In the male the right tentacle is comparatively large and thickened. In the uterus there are usually one or two full-grown embryos and 6-8 ova, but exceptionally there may be as many as 5 embryos. The proportion in the numbers of male to female individuals is not the same in lots collected from different localities. In some places the males and females are equal in number, in others the females predominate. The embryonic shell consists of 3-4 whorls and

has a roughly diamond-shaped outline. The body-whorl is biangulate and bears no prominent spiral ridges or striations.

The embryonic shell is somewhat gray in colour and without spiral bands. It has 3 primary rows of chaetae and several secondary parallel ridges, but the chaetae are liable to drop off when the membranous covering of the embryo is removed. In the larger embryos, however, traces of the primary chaetae may be detected in a minute series of pits on the body-whorl. The secondary parallel ridges are often too minute to be detected. The sculpture of the embryonic shell undergoes modification as the individual grows. The spiral sculpture of the embryonic shell is more or less completely masked in the adult shell by the development of oblique longitudinal striae. The spiral ornamentation appears at first as fine olive-green lines on shells which have grown to a height of 10-15 mm., and as the shells grow further the spiral lines broaden out into bands.

Holotype.—M. $\frac{12841}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

Several hundreds of individuals of the species were dredged from various parts of the Indawgyi Lake, chiefly in the shallower regions near the shore at the north and the south ends of the lake, at Loimon and Lonton, and in the vicinity of the Shwemyzu Pagoda. Many of them were dead shells, but a comparatively small proportion consisted of living individuals. Dr. Chopra observed that samples of dredging in the deeper parts of the lake contained a large number of dead shells and very few living ones. This species seems to be restricted, therefore, to the shallower parts of the lake. The bottom consists of soft, sticky clay of a black colour in the deeper parts of the lake, of reddish clay in the shallow parts, and of a mixture of sand and mud in the intermediate zone. The water is usually clear, but has a greenish tinge on account of the great quantities of minute floating algae. The species seems to live on vegetable debris at the bottom. The Polyzoan *Hislopia lacustris* Carter is found growing on many shells from the marginal region.

There are two shells in the Zoological Survey collection found by the late Dr. R. Hungerford in what is called the 'Endawyne Lake, Burma', and labelled '*Vivipara sumatrensis* Dunker'. I have not been able to find a lake of that name in some of the standard atlases and maps of Burma which I have consulted, and the lake referred to in the label is presumably no other than the Indawgyi itself. The name has obviously been misspelt in transcription. The shells referred to are very different from specimens of *V. sumatrensis*, authentic examples of which have been recently presented to the Zoological Survey by Prof. Max Weber. In texture and ornamentation the two shells under discussion are almost identical with the new species described.

V. indawgyiensis appears to be dimorphic as evidenced by two forms which may be distinguished in collections from most parts of the lake. One is narrow and elongate, and the other is broad and compressed. Both the forms are always found together and in almost equal proportions.

The species is undoubtedly closely related to *Viviparus bengalensis* but differs in having a thicker shell, more convex whorls with deeply

impressed suture, and in the sculpture and ornamentation. The Assamese species *Viviparus crassa* (recorded also from Bengal and Burma) resembles the present species in sculpture and in having a thick shell, but the resemblance seems to be superficial as it differs from the latter in important features such as the form of the shell, the shape of the mouth, and in the total absence of spiral bands.

Family AMPULLARIIDAE.

Genus *Pila* Bolten.

1915. *Pila*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 96.

Pila theobaldi (Hanley).

1925. *Pila theobaldi*, Prashad, *Mem. Ind. Mus.*, VIII, p. 77, pl. xv, fig. 3.

1928. *Pila theobaldi*, Rao, *Rec. Ind. Mus.*, XXX, p. 425.

Several living and dead individuals of this species were obtained from small, muddy streams and ponds in the vicinity of Lonton, Loimon, Kamaing and Hopin. Also from the western shores of the lake a few shells in a fresh condition were collected. They had presumably been washed down to the lake from the neighbouring streams and ponds. The examples from the Indawgyi system are all of moderate size, and are yellowish-green in colour. The spiral bands are more or less conspicuous in most of them. In larger specimens the spire is depressed, and the umbilicus is deep and broad.

The species is common in Upper Burma, and has been previously recorded from Bhamo, and from the Chinese Frontier of the N. Shan States. Its range in countries east and north of Burma is still imperfectly known.

The Shan inhabitants of the villages in the Indawgyi Valley, I understand, eat the animal by breaking the shell and sucking it out.

Family RISSOIDAE.

This family is represented by three genera, e.g., *Bithynia*, *Digoniostoma* and *Parafossarulus*. The first two are widely distributed in India, but the last is confined to China and Burma. Two species belonging to the first and the last named genera respectively are new to Science. *Digoniostoma* is represented by one species, hitherto known only from Assam.

Digoniostoma Annandale.

1920. *Digoniostoma* Annandale, *Ind. Journ. Med. Research*, VIII, p. 104.

Digoniostoma pulchellum (Benson).

1921. *Digoniostoma pulchellum*, Annandale, *Rec. Ind. Mus.*, XXII, p. 541.

The species is recorded for the first time from Burma. It was found in large numbers in the shallow as well as in the deeper parts of the lake near Lonton and Nyaungbin, in small pools and paddy fields near the shores of the lake at Lonton, in streams flowing into the lake at various

points, and in muddy pools or sluggish streams in the vicinity of Kamaing. Specimens from many parts of the lake do not seem to grow to as large a size as those living in pools and streams in the neighbourhood of Kamaing.

The distribution of the species is still imperfectly known. The species appears to be common in parts of Assam, and the adjoining districts of Burma. There are a few records from Calcutta in Bengal, Madras, Ellore and Secunderbad in S. India.

Bithynia¹ Leach.

1928. *Bulmus*, Rao, *Rec. Ind. Mus.*, XXX, p. 427.

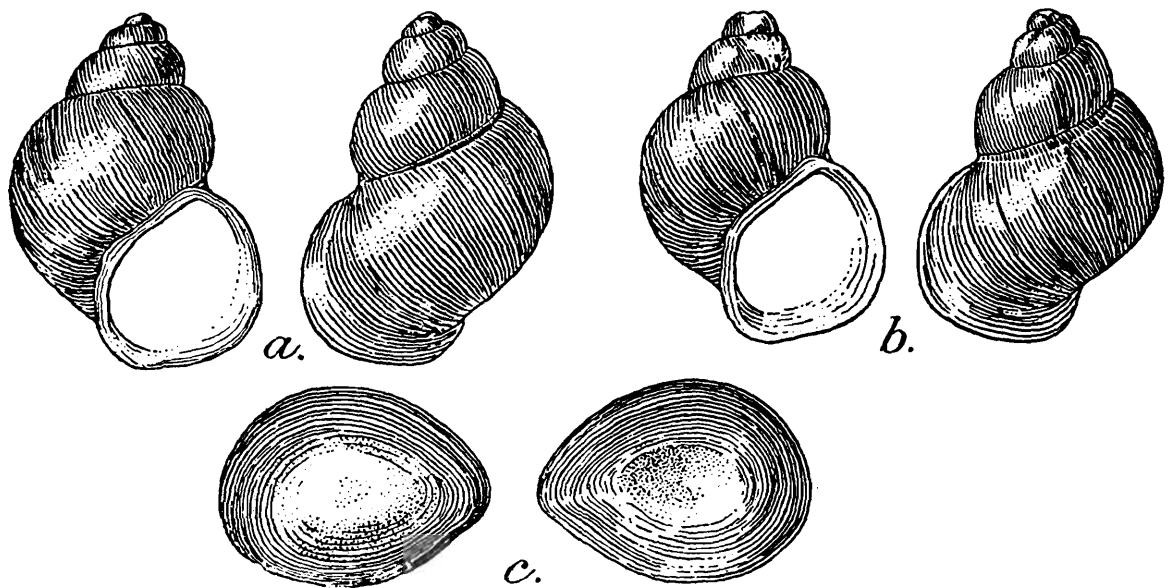
A single species hitherto undescribed and belonging to the subgenus *Alocinma* was found in various parts of the lake.

Bithynia (Alocinma) expansilabris, sp. nov.

The shell is of moderately small size, conico-ovate, longer than broad, and translucent in the fresh condition. It has 4-4½ moderately convex whorls which increase rapidly in size. The apex when not eroded is somewhat obtuse, and the protoconch is very little elevated. The whorls are oblique, particularly the last, in dorsal view. The suture is well-defined and transverse and leaves a minute step just outside it. The body-whorl has a broad trumpet-shaped outline in dorsal view. Its outer side is quite convex, while its anterior end is somewhat broadly produced. The aperture is oblique, roughly elliptical, produced both above and below, and broadest a little below the middle. The peristome is continuous. The outer lip is much more convex than the inner, expanded and slightly reflected at the edge, and is depressed broadly between its middle and the anterior projection. Its edge is smooth and sharper than the inner lip. The columella forms a smooth narrow ridge which has a silky lustre. The umbilicus is entirely closed, and even in very young individuals no chink is left between the body-whorl and the columellar ridge. The sculpture is minute and consists of longitudinal impressed striae. On the body-whorl the impressed striae converge towards the inner edge of the aperture. Traces of very minute spiral lines can sometimes be detected on the body-whorl when the shell is examined under the high power of the binocular microscope. These spiral lines probably represent the ground sculpture in the embryonic shell traces of which persist in the adult. The operculum is oval, produced above and rounded below, depressed in the centre of its outer surface and raised in the corresponding position on the inner side. The

¹ In a recent paper (*Rec. Ind. Mus.*, XXX, p. 427, 1928) on the Molluscs of the N. Shan States I revived the generic name *Bulimus* Scopoli for *Bithynia* Leach on obviously insufficient grounds, following Pilsbry and Bequaert (*Bull. Amer. Mus. Nat. Hist.* LIII, p. 21, 1927). European Malacologists appear, at any rate, to have decided to ignore *Bulimus* as a substitute for *Bithynia*, as Kennard and Woodward have shown (*Proc. Malac. Soc. London*, XVI, pp. 125-127, 1924) that *Bulimus* is a typographical error for *Bulinus*. I am indebted to Mr. Woodward for kindly drawing my attention to this reference which I had unfortunately overlooked. I also understand that the whole question has been referred to the International Commission on Zoological Nomenclature for final opinion.

paucispiral figure is clearly seen on both sides and occupies a greater part of the central area of the operculum. It is enclosed by a number



TEXT-FIG. 2.—*Bithynia (Alocinma) expansilabris*, sp. nov. a, dorsal and ventral views of the holotype; b, the same views of another shell; c, outer and inner views of the operculum.

of concentric lines. The shell is translucent and is of a dull cream colour in the fresh condition, but opaque and of an yellowish or grayish colour in the dead shell.

Measurements in millimeters.

Locality.	Height of shell.	Maximum breadth of shell.	Height of aperture.	Maximum breadth of aperture.
Lake near Nyaungbin pools	5.5	4.5	3.0	3.0
Pools near Lonton	5.5	4.5	3.5	3.5
Shores of lake near Lonton	5.8	4.2	3.0	3.0
Pools near Nyaungbin	5.0	4.0	3.0	3.0
Lake near Lonton	4.8	3.8	2.8	2.8

The radular teeth agree in many respects with the *Alocinma* type, but the central is slightly different. The basal ends of the central tooth are claw-like and produced inwards, and the processes in the centre of the tooth are relatively prominent. The genitalia closely resemble those of *Alocinma sistanica*.

Holotype.—M. $\frac{12843}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

The species was found living in small pools or streams near Lonton and Nyaungbin, and in the shallower parts of the lake near the shore at these places and on submerged posts of the Shwemyzu Pagoda. A large proportion of the specimens taken from the lake were, however, dead shells.

The affinity of this species to Indian, Burmese or Chinese species of *Bithynia* is not quite clear, but the species seems to belong to the fourth group or the *B. fuchsiana* group of Walker.¹ The species is

¹ Walker, *Amer. Journ. Hygiene*, Monographic Series, No. 8, p. 226 (1927).

probably endemic in the Indawgyi Valley, and does not resemble any of the known Indian or Burmese species of *Alocinma*. In the shape of the mouth and in the character of the lip it stands quite distinct.

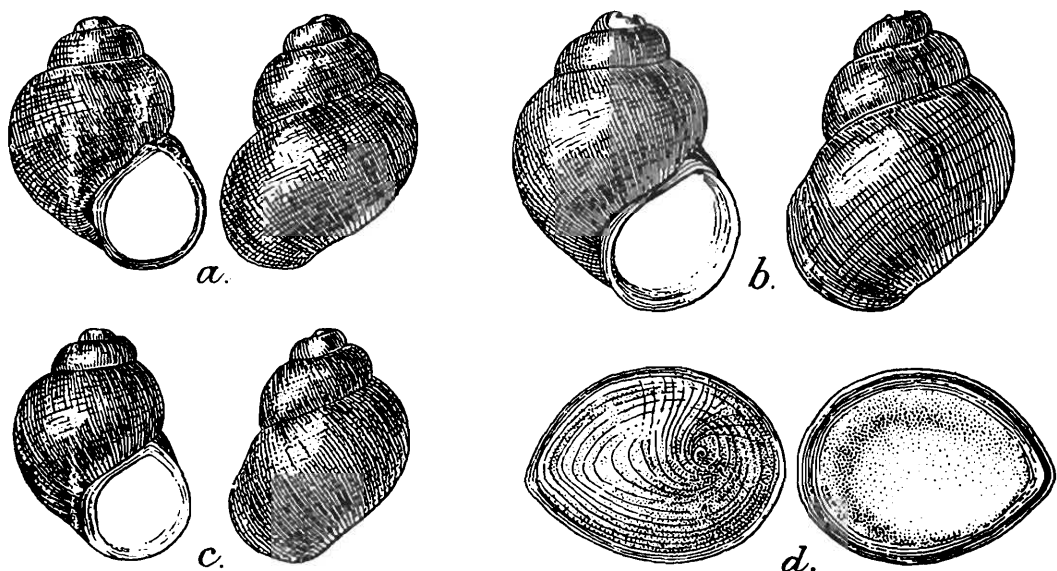
Parafossarulus Annandale.

1928. *Parafossarulus*, Rao, *Rec. Ind. Mus.*, XXX, P. 429.

This genus is represented by a single undescribed species. It is probably confined to the hill-districts of Upper Burma, but with only two records from Burma it is impossible to say anything definite about the distribution of the genus in that country.

Parafossarulus sulcatus, sp. nov.

The shell is oval, only slightly longer than broad, and has $3\frac{1}{2}$ -4 convex whorls which increase rapidly in size. The apex is obtuse and often broadly flattened. The whorls are oblique, particularly the last. The suture is clearly defined and well-impressed, and the whorls outside it are slightly flattened. The body-whorl is large, broader than high, and evenly convex. The breadth at the base of the penultimate whorl is three-fourths of the maximum breadth of the body-whorl. The aperture is nearly half as high as the shell, broadly oval, and widest at or a little below the middle. Its posterior extremity is produced, while its anterior is more or less rounded, but where the inner and outer lips meet in front a right angle is formed. The peristome is continuous and the inner lip is relatively thick, smooth and shining, and exceptionally laminated near the posterior end. The umbilicus is almost closed, but a slight chink may be detected in an oblique ventral view between the columellar callus and the shell. The naked-eye appearance of the shell is smooth, but under a lens the sculpture



TEXT-FIG. 3.—*Parafossarulus sulcatus*, sp. nov. a, dorsal and ventral views of the holotype; b, c, the same views of the paratypes; d. outer and inner views of the operculum.

of the shell is seen to consist of very close and strongly impressed spiral striae. The first two whorls are smooth but the last two have the

sculpture strongly developed. Oblique longitudinal lines are present on the body-whorl, particularly near the margin of the outer lip. The interior of the mouth is smooth. The shell is hyaline and pale yellowish-brown in colour. The operculum is calcareous, oval, acute above and rounded below, concave on the outside and convex on the inner surface. The paucispiral figure is situated a little below the middle part, and is much less clearly visible on the inner than on the outer surface. The peripheral concentric lines are well developed. The edge of the operculum on the inner surface forms a narrow ridge to the periphery of the convex portion.

The radular teeth resemble those of *Bithynia (Alocinma) sistanica*, but the central is relatively broad, and has, as a rule, four latero-basal denticulations on each side, while the inner lateral has a comparatively long and broad ventral process projecting from below the cusps.

The male intromittent organ has a relatively stout spindle-shaped lateral process.

Measurements of type-specimens (in millimeters).

Locality.				
Shores of lake, Lonton	5.5	4.5	3.0	2.0
Nyaungbin	4.5	4.0	2.3	2.0

Holotype.—M. $\frac{12845}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

Only six specimens were found in a living condition near Lonton and Nyaungbin on the western and northern shores of the lake respectively.

In form and sculpture, and in the characters of the radula and the male organ this species differs from other known species of *Parafossarulus* from Burma and China.

Family TIARIDAE (MELANIIDAE).

The genera common to many parts of India and Burma, namely *Acrostoma*, *Melanoides*, and *Paludomus*, are represented in the lake fauna by a few species, some of which are very widely distributed in the Oriental Region, and others are peculiar to Burma.

Genus *Acrostoma* Brot.

1928. *Acrostoma*, Rao, *Rec. Ind. Mus.*, XXX, p. 442.

Acrostoma baccata f. *lirata* Rao.

1928. *Acrostoma baccata* f. *lirata*, Rao, *op. cit.*, p. 445.

This form is represented in the lake fauna by a single incomplete shell collected by Mr. D. Mukerji from the southern shore of the lake near Lonton. The apical part of the shell is missing and there are only 3 whorls present. The mouth is shorter, relatively broad, and rounded at its anterior extremity. The shell is devoid of tubercles, but the ridges characteristic of this form are present on the lower part of the last whorl. The upper two whorls are comparatively smooth except for a shallow groove near the suture.

Acrostoma baccata and its forms in Burma are all inhabitants of streams in the uplands, chiefly in the Shan plateau.

The various parts of the lake were dredged by Dr. Chopra and his party but not a single specimen of this form was found in the bottom mud, which generally contained large numbers of shells of Viviparidae and Tiaridae. Its occurrence in the lake, therefore, is probably accidental. The shell found by Mr. Mukerji on the shore was presumably washed down into the lake from an adjoining stream during flood time.

This form is known only from Tangyan in the S. Hsemod State of the N. Shan States.

Genus *Melanoides* Brot.

1928. *Melanoides*, Annandale & Prashad, *Rec. Ind. Mus.*, XVIII, p. 21.

Melanoides tuberculatus (Muller).

1918. *Melania tuberculata*, Annandale, *Rec. Ind. Mus.*, XIV, p. 114, pl. xii, figs. 1, 2.

1928. *Melanoides tuberculatus*, Rao, *Rec. Ind. Mus.*, XXX, p. 448.

The species is very common on the shore and at the bottom of parts of the lake, and in small streams in the vicinity of Kamaing and Chaungwa. Specimens from the bottom of the lake were mostly dead, relatively narrow, and considerably eroded and bleached. Those from streams were all living but of small size, not exceeding 20 mm. in height and 10 mm. in breadth. They were black in colour with faint brownish marks on the body-whorl.

Melanoides scabra (Muller).

1844. *Melania (Plotia) scabra*, Nevill, *Handlist Moll. Ind. Mus.*, II, p. 281.

1915. *Tiara (Plotia) scabra*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 35.

1919. *Melania scabra*, Annandale, *Rec. Ind. Mus.*, XVI, p. 147, pl. v, fig. 6.

Several dead and worn shells of this species were dredged from the shallower parts of the lake near Lonton and Loimon. They are of small size, but the characteristic features of the species in form and sculpture are distinctly present. The distribution of this species in Burma is not fully known. The species does not occur in the Shan States, but it seems to have a fairly wide distribution in Lower Burma. The range of the species in the East is certainly wide, but in the Indian Empire it is somewhat restricted. The species has been recorded from the Bombay and Madras Presidencies, Lower Bengal, Assam, Burma and Ceylon.

Genus *Paludomus* Swainson.

1919. *Paludomus*, Annandale, *Rec. Ind. Mus.*, XVI, p. 147.

Though the number of species of this genus known from India, Burma and Ceylon is very large, the characters by which the species are distinguished from one another are not clearly understood. The species can presumably be assigned to a few sections or groups having certain distinguishing features in the operculum. The shell-form is

obviously an important character, and most of the well-defined species are based on this character. This is, however, difficult to make out in many species of the genus as the spire is in most instances worn, often up to the last whorl. Sculpture, texture, colour, and ornamentation are also characters used for the identification of the species, but these characters are often so very variable even in individuals of the same species that their reliability is open to question. Besides some species are liable to form local races which are often given specific rank. The anatomy of most, if not all, of the species is unknown, but so far as my knowledge of the anatomy goes, particularly of the radula, the mantle-edge and the gills of a few Indian and Burmese species, there is no diagnostic feature of value in these characters which will help in the identification of the species.

The genus as a whole stands in need of a thorough revision. Species of *Paludomus* have hitherto been found chiefly in Assam, Burma, South India and Ceylon.

Three species of *Paludomus* were found in the Indawgyi Valley. One is the common *P. regulata* of Burma and the other two are new to Science. The latter do not belong to the lake system or the valley. They were found in streams in the vicinity of Kamaing, about 50 miles north of the Indawgyi Lake.

I have thought it convenient to include in this paper the description of two more new species which do not belong to the lake fauna. Individuals of both these species are from Burma, presumably from the deltaic region of the Irrawady, and have been preserved in the Zoological Survey collection for many years without receiving a name. They are, however, related to other species dealt with in this paper.

***Paludomus regulata* Benson.**

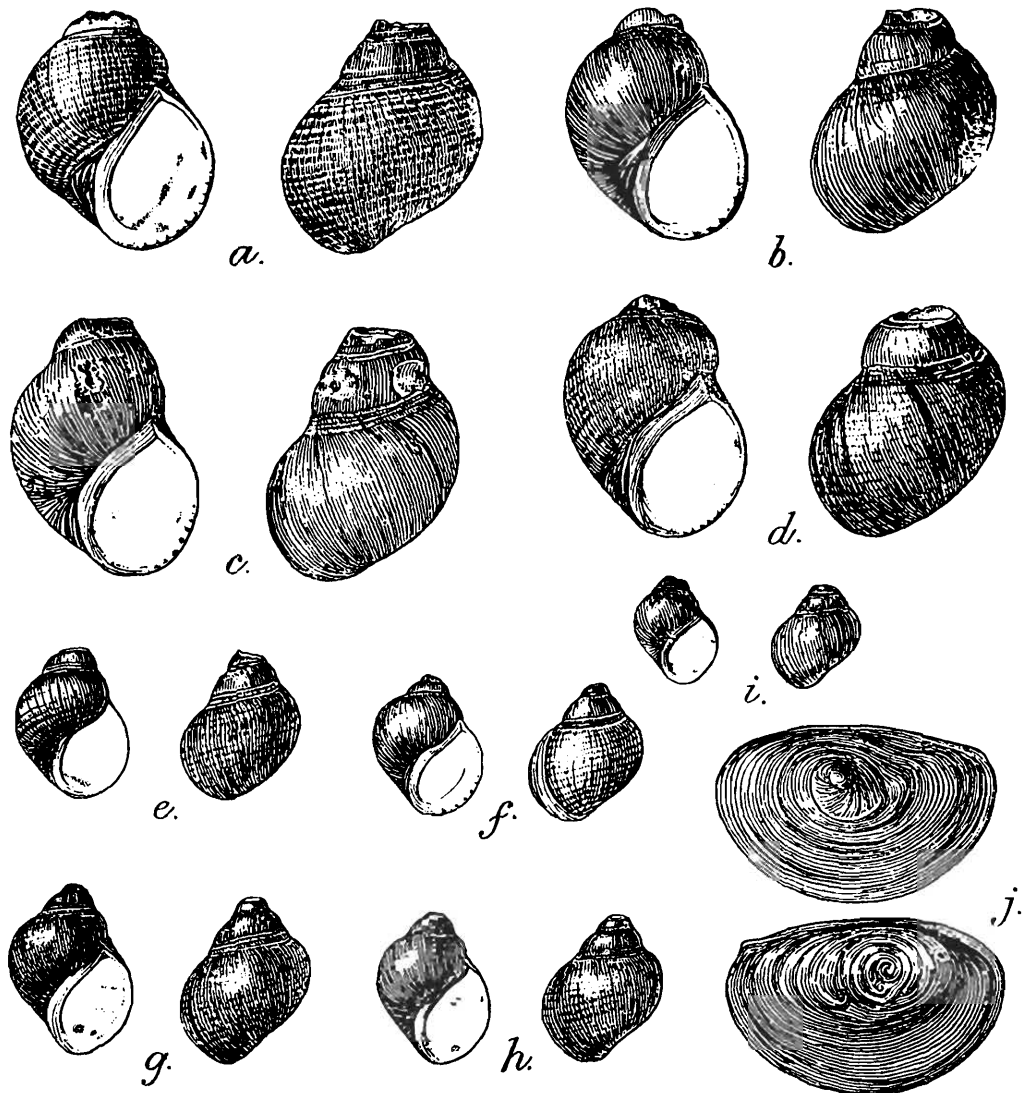
1928. *Paludomus regulata*, Rao, *Rec. Ind. Mus.*, XXX, p. 452.

Several individuals of this species were obtained in a living condition from streams and pools near Lonton and Loimon on the shores of the lake, and from rocky streams in the vicinity of Namma and Hopin. A few living specimens were also dredged from the shallower parts of the lake near Loimon.

***Paludomus crassicallosa*, sp. nov.**

The shell is conico-ovate, not much longer than broad, and is usually decollate, much more in the adult stage than in the young shells, which have as a rule 2-2½ whorls in the spire. The sculpture consists of rather ill-defined spiral ridges, which are obliterated in many shells, with the result that the shells appear to be smooth. The shells are, however, never absolutely smooth, a few ridges near the suture persisting in almost all the individuals. The spire is slightly oblique, minute and very little impressed. The aperture is slightly variable in form, being narrow in some and expanded in others. It is more or less regularly oval in form, acuminate above and rounded below. The columellar callus is relatively thick, convex, and somewhat reflected above with a very minute chink outside it in some individuals. It is broader and thinner

above than below. The interior of the mouth and the columellar callus have a bluish tint and are smooth and polished. There are not more



TEXT-FIG. 4.—*Paludomus crassicallosa*, sp. nov. a-i, dorsal and ventral views of shells of different sizes; a, represents the holotype; j, outer and inner views of the operculum.

than four colour bands which are never continuous. They are broken up into a series of dashes or irregularly-shaped spots. These bands are not visible externally on the outside of the shell, except in younger individuals, in which a dark deposit has not begun to form. The colour of the shell is generally a dirty yellow, obscured by a thin black deposit.

Measurements in millimeters.

Locality.	Height of shell.	Maximum breadth of shell.	Height of aperture.	Maximum breadth of aperture.
Rocky stream, Kamaing	14.5	12.5	9.0	6.0
Stream near Pandawmu cave	14.0	12.0	8.2	5.2
Kamaing-Jade Mines Road	13.5	12.0	9.0	5.5

Holotype.—M. $\frac{12353}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

The holotype was obtained in Sankha, a large hill-stream between Kamaing and Mogaung.

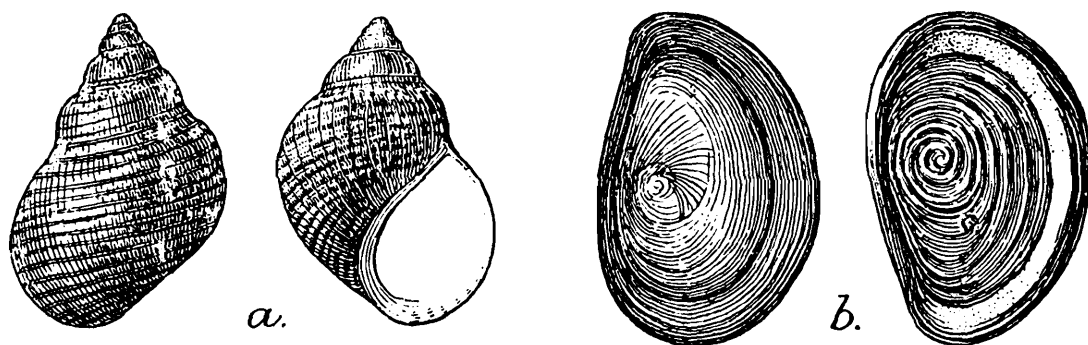
The radular teeth agree with the feature characteristic of the *Paludomus* type. The laterals and marginals are inclined at an angle of about 45° with the line connecting the bases of the teeth. The central has large cusps, the median being enlarged. The inner lateral tooth has also large cusps, but the 3rd or the 4th from the inner or axial side is much enlarged and squarish. The outer lateral has usually seven large and conical cusps. The marginal has numerous, elongate, narrow and sharp denticles on the margin which are usually about 18 in number. The short, broad-based conical process on the central is somewhat depressed in the middle.

Several hundred specimens of this species were obtained in the living condition from rocky or muddy streams within a radius of 10-15 miles from Kamaing.

This species seems to be closely related to *Paludomus nana* Nevill described below from Pegu in Lower Burma, but differs from the latter species in having a decollate spire and more convex body-whorl, in the more prominent sculpture, in the columellar callus being convex instead of sloping inwards, in colour, and in having interrupted colour bands.

Paludomus kamaingia, sp. nov.

The shell is conico-ovate, of moderately small size, not exceeding 15 mm. in height, and is moderately thick. It has 6-6½ whorls gradually increasing in size. The breadth of the spire at its base is a little more than half the breadth of the last whorl, and its height nearly half that of the entire shell. The whorls are moderately convex, and there is a slight shelf between successive whorls of the spire so that the outline of the shell is somewhat interrupted. The body-whorl in dorsal view is oblique, and below the middle on its left side is abruptly narrowed down. The suture is very minute and not impressed. The aperture



TEXT-FIG. 5.—*Paludomus kamaingia*, sp. nov. a, dorsal and ventral views of the holotype; b, outer and inner views of the operculum.

is oval, acuminate above and rounded below. The outer lip is relatively thin, crenulated as in most species of *Paludomus*,¹ and very slightly

¹ This crenulation seems to follow closely the contour of the mantle-edge and is doubtless the result of its activity.

depressed at its commencement above. The inner lip is relatively less arched. The columellar callus is well developed, rather thin at its junction with the apex of the aperture, relatively narrow, and flattened. It has a bluish tinge, and appears to be smooth to the naked eye, but is in reality minutely pitted or granular, and never conspicuously reflected, if at all. The interior of the mouth is smooth and shining. Three conspicuous but discontinuous brown bands are usually visible on the inner surface of the shell when the mouth is viewed. A fourth, which is sometimes clear, is found near the apex of the aperture close to the suture. These broken bands take the form of irregular dots or dashes. The sculpture consists of a number of spiral ridges, which are alternately broad and narrow. Immediately below the suture there are two or three much narrower but well-defined ridges. On the whorls of the spire and on the ventral side of the body-whorl the sculpture is somewhat feeble. Very minute longitudinal striae form the ground-work of the sculpture, but they can only be detected under the high power of the binocular microscope near the edge of the outer lip in adult shells or on the body-whorl in young individuals. The colour of the shell is yellow but is obscured by a black deposit which could not be removed except by prolonged treatment with a dilute solution of caustic potash.

The young shells are globular in form with the spire decollate. The sculpture is as prominent as in the adult, and the colour bands can be detected on the outside of the shell.

The operculum of the adult is narrowly ovate with its apex directed towards the columella; it is concave above and convex below. The paucispiral is clearly visible on both sides of the operculum with the nucleus situated near the columellar side and a little below the middle. Fine concentric lines are present outside the area occupied by the paucispiral. On the inner side the spiral is marked by well-defined ridges flanked by a smooth, broad ridge on the columellar side. The operculum is always covered on the outer surface by a firm, black deposit which can be removed by treatment with caustic potash and by scratching the surface with a fine scalpel or needle.

Measurements in millimeters.

	Height of shell.	Breadth of shell.	Height of aperture.	Breadth of aperture.
Holotype	15.0	11.0	8.5	5.5
	14.5	11.3	8.5	5.5
	14.2	10.5	8.0	5.0

Holotype.—M. $\frac{12851}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

The radular teeth closely resemble those of *P. crassicallosa* but are subject to slight variations in individuals.

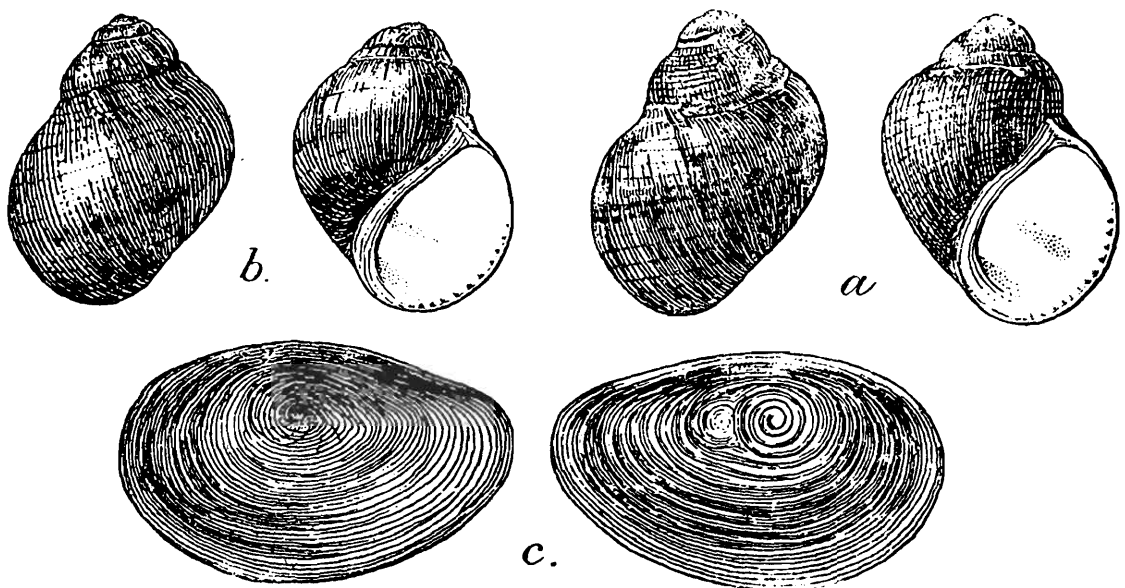
Several living specimens were collected from a small rocky stream near Kamaing.

The species is closely allied to *P. crassicallosa* but differs chiefly in the columellar callus not being convex, and in having a relatively prominent sculpture.

Paludomus nana Nevill.

1881. *Paludomus andersoniana* subsp. *peguensis* subvar. *nana*, Nevill, *Journ. As. Soc. Bengal*, L, p. 160.

The shell is of moderately small size, the largest not exceeding 16 mm. in height and 12 mm. in breadth, ovate, and has 4-4½ moderately convex whorls which increase in size more or less rapidly. The spire is, as a rule, entire and rarely decollate, but the protoconch is scarcely, if ever, exerted, with the result that the apex of the spire is nearly always obtuse. The suture is transverse, distinct but lightly impressed. The body-whorl is about two-thirds as high as the shell, swollen and broadest in the middle. The aperture is ovate, acuminate above and relatively rounded below. The outer lip is thin and sharp and much more arched than the inner lip. The columellar callus is broad above and slightly narrow below towards the anterior end of the aperture. It is more or less flat and slopes down from the umbilical margin towards the interior of the mouth. No chink is left between the callus and the umbilical region. The callus is cream-white in colour, smooth and shining, but very minutely pitted. The sculpture is rather poorly developed, and there is a tendency for smoothness in the shells. Both longitudinal and spiral sculpture can, however, be easily made out with the help of a lens. The shell



TEXT-FIG. 6.—*Paludomus nana* Nevill. *a*, dorsal and ventral views of the holotype; *b*, the same views of another specimen; *c*, outer and inner views of the operculum.

is blackish or a dark brown in colour. Looking into the aperture four colour bands may usually be seen but these bands are subject to great variation. In young shells and in some adult ones traces of the colour bands are often present on the outside of the body-whorl. The operculum is thin, narrowly ovate, slightly depressed in the centre of the outer surface, and has no granular thickening in the centre of the inner surface. The paucispiral is visible from the inner surface also.

Measurements in millimeters.

	Height of shell.	Breadth of shell.	Height of aperture.	Breadth of aperture.
Holotype	14.5	11.5	10.0	6.0
	15.0	12.5	10.5	6.5
	16.2	13.0	10.0	7.0

Holotype.—M. $\frac{12847}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

Nothing is known about the anatomy. The shells have been cleaned and no trace of the animal is left behind.

A few shells of this species were collected by the late Dr. F. Stoliczka in Pegu in Lower Burma. Nevill considered them to be an undescribed variety of the subsp. *peguensis* of his species *Paludomus andersoniana*.¹ On careful comparison of the specimens catalogued by Nevill in his 'Hand-List' with *P. regulata* I find sufficient justification to give them a distinct specific status.

P. nana differs from *P. regulata* in several features but chiefly in the proportionately shorter and broader spire, in the relatively well-developed and somewhat flattened columellar callus, in the shell being comparatively thick, and in the operculum being devoid of a granular thickening in the centre of the inner surface. In sculpture and colour also the difference between the two species is apparent.

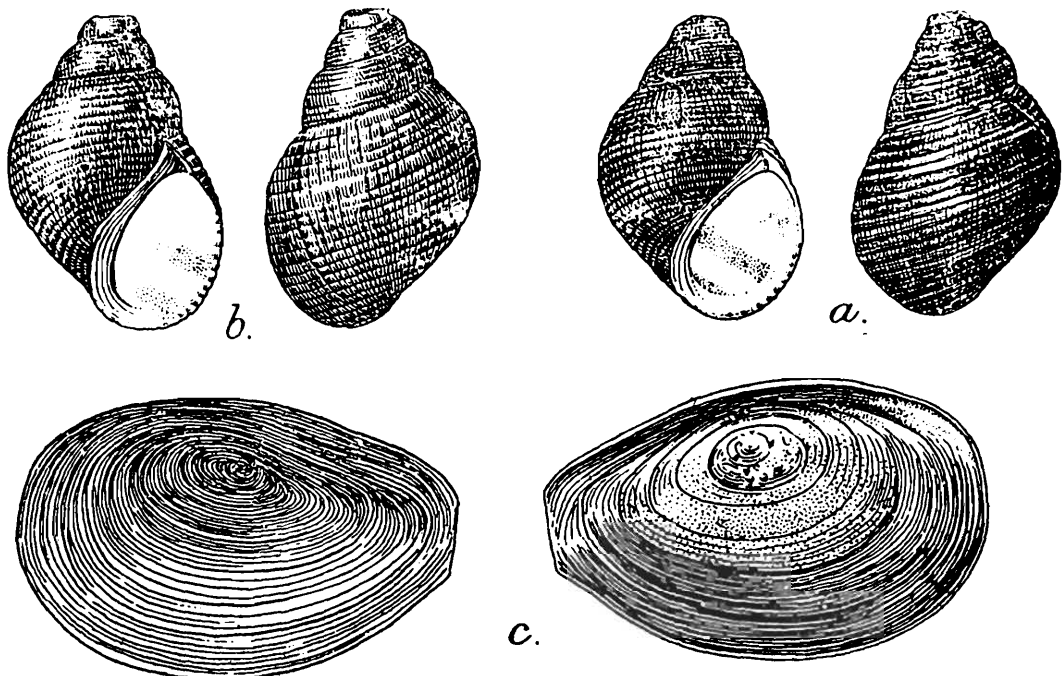
The Burmese species of *Paludomus* seem to have evolved from forms resembling *P. regulata* which is widely distributed in Burma. They seem to exhibit a certain degree of plasticity, and the differences in habitat have probably contributed their share to the factors operating on the evolution of various slightly differing forms from a common stock.

***Paludomus parvula*, sp. nov.**

The shell is regularly ovate or roughly elliptical, slightly decollate, and has only four whorls which are not at all swollen. The body-whorl is nearly as broad as high and two-thirds as high as the entire shell. The suture is oblique, well-defined and moderately impressed, and the outline of the shell is only slightly interrupted by the aperture. The aperture is elongate, oval, acuminate above and rather narrowly rounded below. The outer lip is thin and crenulated at its margin and is not very much arched, though more conspicuously than the inner lip. The columellar callus is flattened, fairly broad, of equal breadth throughout its entire length, and is continued to the anterior end of the aperture. The interior of the mouth is smooth, and has four broad bands, of which the third from above is the broadest. If the shell surface is without a black deposit these bands are also clearly visible on the outer surface of the body-whorl. The sculpture is very prominent and consists of broad spiral ridges separated by deep grooves. The ridge near the suture is

¹ In a previous paper on the Molluscs of the N. Shan States (*Rec. Ind. Mus.*, XXX, p. 452 1928) I have shown that Nevill's species is a synonym of *P. regulata* Benson.

particularly thickened. The ground sculpture consists of minute longitudinal striae visible on the ridges and in the grooves. The operculum



TEXT-FIG. 7.—*Paludomus parvula*, sp. nov. a, dorsal and ventral views of the holotype; b, the same views of another specimen; c, outer and inner views of the operculum.

is ovate, broadly pointed at apex, concave on the outer surface and convex on the inner. The paucispiral is visible from both surfaces, but the ridges of the nuclear part are very feebly developed on the inner surface. The concentric lines are minute.

Measurements in millimeters.

	Height of shell.	Breadth of shell.	Height of aperture.	Breadth of aperture.
Holotype	14·8	10·5	9·8	5·2
	15·5	11·0	9·5	5·5
	15·0	10·5	9·3	5·5

Holotype.—M. $\frac{12349}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

Only seven shells from an unknown locality in Burma are preserved in the Zoological Survey collection. They do not match with any known species from that country. They, however, resemble in external features only the Ceylonese *P. sulcata* var. *minor* Nevill. The operculum of the two species are so different that there can hardly be any specific relationship between them. From a label with the name *parvula* on it found along with the shells it seems possible that Benson intended to regard them as a new variety of *P. regulata*. I cannot find any reference to this name in literature, or any published figures with which the shells in question agree in every respect.

The radular teeth closely resemble those of *P. regulata*, particularly in having fewer denticles on the outer lateral and marginal teeth, and in the median cusp on the central not being conspicuously enlarged.

Family LIMNAEIDAE.

This family is represented by three species of which one is new to Science.

Only one species, *L. acuminata*, occurs in great abundance in the lake and its surroundings. Two specimens of another species, *L. luteola*, and a few of a new form of *L. acuminata* were also taken from the shores and shallow regions of the lake. The description of the new species is based on a single example from the lake.

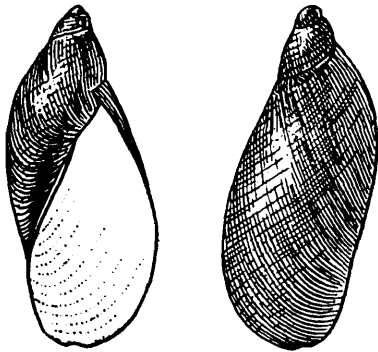
***Limnaea acuminata* f. *patula* Troschel.**

1925. *Limnaea acuminata* f. *patula*, Annandale & Rao, *Rec. Ind. Mus.*, XXVII, p. 181, fig. iii, 9, fig. vi, 1 & 2.

Several hundred specimens of this form in various stages of growth were taken in ponds and pools round about Lonton and Nyaungbin, and in the shallow parts of the lake near the shore in the vicinity of Lonton, Loimon, Nyaungbin and the Shwemyzu Pagoda.

***Limnaea acuminata* f. *pseudohorae*, nov.**

Though in size and sculpture this form approaches *L. horae* Annandale & Rao, it has, I think, no specific relationship with it. In the form of the shell and the spire, and in the nature of the columellar callus, which though very thin is always distinct, this form is undoubtedly closely allied to *L. acuminata*, particularly to the form *patula*, but in having minutely decussated longitudinal striae, which are so characteristic of *L. horae*, its resemblance to this species is remarkable.¹



TEXT-FIG. 8.—*Limnaea acuminata* f. *pseudohorae*, nov. Dorsal and ventral views of the holotype.

Holotype.—M. ¹²⁸⁵⁸/₂ *Zool. Surv. Ind. (Ind. Mus.)*.

Three fresh shells were taken along with *L. acuminata* f. *patula* from the shallow part of the lake near Shwemyzu Pagoda. The animals were unfortunately not preserved.

***Limnaea luteola* f. *australis* Annandale & Rao.**

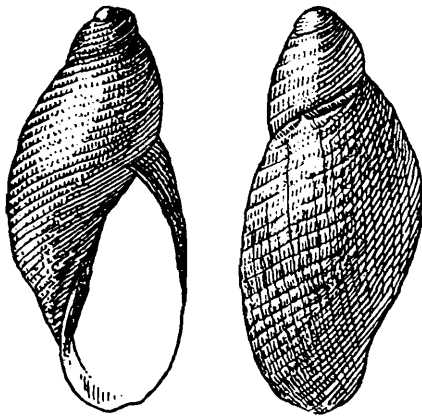
1925. *Limnaea luteola* f. *australis*, Annandale & Rao, *Rec. Ind. Mus.*, XXVII, p. 184.

This form is recorded for the first time from Burma. It has a wide distribution in India and Ceylon. The form *siamensis* Sowerby, which seems to be more or less in the nature of a local race of the species and known from the Shan States and the Irrawady delta, is curiously absent in the Indawgyi Valley and its neighbourhood.

Only two small living specimens were found sticking to aquatic weeds in a clear pool more or less connected with the Indawgyi Lake.

***Limnaea decussatula*, sp. nov.**

The shell is of small size and does not exceed 4 mm. in height and 2 mm. in breadth. It is elongate, narrowly elliptical, thin but not brittle, and consists of three whorls which are not at all swollen. The body whorl is large, and is about two-thirds the height of the entire shell. The apical whorl is small, knob-like, and is a little more than one-third



TEXT-FIG. 9.—*Limnaea decussatula*, sp. nov. Dorsal and ventral views of the holotype.

the height of the penultimate whorl. The suture is oblique and moderately impressed. The aperture is elongate, unusually narrow and compressed, but broadens out gradually from the posterior end to the anterior. The columella is well defined, but the callus is thin and poorly developed. It is somewhat twisted in appearance and forms a thin but conspicuous ridge along the greater portion of the periphery of the inner lip. The inside of the mouth is smooth and has an oily lustre. The outer lip is comparatively thin. The sculpture is very

minute and peculiar. The ground sculpture is longitudinal, but these longitudinal lines seem to be broken up later on into short decussating vertical but curved lines throughout the second and the last whorls. The concavity of these curved lines is always directed towards the columellar side. Parallel shallow grooves are formed between successive series of decussating lines and give the shell a spirally striated appearance. The apical whorl is smooth.

Holotype.—M. $\frac{12857}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

The animal is only partially preserved, and I have not been able to study its anatomy.

A single example of this species was found along with specimens of *L. acuminata* f. *pseudohorae*, nov. in the shallow part of the lake near the Shwemyzu Pagoda.

The compressed nature of the shell and the aperture, the curious sculpture, and the columellar ridge mark this species as very distinct from any other Indian or Burmese lacustrine species of *Limnaea*. Though the species approaches *L. horae* in sculpture, it differs from it in having the mouth not at all expanded.

Family PLANORBIDÆ.

In the fauna of the lake this family is fairly well represented by four genera and six species. Three of the six species have a wide distribution in the Oriental Region. *G. velifer* has hitherto been known from the Inle Lake, and its occurrence in the Indawgyi Lake seems to show that it is a purely lacustrine species. *G. rotula*, a rare Indian species, is recorded for the first time from Burma.

Indoplanorbis exustus (Deshayes).

1928. *Indoplanorbis exustus*, Rao, *Rec. Ind. Mus.*, XXX, p. 457.

The species is very common in the Indawgyi Valley and the adjoining country. Several hundred specimens, living and dead, were taken in ponds near the lake at Lonton and Hopin and near Kamaing. Some of them are of large size. Those collected near the north end of the lake contain a large number of small and young specimens.

Gyraulus velifer (Annandale).

1918 *Planorbis velifer*, Annandale, *Rec. Ind. Mus.*, XIV, p. 112, pl. xi, figs. 7-11.

In the shallow parts of the lake near Lonton and the Shwemyzu Pagoda this species is very common. Several living specimens were collected at these places, some of them from the latter locality being particularly large. The velum is well developed in all specimens. The species has hitherto been known only from the Inle Lake in the S. Shan States. In that lake it is common amongst dense masses of aquatic weeds.

Gyraulus velifer var. **ciliata** (Annandale).

1918. *Planorbis velifer* var. *ciliata*, Annandale, *op. cit.*, p. 112.

Several examples of this variety were taken along with the typical species mostly in the living condition. They seem to stray occasionally into the deeper parts of the lake. The spiral ridges characteristic of this variety vary in number, but are more numerous than in the specimens from the Inle Lake.

Gyraulus convexiusculus (Hutton).

1928. *Gyraulus convexiusculus*, Rao, *op. cit.*, p. 457.

The species is common in the shallow parts of the lake near Lonton and Nyaungbin. Large numbers of specimens were found in weedy ponds round about Lonton, and amongst submerged floating weeds near the shore of the lake at Nyaungbin.

Gyraulus rotula (Benson).

1850. *Planorbis rotula*, Benson, *Ann. Mag. Nat. Hist.*, Ser. 2, V, p. 351.

1876. *Planorbis rotula*, Hanley & Theobald, *Conch. Ind.*, p. 40, pl. xcix, figs. 2 & 3.

With some hesitation I refer to this species two shells from the shores of the lake near Lonton. They are not quite fresh, and the mouth of the shells is not entire. The sculpture is somewhat coarse and there is no trace of the spiral striae referred to in Benson's original description. The whorls are uniformly convex, and the mouth is small and rounded. The apex is relatively depressed. In the number and general features of the whorls, the shells agree with the description of *G. rotula*.

Shells from Bombay in the collection of the Zoological Survey of India referred to by Nevill (*Hand-List Moll. Ind. Mus.*, I, p. 245) as "*Planorbis (Nautilina) rotula* (?)" are included by Germain in *G. rotula*

(Benson).¹ I have examined the full-grown shells in this lot and find that they are in no way related to *G. rotula*. In the departure of the last whorl from the axis of the inner whorls and in the presence of a whitish rib within the lip, the shells under discussion agree very well with *G. labiatus* (Benson).

Benson, who first discovered the species at Moradabad as early as 1841, regarded it as a rare species, and this is borne out by the fact that there has been no record of the species since then from any other part of India. Drs. Prashad and Hora, however, rediscovered the species in 1920 in a pond in Moradabad, but unfortunately their collection consists of only one small shell, which agrees very well with Benson's description of the species.

Dr. Prashad² has referred to this species shells from Ceylon described by Westerlund as *Planorbis (Gyraulus) liratus*. His figure of the species compared with the specimen from Moradabad indicates that the Ceylon specimens are identical with *G. rotula*.

The anatomy of the species is totally unknown. Benson has referred to the peculiar mode of progression of this species. I have observed *G. convexiusculus* and *G. euphraticus* in their natural environment perform occasional jerky movements of the shell when suspended from the surface film, but they did not move very far from their original position. The rapid progression of *G. rotula* by sudden jerks is presumably a unique character.

From the little known records of the species, e.g., from the Indawgyi Lake in Upper Burma, from Moradabad in N. India, and from Ceylon in the extreme south, it is only possible to surmise that its distribution is discontinuous.

Segmentina calathus (Benson).

1921. *Segmentina calathus*, Annandale & Prashad, *Rec. Ind. Mus.*, XXII, p. 585.

This species is apparently rare both in the lake and in the streams and pools in the valley and in the plains north of the lake. Only one young example in a dead condition was found along with other species of Planorbidae from the shores of the lake near Lonton. The mouth is not entire, and the whorls are comparatively broad in dorsal view. The internal partitions in the shell, two of them at any rate, are quite distinct though relatively thin.

The species is common in Northern India, Burma and Ceylon. Its range outside India extends up to Seistan in the North-west and up to Siam and Sumatra in the East and South-east.

Hippeutis sp.

Six small dead shells dredged from the south end of the Indawgyi Lake near Lonton are referred to this genus. With some of the generic characters of *Hippeutis*, e.g., the tentacular shape, the convex dorsal and flattened ventral surfaces, and the deep umbilicus, the shells

¹ Germain, *Rec. Ind. Mus.*, XXI, p. 128 (1922).

² Prashad, *Rec. Ind. Mus.*, XXVII, p. 347 (1925).

agree closely, but differ in being greatly depressed and in the rapidly increasing size of the whorls. With only a few dead and much worn shells it is impossible to be certain about its specific identity.

The shells are whitish in colour and have well-defined, impressed, oblique, longitudinal striae. The periphery is carinate, and in one shell it carries a pair of bacterial vela, one below the other, the lower being more prominent than the upper. The aperture is heart-shaped.

Family SUCCINEIDAE.

This family is very poorly represented in the Indawgyi Valley, the only record being a form of the species *Succinea gravelyi* Rao.

Succinea gravelyi f. *deccanensis* Rao.

1924. *Succinea gravelyi* f. *deccanensis*, Rao, *Rec. Ind. Mus.*, XXVI, p. 403.

A single example in the living state was found at the edge of a stream near Lonton. Unfortunately the animal is in a bad state of preservation, and I am, therefore, unable to verify my identification by an examination of the internal organs, except the radular teeth, which agree closely with those of *S. gravelyi*. The shell is smaller than any of the typical specimens from India, and is somewhat abruptly narrowed from the middle. The last whorl is not evenly arched in dorsal view. The sculpture is coarse and consists of irregular longitudinal striae.

Succinea gravelyi, like *S. daucina* and *S. godivariana*, seems to have a restricted distribution in India and Burma.

CORALS OF THE GENUS *FLABELLUM* FROM THE INDIAN OCEAN.

By J. STANLEY GARDINER, M.A., F.R.S., Professor of Zoology and Comparative Anatomy, University of Cambridge.

(Plate XIII.)

Twenty years ago I received a number of specimens of Corals of the genus *Flabellum* from the Indian Museum, Calcutta. I compared them with specimens in the British Museum and in the Smithsonian Institute; Drs. Wayland Vaughan and Von Marenzeller as well as Dr. Alcock allowed me to consult with them as to the validity of the species. My report was drawn up, but the difficulties of the war and subsequent years delayed further action. I have now re-examined the collection and also the British Museum specimens, and I have to express my thanks to the late Professor Jeffrey Bell and to Captain Totton in respect to the latter.

The genus is almost cosmopolitan with its centre, as shown by variety of species and the numbers of specimens obtained, in the East Indies, especially in the Philippines. It occurs sparingly in the Atlantic, but Duchaissaing and Michelotti, Pourtalés and Vaughan do not mention it from the West Indies. So far as we can judge it is essentially a species of the higher land slopes, but several species are recorded down to 1,000 fms., 1,500 fms. being its present maximum depth. It has lived from the Eocene, in which there would appear to have been more species than to-day. There are plenty of varietal forms of each species, for their growth, as is that of all attached forms, is greatly influenced by the movements of the surrounding water and the consequent scouring, and by the rate of deposition of deposits. The outer wall is an epitheca, not covered by tissue, and it may be dissolved or abraded away by water movements, or rasped off by sea urchins and other organisms; the consequent reaction is seen in that the polyp deposits fresh corallum between the septal ends against this destruction, and the whole calicle becomes relatively dense and heavy. This pathological condition often results in seeming costae, whereas true costae cannot exist with an epithecate wall. These false costae are sometimes the now free outer edges of the septa, but as frequently this is reversed and the secondary corallum forms a convexity or ridge between the septa, the destruction of which has gone deeper.

Modern investigators have tended to restrict severely the number of species. They demand a suite of specimens, and they base their views on various measurements and on their correlation with each other and with counts of the septa of various sizes and the numbers of the same joined by trabeculae in a columella. These are all very well, but it has to be recognised that any character, such as teeth on the septal edges or even so minute as spines on the growth lines of the septa is sufficient if constant. However, marked septal teeth are

unusual in the genus and such of the latter characters, as are visible without sections of the septa, are so fluctuating that they must be assumed to be correlated with environment. Furthermore, the polyps of many forms of *F. rubrum* (or possibly of several species of this type of growth) exhibit practically no variation either in their gross anatomy or in their minute histology. In this connection the opinions of Vaughan are of especial value, for he has studied the range of both living and fossil species, and I am in essential agreement.

The method of reproduction of *Flabellum* is by internal fertilisation and the extrusion of planulae. The young coral is always attached by a narrow base, but the very old coral is nearly always freed either by breaking away or by the solution or destruction of its base of attachment. In some cases, especially of the *rubrum*-type of growth, there is a distinct scar left in which the septa are clearly visible though their interspaces are usually filled by secondary corallum. This suggests "multiplying asexually by transverse division from a fixed nurse stock" and a comparison with the method of reproduction of *Fungia*. It is difficult to imagine a withdrawal of the tissues in this rupture, the calicoblastic ectoderm being so closely attached to the corallum, but as any part of the polyp, if broken into, can form a cup, which will grow up into a fresh corallum, it seems reasonable to suppose that such a sexual reproduction can take place. Furthermore, I have examined specimens, evidently very recently detached and without corallum between the septa of the scar, the tissues of which showed rupture. Yet, in over 1,000 specimens examined, I have found no calicle that I can suggest to have been so formed from "a fixed nurse stock," and I can only ask future collectors to look out for such. In this connection I may mention that in a suite of 6 specimens of *Blastotrochus nutrix* Ed. and H. in the British Museum, so identified by Bruggemann, I discovered that most show traces of splitting or imperfect formation of corallum with bud formation at the sharp lateral edges of their flattened calicles. I suggest that the polyps of this genus—and also of *Rhizotrochus*—must be properly examined before its proposed absorption into *Flabellum*, based on corallum alone, can be accepted.

Most of Milne Edwards and Haime's species of *Flabellum* fall under two types of growth represented by the species *rubrum* Q. & G. and *pavoninum* Lesson. A third type is represented by *F. japonicum* Moseley, *F. alabastrum* Moseley and *F. deludens* von Marenzeller and yet a fourth by *F. curvatum* Moseley and *F. multifore* Gardiner. All are represented in Indian Seas.

Flabellum pavoninum Lesson.

(For literature and synonymy see Gardiner, *Marine Invest. in S. Africa*, II, p. 123, 1902; Vaughan, *Bull. U. S. Nat. Mus.*, LIX, p. 49, pl. i-iii; and Faustino, *Monograph Bureau of Science, Manila*, XXII, p. 43, 1927.)

I have seen a large number of specimens of this species including those in the U. S. National Museum which Vaughan described. I accept Vaughan's synonymy, but I do not agree that the species "can best be handled" by recognising varietal forms. I do not think they represent any elements in heredity, basing my views on my failure

to find any distinctions in the gross anatomy (polyp and corallum) of three of these "varieties" after my return from Washington in 1909.¹ I consider all to be growth-forms produced by environment, the chief variations of importance in which I deem to be (1) sedimentation, (2) food, (3) water movements and (4) depth and temperature, in this order—and I think that the localities from which specimens have been obtained supports this conclusion.

Yet, it is necessary to recognise that this may be an error and that we are dealing with several species overlapping in the appearances of their calices, distinguishable only by their polyp characters. This remark applies particularly to the typical form, var. *distinctum* Ed. and H., and var. *paripavoninum* Alcock, which are mainly separable by the angles of divergence of the lateral ends of their compressed coralla. The original type of Alcock's *paripavoninum* (*Madreporaria of the Investigator*, p. 21, pl. ii, fig. 3, 1898) is interesting in that it is a specimen which has been broken off its pedicle, in the scar 24 septa being distinguishable of which half meet in a pseudo-columella.² My doubt lies in the fact that Vaughan had a considerable suite of specimens of all three from the Hawaiian Island and Laysan, and Faustino of the first and last from the Philippines, apparently with very few intermediates. The special localities given show a wide range of depth and hence temperature, and in consequence the angles of the lateral edges of the *pavoninum* forms could only be correlated with sedimentation in respect to which we have no information.

Localities : (a) ZEV $\frac{165}{7}$, Sta. 239, 11° 49' 30" N., 92° 55' E., 55 fms., 9 specimens, 5 damaged, all rather dark coloured, bluish, shiny, shapes transitional between Vaughan's typical form up to his form *distinctum* (*loc. cit.*, pl. ii, figs. 3-5), size about the same : (b) $\frac{3268}{9}$, 6° 1' N., 81° 16' E., 34 fms., a single dead specimen, recently broken off its pedicle, with some *Lithothamnium* growing on its outsides, colourless corallum, near *distinctum*-form : (c) ZEV $\frac{1887}{7}$, Sta. 237, 13° 17' N., 93° 7' E., 90 fms., one specimen, dead, calice 31 mm. long by 19 mm. high, transition type to *distinctum*-form ; (d) ZEV $\frac{774-7}{7}$, Sta. 246, 11° 14' 30" N., 74° 57' 15" E., a single specimen, dead, calice 25 mm. long by 21 mm. high, shape towards *latum*-form : (e) ZEV $\frac{5322}{7}$, Andamans, 53 fms., a single living specimen of dark colour, calice 26 mm. long by 28 mm. high, very low arch to calicular margin, fairly compressed, slight wings on lower part, rather constricted just below calicular opening, a pathological specimen of *distinctum*-type : (f) ZEV $\frac{5324}{4}$, Sta. 389, 9° 1' 50" N., 75° 55' 50" E., 81 fms., 2 specimens—no. 1, dead, colour dark, calice 44 mm. long, 24 mm. wide, edge slightly ingrowing above, arch considerable, 24 mm. high, broken off from pedicle, scar 8 by 5 mm., whole corallum heavy and close to original *paripavoninum*-form ;—no. 2, also dead but cleaner, colourless, calice 42 mm. long, 23 mm. wide, rounded ends and no trace of wings, arch low, 42 mm. high, whole corallum very coarse,

¹ The polyps were examined by sections ; they were sufficient up to the point where histological study commences.

² There is an excellent specimen close to Vaughan's var *latum* Studer in the Cambridge Museum with a similar but much larger scar.

especially columella, considerably eaten into at base between the septa with extra deposition of corallum inside, comparable to Vaughan's pl. ii, fig. 1: (*g*) ZEV $\frac{1250-1}{7}$, Sta. 277, 5° 48' 15" N., 80° 56' E., 859-880 fms., alive when obtained but broken in dredge, remarkably similar to last but a rather smaller specimen.

To the above localities must be added Alcock's *paripavoninum*-form ("Investigator" *Deep Sea Madreporaria*, p. 21, pl. ii, figs. 3, *a*, *b*, 1898), a dead specimen off Pedro Bank, Laccadive Sea, 636 fms., admirably figured, scar 7 × 5 mm., not looking like an "accident" but rather a cutting off as in *Flabellum rubrum*, this remark also applying to (*f*, no. 1) above.

The "Sealark" collections contain specimens from Saya de Malha: C 4, 125 fms., 3; C 5, 125 fms., one much overgrown by "oysters"; C 6, 145 fms., 5 specimens, one broken off its attachment and showing in scar 24 septa joining in a columella. They approximate in size to the smaller S. African forms. All were dead, apparently recently killed, and white. Their septal edges are pleated and sides spiny. They belong either to Vaughan's *distinctum*-form or are intermediate between this and the typical. They come off a smooth sandy (glob. ooze) bottom.

The specimens described by Marenzeller as *Flabellum stabile* from Cape Verde Islands, 1694 metres (*Steinkorallen, Valdivia Exped.*, p. 273, pl. xvii, fig. 12, 1904) are certainly not widely separated from specimens (*f*, no. 2) and (*g*) above as well as from Vaughan's pathological specimen (pl. ii, fig. 1). I can find no evidence that Marenzeller has examined any considerable suite of *pavoninum* and I am disposed to think that his *F. stabile* as well as his *F. chunii* are synonyms of *F. pavoninum*.

F. campanulatum Holdsworth (*Proc. Zool. Soc.*, 1862, p. 198) from the Philippines may belong here, but the type specimens are not in the Museum of the Royal College of Surgeons, nor are there labelled specimens in the British Museum. Faustino suggested a re-examination, but, in the absence of types and of sufficient description, the species had better disappear from literature. I suggest the same course in respect to *F. nobile* Holdsworth as founded on dead material through the specimens still exist in the College.

Flabellum multifore Gardiner.

Gardiner, *Fauna Geogr. Maldives and Laccadives*, p. 954, pl. xciii, figs. 28 and 29, 1905; Faustino, *Monograph Bureau of Science, Manila*, XXII, p. 57, 1927.

In addition to my suite of specimens from the Maldives, 24-28 fms., the "Sealark" obtained 1 specimen from Seychelles, F 7, 34 fms. When alive the polyp was green standing up on the corallum for over 2 cm. The calicle was 53 × 17 mm., rather pinched in the central part, vertical height at sides 34 mm. and at ends 15 mm. above its attachment, growth rings 6, septa 180, one stomodoeum. It is of rather less coarse growth than the Maldivian specimens.

Faustino had a suite of 15 specimens from the Philippines from 97 fms. His largest specimen is about the size of my largest specimen and is stated to have over 800 septa, whereas mine has only 302; surely a clerical error in the doubling of his numbers has crept in.

There are three well figured "Challenger" specimens of *F. curvatum* Moseley from the Rio de la Plata region, 600 fms.; they clearly belong to the same species group of the genus.

Flabellum deludens Marenzeller.

F. laciniatum, Alcock, "Investigator" *Deep Sea Madreporaria*, p. 21, pl. ii, fig. 4, a, 1898.

F. deludens, Marenzeller, *Steinkorallen "Valdivia" Exped.*, p. 269, pl. xvii, fig. 10, 1904.

F. deludens, Vaughan, *Bull. U. S. Nat. Mus.*, LIX, p. 63, pl. iii, figs. 5, a-b, 1907.

The specific name *laciniatum* should disappear from literature as the material on which the species was founded by Philippi was too fragmentary for positive identification. I have compared the specimens with the British Museum specimens of *F. alabastrum* Moseley and I agree with Vaughan as to the distinctness of this species. The shapes of the coralla looked at from the side vary in a parallel way to Vaughan's *pavoninum*-form from *lamellulosum* through the typical to the *distinctum*-form. They have a tendency to be widely open in their transverse diameter, looking into the calices, but their ends are sharp.

Localities.—(a) ZEV $\frac{1431}{7}$, Sta. 280, 11° 29' 45" N., 80° 2' 30" E., 446 fms., two dark coloured specimens, largest length of calice 44 mm., breadth 34 mm., height 34 mm. : (b) ZEV $\frac{5334}{7}$, Sta. 392, 8° 43' 30" N., 76° E., 400 fms., two rather smaller and very delicate white specimens, apparently living when obtained : (c) spirit specimen ZEV $\frac{2105}{7}$, Sta. 322, 11° 26' 30" N., 92° 53' 45" E., 378 fms., a young specimen.

Alcock calls this species "a common inhabitant" of Indian Seas at 400—600 fms. The "Sealark" obtained two specimens from Saya de Malha : C 20, 300-500 fms., and C 4, 125 fms. The first specimen is 24 mm. along the base and the wings extend below the pedicle ; the height is 34 mm. In the species it occupies about the same position as the *lamellulosum*-form in *F. pavoninum*.

Other records are west of Sumatra, 614 and 660 metres (Marenzeller), Hawaii, 670-900 fms. (Vaughan). Faustino had a suite of specimens from 24 stations near the Philippines, 19 to 502 fms. ; he is evidently doubtful whether the species is not a synonym of *japonicum* Moseley which is not naturally a compressed species with sharp angles as this species almost universally is, in at least the young forms. I also found an unnamed specimen from Japan in the British Museum.

In the British Museum I have seen certain specimens labelled *F. laciniatum* reputed to be those of Duncan (*Trans. Zool. Soc.*, VIII, p. 322, 1873) ; they are not this species, which so far has not been found in the Atlantic.

F. alabastrum Moseley = *F. goodei* Verrill would seem to be related here, but it has not been obtained from Indian Seas. Vaughan mentions a suite of 170 specimens in the U. S. National Museum some of which I have seen. Young forms might be confused, but mature forms do not intergrade.¹

¹ See also Vaughan, *Bull. U. S. Nat. Mus.*, LIX, p. 64, 1907.

Flabellum japonicum Moseley.

(Plate XIV, figs 1—6.)

Flabellum japonicum, Moseley, *Deep-Sea Madreporaria* ('Challenger'), p. 168, pl. vii, fig. 3, a, 1881; Wood-Mason & Alcock, *Ann. Mag. Nat. Hist.* (6) VIII, p. 449, 1891; Alcock, "Investigator" *Deep-Sea Madreporaria*, p. 23, 1898, and 'Siboga' *Exped.*, p. 32, 1902.

Flabellum angulare, Moseley, *Deep-Sea Madreporaria* ('Challenger'), p. 164, pl. vi, fig. 2, a, b; *F. apertum*, Moseley, *l. c.*, p. 167, pl. vi, fig. 7, a, c.; *F. conuis*, Moseley, *l. c.*, p. 165, pl. vii, fig. 6, a, b, 1881.

The 8 'Challenger' specimens of Moseley's *F. apertum* were all dead when obtained and partially decomposed, perhaps with extra lime deposits from the surrounding water on the corallium, giving a peculiar opaque appearance. The 'Challenger' figure on p. 168 is $1\frac{1}{2}$ times natural size, and is the largest specimen of station 145. All the drawings are accurate in respect to numbers of septa but bad. The specimens from station 3 are negligible being too much decomposed for identification. They are clearly referable to *japonicum*, the very delicate septa of cycle V having usually been destroyed in most systems.

There is no doubt that the younger specimens under consideration are indistinguishable from the single form described by Moseley as *F. angulare* as direct comparison showed them to be similar in all respects but hexamerous instead of pentamerous.

The single 'Challenger' specimen of Moseley's *conuis* is alike in all respects to similarly fast-grown specimens of *japonicum* of about the same size such as (d) mentioned below. The latter is rather more open, viz., less conical, than the type and it has the same 4 cycles of septa. There are indications of wrinkling in the septal sides of this and many forms but in no case so marked as in Moseley's specimens; this character becomes progressively less marked with the thickening of septa which takes place as the growth attains its maximum.

The present specimens might be described under any of the above names, but they are still more clearly referable to *japonicum* of which there are a series of forms with a correct figure and a good description. I should not term the types wedge-shaped and the description of an "opaque white epitheca etc.," is incorrect, the appearance described being due to the decay of the epitheca, which stands up as a "glistening and polished" wall above. Only 4 of the supposed 8 'Challenger' specimens could be found (1929). I note a few points of difference from the suite of specimens before me:—

- (a) The transverse section of the corallium of any level varies from round to oval and nowhere can be termed "wedge-shaped."
- (b) The septal ridges, so-called 'costae' of Moseley, are not well-marked in the "Challenger" specimens that I have seen, though they are clearly shown in the figured specimen; the present specimens generally, if undamaged externally, have 12 marked ridges essentially similar to those shown in the figure.
- (c) Most of the present specimens are not much corroded, but two have lost nearly all their ribs, for the corrosion particularly takes place outside, on the lines where the septa run into

the epitheca, in some cases the septal ridges being even replaced by grooves.

- (d) The centre of the corallum is filled in to a very varying degree in different specimens by false columellar corallum, varying from fused thickenings of septal sides and ends to masses of anastomosing trabeculae of varying coarseness. The adjective "fascicular" used by Moseley can scarcely be applied even to the 'Challenger' specimens.
- (e) The present specimens in spirit showed tentacles over all the septa, but in only one specimen can all the tentacles over each cycle of septa be recognised. Usually the tentacles over the septa of cycle V are most clearly seen, being most external and the last to contract, and then progressively those over cycles IV, III, II and I. Each tentacle ends in a white knob.

In all other respects the present specimens agree with Moseley's type, and of the above points (a—d) are of little specific importance, being easily explicable. The difference noted under (e) may be due to different methods of preservation being employed but Moseley's fig. 12 on pl. xvi is a bad diagram.

The type of *F. conuis* Moseley has likewise 4 cycles of septa.

Localities.—(a) ZEV $\frac{5335}{7}$, Sta. 242, 17° 27' N., 71° 41' E., 56-58 fms., one specimen, measuring length \times breadth of calice, 60 \times 46 mm., \times vertical height of corallum, \times 53 mm., outside considerably corroded and no marked septal ridges, no columellar tissue; (b) ZEV $\frac{2162}{7}$, Sta. 321, 5° 4' 8.5" N., 80° 22' E., 660 fms., one, 51 \times 37 \times 29 mm., rather a wide open form, little corroded, septal ridges well marked, thick anastomosing trabeculae from septal edges forming a conspicuous false columella; (c) ZEV $\frac{1238-45}{7}$, Sta. 275, 8° 27' N., 75° 35' E., 771-731 fms., 6 specimens measuring 52 \times 42 \times 32 mm., 43 \times 33 \times 30 mm., 31 \times 28 \times 15 mm.; 24 \times 23 \times 13 mm., 29 \times 26 \times 17 mm., and 26 \times 23 \times 15 mm., all with septal ridges, smaller specimens four cycles of septa and shape approaching *F. apertum* Moseley in side view—last two specimens dead when obtained, corallum opaque and appearing thickened, giving a still closer resemblance to the same species—columella various, first specimen merely thickened edges of septa fused; (d) ZEV $\frac{772}{7}$, Sta. 256, 7° 58' N., 79° 23' E., 937 fms., one, 35 \times 31 \times 22 mm., general resemblance to *F. conuis* Moseley in all respects except that it is lower and therefore appears more open; (e) ZEV $\frac{1248-9}{7}$, Sta. 273, 12° 47' N., 73° 44' 45" E., 870-823 fms., two, 47 \times 40 \times 35 and 17 \times 13 \times 14 mm., larger specimen much corroded as (a) above and no septal ridges, smaller specimen showing a tentacle over each septum; (f) ZEV $\frac{1751-5}{7}$, Sta. 306, 9° 20' N., 75° 24' E., 930 fms., five, measuring 37 \times 30 \times 25 mm., 25 \times 21 \times 16 mm., 17 \times 12 \times 10 mm., 18 \times 17 \times 9 mm., and 18 \times 15 \times 7 mm., last two specimens showing septal cycles I and II markedly distinct; (g) ZEV $\frac{1757-60}{7}$, Sta. 307, 7° 28' 30" N., 76° 26' 30" E., 888 fms., four, 41 \times 35 \times 27 mm., 36 \times 31 \times 22 mm., 33 \times 27 \times 25 mm., and 22 \times 23 \times 22 mm.,

The depth range of the species is from 56 to 1250 fms., the latter *F. angulare* Moseley, 'Challenger' specimen. This latter is the only certain record from the Atlantic, having been obtained off Nova Scotia. The species appears to be common in Indian Seas and probably ranges widely in the Indian and W. Pacific Oceans.

Note on a polyp:—The smallest specimen from (g) above was cut into sections. It had 12 large septa (cycles I and II), trabeculae from which shared in the formation of the columella, and 12 further conspicuously thick and broad septa (cycle III); there were only traces in low ridges of septa cycle IV. The two pairs of directive mesenteries are well marked and the first 24 septa are all entocoelic; as yet there is no formation of any further mesenteries, but these may form subsequently as the sections reveal the fact that the 12 septa of the second size are visible in the sections below their bounding mesenteries. I think all these mesenteries reach the stomodaeum. There are tentacles over all the septa, but those over the first 12 septa are so tightly pulled down as to be only recognisable by their batteries of nematocysts. The tentacles over the next 12 septa are partially invaginated and there are indications in nematocyst batteries of a further cycle of tentacles. The stomodaeum is so pulled out that it is difficult to see where the peristome merges into the stomodaeum and the latter into the filaments, all three parts having the same histological elements. The mesenterial filaments have fewer nematocysts than usual and their lower ends are not free or extrusible as acontia. There is indication of a good miscellaneous diet, as seen by sponge and other spicules and chitin remains. Ova occur very low down in a few of the primary mesenteries, and there are a few free eggs and planulae in the coelenteron.

Allied to this species is Moseley's 'Challenger' *F. patagonicum* which has not since been recorded. Few of the type-specimens are larger than the smallest of the present series of *japonicum*; their growth is more cup-like. The edges all show some scalloping between the tops of the septa. Four cycles of septa is a definite character and at present must be so regarded and not a size matter. More important is the tooth-ing of the septal edges especially where they fall to the columella. The ridges and granules on the septal sides are much more marked than in *F. japonicum*. At present the species must be regarded as good, but may conceivably prove to be a growth-form of *F. japonicum*.

Flabellum rubrum Q. et G.

F. rubrum, Gardiner, *Marine Investigations S. Africa*, II, pp. 125-52, pls. i-iv, 1902; Harrison & Poole, *Proc. Zool. Soc.*, 1909, p. 899.

For *F. stokesi*, Ed. et H., *vide* Gardiner, *l. c.*, p. 131; also Alcock, *Journ. As. Soc. Bengal*, LXII, p. 138, 1893.

F. crassum et rubrum, Bourne, *Report Pearl Oyster Fisheries, Ceylon*, pp. 196-200, 1905.

I don't think there is any use in my dealing with Bourne's attack on, and misrepresentation of, the methods adopted in my paper cited above; Bourne dealt with 5 specimens only, while I had actually examined over 700 specimens which he could have examined. I hesitated to regard *stokesi* as a synonym of *rubrum*, and the collection before me

is not sufficiently large to cause me to alter my position, although I could not find any differences in the polyps of the two "species."

In 1898, in 1901 and again in the present year I examined the British Museum collection which contains 41 items, 120 specimens, of the growth-form of *rubrum*—*stokesi*. Bruggemann identified these with the species *stokesi* E. & H., *rubrum* Q. & G., *elongatum* E. & H., *spheniscus* Dana, *aculeatum* E. & H., *debile* E. & H., *crassum* E. & H., *bairdi* E. & H., *profundum* E. & H., *crenulatum* E. & H., *candeanum* E. & H., *spinosum* E. & H., *elegans* E. & H., while he evidently intended to describe six new species to which he gave the names *amethystinum* (whole corallum of a beautiful strong amethyst colour), *lewisi*, *ayleni*, *belcheri*, *laeviusculum* and *angustum*. Among the specimens are forms from New Zealand whence came the original types of Quoy and Gaimard. Seven of the above "species" were represented in Capt. Sir Edward Belcher's collection from Malacca. Apparently Bruggemann considered *affine* E. & H. = *spheniscus* Dana as he labelled some of the latter "types of *F. affine*," "types" being used as meaning typical. I do not agree with Bruggemann's views as indicated above, but I have pleasure in recording them as they are always worthy of careful consideration.¹

Of the British Museum specimens 26 coralla in form approach *stokesi*, 66 *rubrum* and 15 are doubtful; 13 young or attached forms are omitted. The present collection contains 20 specimens from 7 localities. Of these most approach *stokesi* in mode of growth, wings or processes from side of corallum, size of scar, etc. Superficially, they can be roughly divided between *rubrum* and *stokesi*, but the more carefully they are examined the more difficult the division becomes. I have searched for and cannot find differences in the characters Bourne suggests (*loc. cit.*, p. 200) and I have to confess my inability to differentiate between the two forms.

Localities.

Mark.	Station.	Position.	Depth.	No.	
774-7 ZEV— 7	246	Lat. N. 11° 14' 30". Long. E. 74° 57' 15".	68—148 fms.	4	<i>rubrum</i> .
3268 — 9	not given	Lat. N. 6° 1'. Long. E. 81° 16'.	34 fms.	9	"
5327-8 ZEV— 7	387	Lat. N. 15° 25'. Long. E. 93° 45'.	40—49 fms.	2	v. <i>stokesi</i> .
1636 ZEV— 7	291	Lat. N. 26° 22'. Long. E. 56° 10'.	49—48 fms.	2	"
8793 — 6	not given	Andamans.	not given		
5344 ZEV— 7	not given	2mi., N. Gt. W. Tares.	40 fms.	1	"
5895 ZEV— 7	not given	Snod I., Andamans.	not given	1	"

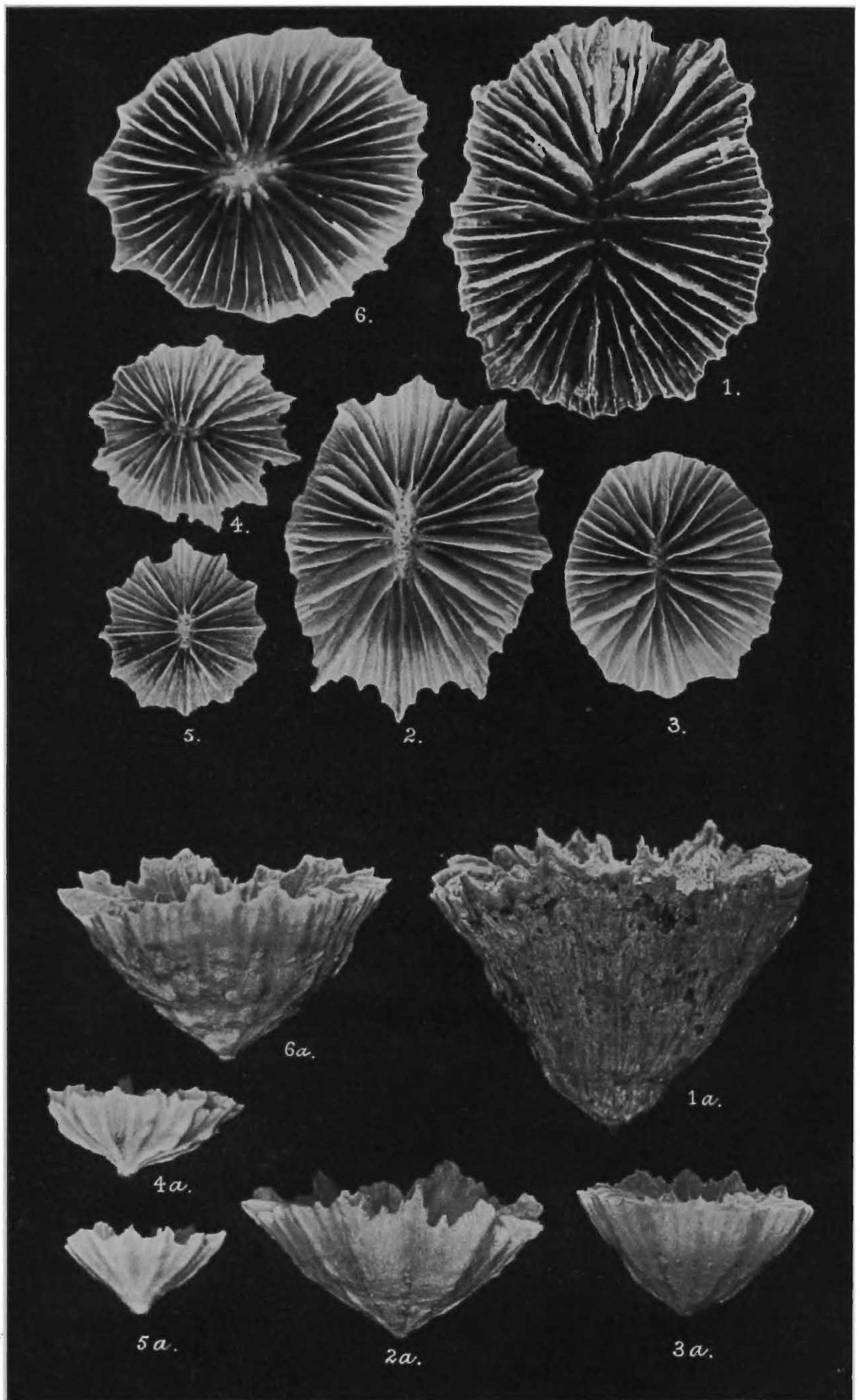
¹ I am indebted to the late Professor Jeffrey Bell, who in 1901 kindly worked out for me the authorship of the names and labels of these specimens in the British Museum.

The species is evidently of wide distribution throughout the Indian and W Pacific Oceans. No certain specimen has as yet been recorded from the Atlantic. Its depth range is 0—100 fms. I obtained specimens from the Maldives, but none from the island groups between this archipelago and Madagascar; I can find no record from any locality distant from continental areas.

EXPLANATION OF PLATE XIII.

Flabellum japonicum Moseley. Nat. size.

- FIG. 1.—Surface view, from Sta. 242, 56-58 fms.
FIG. 1*a*.—Side view of same specimen.
FIG. 2.—Surface view, from Sta. 231, 660 fms.
FIG. 2*a*.—Side view of same specimen.
FIG. 3.—Surface view, from Sta. 275, 771-731 fms.
FIG. 3*a*.—Side view of same specimen.
FIG. 4.—Surface view, from Sta. 275, 771-731 fms.
FIG. 4*a*.—Side view of same specimen.
FIG. 5.—Surface view, from Sta. 275, 771-731 fms.
FIG. 5*a*.—Side view of same specimen.
FIG. 6.—Surface view, from Sta. 256, 937 fms.
FIG. 6*a*.—Side view of same specimen.



Flabellum japonicum Moseley.

NOTES ON FISHES IN THE INDIAN MUSEUM.

XVII.—LOACHES OF THE GENUS *NEMACHILUS* FROM BURMA.¹

By SUNDER LAL HORA, *D.Sc. (Punjab), D.Sc. (Edin.), F.R.S.E., F.L.S., F.Z.S., Zoological Survey of India, Calcutta.*

(Plates XIV, XV.)

The fishes of the genus *Nemachilus* are widely distributed in the hill streams of India and Burma and only a few of them are adapted to life in slow-running or stationary waters at high altitudes. Usually they are of a small size and are characterized by the possession of an almost cylindrical or a somewhat depressed body. They live among pebbles and shingles at the bottom of a stream and are very active in their habits. At the slightest provocation they dart from one place to another and always rest with their heads pointing upstream,² and are thus able to offer a minimum resistance to the force of the rushing current. The colouration of these loaches is very characteristic so far as the Indian species are concerned. With the exception of a few species they are marked with a variable number of vertical bars. These stripes have a great biological significance as they make the fishes living among pebbles in shallow, clear, rapid-running water inconspicuous. It has very often happened that the net revealed the presence of these fishes where I could not see them in the clear water even when a few inches deep.

Nemachili are Cobitidae without a pre- or sub-orbital spine and with a relatively short dorsal fin in which the number of branched rays does not exceed 20. Among the Indian freshwater fishes there are few genera whose taxonomy is involved in such great confusion as that of *Nemachilus*. This is in part due to the fact that many of the species exhibit considerable individual variability. Moreover, most of the

¹ For a number of years I have been collecting material for a revision of the fishes of the genus *Nemachilus* found in India. My colleagues in the Zoological Survey of India and I have made extensive collections of these loaches and a considerable amount of material has been got together from almost all parts of India. During my recent visit to Europe I compared this material with the types and the old specimens in the collection of the British Museum. Specimens of the Indian species were also examined in the Museum National d'Histoire Naturelle, Paris; in the Zoologisches Museum der Universität, Berlin and in the Museo Civico di Storia Naturale, Genova. The collection at my disposal is so large and the taxonomy of these loaches is so confusing that I have thought it best to treat them in small batches according to their distribution. The present paper is the first of the series that I propose to publish in this journal from time to time.

² Fishes of the genus *Nemachilus*, on account of their active habits, are very difficult to catch. The best way to collect them in large numbers was to divert the course of a small channel by a dam. In the portion of the bed thus made dry these fishes can be obtained by turning over stones. Where this was not possible a bag-net was dragged at a great speed among the pebbles in the shallow portion of a stream. In this way all those forms that rest underneath stones could be netted. The presence of pebbles in the net provides the fish with hiding places and at the same time obstructs them from getting away. I have often collected large numbers of specimens in this way.

specific standards, such as number of fin-rays, scale counts, body proportions, colouration, etc., which are used in distinguishing species of most of the other Cyprinoid genera, are of very little significance in the case of *Nemachilus*. Fortunately most of the Burmese species are very peculiar and, therefore, little difficulty has been experienced in characterizing them. In distinguishing closely allied species I have relied on the character of the lateral line, the position of the anal opening with regard to the ventrals and the position of the commencement of the dorsal with regard to its distance from the tip of the snout and the base of the caudal. It is a well-known fact in biology that similar environmental conditions tend to produce similar characters, and it is probable that the great resemblance between the various species of *Nemachilus* is due to a similarity in their environment, for wherever any species has taken to a life in slow running waters, it has become peculiarly modified. The usual environment—rapid-running water—of these loaches is full of storm and stress and the animals that inhabit it have to adjust themselves constantly to any fluctuations in the external conditions of their existence. In these circumstances the organisms are being modelled and remodelled till ultimately the elucidation of their true systematic position becomes a matter of considerable difficulty. This is not only true of the fishes of the genus *Nemachilus* but is also the case with all other hill-stream genera of fishes that I have studied so far.

Attempts have been made to subdivide the vast assemblage of species grouped under the generic name *Nemachilus*, but, so far as I am aware, none has proved satisfactory. In 1903, Jordan and Fowler¹ established the genus *Elixis* to accommodate those species of *Nemachilus* which possess a nasal barbel. This genus has been accepted by Weber and Beaufort² but, in 1920, Annandale and I³ doubted the generic value of this character though at that time we did not assign any reasons for our views. A perusal of the descriptions of the Burmese species is enough to show that the nasal barbel is very variable and that no specific value can be attached to it, except in such species as *N. evezardi*, where it is extremely well developed. In the material that I have examined there are a number of species showing all possible gradations between the total absence and the presence of a distinct nasal barbel. Among the Burmese species *N. cincticauda* possesses a short but well-marked nasal barbel; in *N. acuticephalus* the membrane between the nostrils is well developed and is produced into a short process in the middle; in *N. raoe* the anterior nostril is somewhat tubular and the tube is produced into a flap-like projection and in *N. brevis* the anterior nostril is produced into a long, tube-like structure.

Attention may here be directed to a species—*N. guttatus*—described by McClelland⁴ from Jorhat in Assam and characterized by the possession of only four barbels. I have not examined any specimen of this

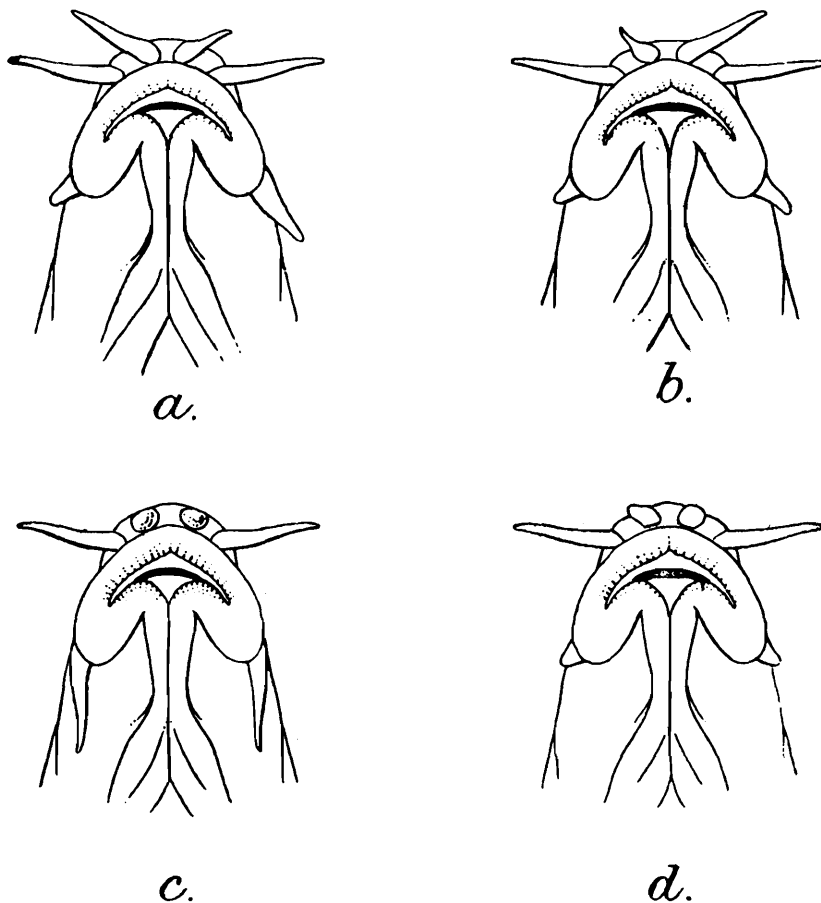
¹ Jordan & Fowler, *Proc. U. S. Nat. Mus.* XXVI, p. 768 (1903).

² Weber & Beaufort, *Fish. Indo-Austral. Archipel.* III, p. 35 (1916).

³ Annandale & Hora, *Rec. Ind. Mus.* XVIII, p. 185 (foot-note), (1920).

⁴ McClelland, *Ind. Cyprinidae in As. Res.* XIX, pp. 305, 438, pl. lii, figs. 5 & 6 (1839).

species, but it seems likely that McClelland was dealing with an abnormal specimen in which one of the pairs of barbels was greatly reduced



TEXT-FIG. 1.—Ventral surface of head of 4 specimens (a-d) of *Nemachilus kessleri* Günther showing defective barbels.

or totally lost. In a large series of examples of *N. kessleri* I have found a number of specimens in which the barbels are defective and one specimen, in which both the anterior rostrals are rudimentary (text-fig. 1, c.), appears to possess only 4 barbels. I have briefly referred to this example here to show that little importance should be attached to the number of barbels in separating the different species of *Nemachilus*.

Nichols,¹ as a result of his examination of the Chinese collection in the American Museum of Natural History, has recently proposed four groups in the genus *Nemachilus*. In the absence of any Chinese material for examination in Calcutta I do not feel myself justified in offering any remarks on Nichols' classification. It may, however, be remarked that the characters he has employed in distinguishing his groups show considerable variation in the material before me and consequently I have not been able to adopt his classification. When the systematic treatment of Indian species is completed it may be possible to review the generic classification of *Nemachilus* and related loaches.

¹ Nichols, *American Mus. Novitates*, No. 171, pp. 1-7 (1925).

Many lacunae remain to be filled up in our knowledge of the fresh-water fish-fauna of Burma. From the results of the areas investigated by the Zoological Survey of India, *viz.*, the Inlé Lake ¹ and the Indawgyi Lake,² it is evident that there is a considerable endemic element in the fauna, especially among the smaller forms. This conclusion applies with greater force to the inhabitants of the torrential streams. Of the 13 species of *Nemachilus* discussed here, 6 are described as new and of the remaining, 4 are endemic in Burma. Of the 3 species known from outside the political limits of Burma, 2—*N. zonalternans* and *N. sikhmaiensis*—have only been recorded from the Manipur valley, the waters from which ultimately flow into the Chindwin, a tributary of the Irrawaddy River. The only remaining species—*N. botia*—is widely distributed in Indian waters, but its precise specific limits have not been properly defined and in referring certain specimens from Burma to *N. botia* I have included this species in its broadly accepted sense.

Besides the species enumerated in this paper there are some doubtful forms described or recorded from Burma. In 1869, Day ³ described *N. blythii* from two specimens in the collection of the Indian Museum and remarked in his later works ⁴ that its locality was doubtful. These specimens are still preserved in the collection of the Zoological Survey of India but are badly damaged and are not fit for any detailed work. They are, however, entered in the register as having been obtained in Burma. Without any fresh material I am not able to characterize *N. blythii* properly and consequently to include it in the synoptic table of the Burmese species.

In 1890, Vinciguerra ⁵ recorded 4 species of *Nemachilus* from Burma, namely *N. rubidipinnis*, *N. rupicola*, *N. multifasciatus* and *N. savona*. I have examined the specimens on which Vinciguerra's determinations were based. There is no doubt about the first species but the other three appear to me to have been wrongly identified. Vinciguerra's *N. savona* is the same as Blyth's *N. cincticauda* and his *N. multifasciatus* appears to represent a new species. I have not yet determined exactly the specific characters of Day's *N. multifasciatus* ⁶ and have, therefore, left out of consideration Vinciguerra's specimens referred to this species. The examples referred to *N. rupicola* by Vinciguerra are very much like those of my new species *N. rivulicola* but differ in certain points. In the absence of well-preserved fresh material I am unable to assign any exact specific position to them.

The following is an artificial key to the Burmese species of the genus *Nemachilus*. *N. peguensis* is so remarkable in the character of its funnel-shaped mouth that it could be made the type of a distinct genus, but as it is represented by a single, partly damaged specimen I have refrained from adopting this course. In its general facies and build *N. shanensis* is also very striking. *N. brevis*, *N. brunneanus*, and *N. raoe* live in stationary waters and are consequently peculiarly modified.

¹ Annandale, *Rec. Ind. Mus.*, XIV, pp. 32-64, pls. i-vii (1918).

² Prasad & Mukerji, *Rec. Ind. Mus.* XXXI, pp. 161-223, pls. vii-x (1929).

³ Day, *Proc. Zool. Soc. London*, p. 552 (1869).

⁴ Day, *Fish. India*, p. 621 (1878); *Faun. Brit. Ind. Fish.*, I, p. 236 (1889).

⁵ Vinciguerra, *Ann. Mus. Civ. Stor. Nat. Genova*, (2) IX, pp. 208-211 (1890).

⁶ Day, *Fish. India*, p. 617, pl. cliii, fig. 7 (1878).

The form *ct N. acuticephalus* suggests as if the fish has adapted itself to a burrowing habit. In many respects the *Nemachili* of Burma are a very striking and diversely modified lot.

Key to the Burmese species of *Nemachilus*.

- I. A black ocellus near superior margin of base of caudal *present*. (Body finely scaled).
 - A. More than 12 branched rays in dorsal (lateral line complete) *N. rubidipinnis* (Blyth).
 - B. Less than 12 branched rays in dorsal.
 1. Distance between anal opening and ventral more than diameter of eye (lateral line almost complete) .. *N. botia* (Ham. Buch.).
 2. Anal opening close to ventral (lateral line ending below dorsal) .. *N. zonalternans* (Blyth).
- II The black ocellus near superior margin of base of caudal *absent*.
 - A. Anterior nostril in a long, flap-like tube; eye large and visible from ventral surface .. *N. brevis* Boulenger.
 - B. Anterior nostril normal or slightly tubular; eye not visible from ventral surface.
 1. Lateral line complete or at least extending beyond ventral.
 - a. Lips produced into a funnel-like structure (lateral line complete) .. *N. peguensis*, sp. nov.
 - b. Lips normal, not produced into a funnel-like structure.
 - i. Length of base of dorsal almost equals length of head (lateral line complete) .. *N. shanensis*, sp. nov.
 - ii. Length of base of dorsal considerably shorter than head (lateral line extending to middle of anal fin).
 - α. Depth of body 6 or more than 6 times in length without caudal .. *N. sikmaiensis* Hora.
 - β. Depth of body 5 or little over 5 times in length without caudal .. *N. rivulicola*, sp. nov.
 2. Lateral line incomplete, not extending beyond ventral.
 - a. Commencement of dorsal nearer base of caudal than tip of snout. Pectoral shorter than head.
 - i. Ventral extending considerably beyond anal opening (lateral line terminating above pectoral) .. *N. cincticauda* (Blyth).
 - ii. Ventral just reaching or not extending as far back as anal opening.
 - α. Width of head almost equals height of head at occiput (a prominent black blotch in middle of base of caudal) .. *N. acuticephalus*, sp. nov.
 - β. Width of head considerably greater than height of head at occiput (a vertical black bar at base of caudal) .. *N. paucifasciatus*, sp. nov.

- b. Commencement of dorsal nearer tip of snout than base of caudal or equidistant between the two. Pectoral longer than head.
- α. Body covered with rudimentary scales, snout more than 1.5 times diameter of eye *N. raoe*, sp. nov.
- β. Body covered with well-marked, imbricate scales, snout equal to or only slightly longer than diameter of eye *N. brunneanus* Annandale.

Nemachilus rubidipinnis (Blyth).

1860. *Cobitis rubidipinnis*, Blyth, *Journ. As. Soc. Bengal*, XXIX, p. 169.
 1860. *Cobitis semizonata*, Blyth, *ibid.*, p. 170.
 1868. *Nemachilus rubidipinnis*, Günther, *Cat. Brit. Mus. Fish.*, VII, p. 348.
 1868. *Nemachilus semizonata*, Günther, *ibid.*, p. 348.
 1878. *Nemacheilus rubidipinnis*, Day, *Fish. India*, p. 614, pl. cliii, fig. 4.
 1889. *Nemachilus rubidipinnis*, Day, *Faun. Brit. Ind. Fish.*, I, p. 226.
 1890. *Nemachilus rubidipinnis*, Vinciguerra, *Ann. Mus. Civ. Stor. Nat. Genova*, (2) IX, p. 208.

Blyth described two species of *Nemachilus* from Tenasserim with a long dorsal fin, viz. *N. rubidipinnis* and *N. semizonata*. Both these species were included by Günther in his *Catalogue* without any comment and were characterized after Blyth. It appears likely that Günther was greatly influenced in recognising these two as separate species by the number of rays in the dorsal fin which is stated by Blyth to be 16 in *N. semizonata* and 15 in *N. rubidipinnis*. Day obtained a specimen from Dr. Anderson of the Indian Museum, Calcutta, and described and figured it as *N. rubidipinnis* of Blyth. This very specimen appears to have been later on purchased from Day by the Indian Museum and is now preserved in our collection. It is entered in the register, No. 2680, as the type of *N. rubidipinnis* from Tenasserim. Day's figure of the specimen is of natural size and from its measurements and colouration it seems to me to be the type of *N. semizonata* and not of *N. rubidipinnis* even if the two species be considered synonymous now. The type of *N. rubidipinnis* was $3\frac{3}{4}$ inches in length, while the specimen under consideration is much smaller.

According to Blyth the main difference between the two species lies in that the body is "proportionately less deep" in *N. semizonata* than in *N. rubidipinnis*. Another peculiar character of *N. rubidipinnis* according to Blyth "consists in a short broad obtuse spine-like process projecting from the middle of the upper lip" This spine-like process of the premaxillaries is found in several species of *Nemachilus* and is usually well developed in those that possess a long dorsal fin such as *N. pavonaceous* and *N. botia*. This structure is also found in the type-specimen of *N. semizonata* referred to above. In the description of *N. semizonata*, Blyth refers to "a minute spinelet above the muzzle (as in *C. monocera*, McClelland)" I have carefully examined the type-specimen for this structure and find that it consists of a sharp, dorsally directed process of the premaxillaries, corresponding in position to the spine-like process projecting from the upper jaw, and it seems likely

that the two structures are produced in correlation to each other since this spinelet on the muzzle is present in a more or less well-developed form in all the species of *Nemachilus* with a long dorsal fin.

As regards differences in the colouration of the two species it seems probable that on account of age or as an abnormality the ground-colour of *N. rubidipinnis* was "olive-brown with a ruddy wash" in the type-specimen, whereas in the smaller specimen described as *N. semizonata* the body had "a series of twelve to fourteen dark transverse dorsal bands"; etc. I have noticed such differences in colouration among specimens of other species. The colour markings on the dorsal and the caudal fins is the same in the two species except that there is a slight variation in the number of rows. The black ocellus at the base of the caudal fin described by Blyth for his *N. semizonata* is a common character of a number of species of *Nemachilus* and especially of those that possess a long dorsal fin.

From the above it is clear that Blyth's two species from Tenasserim, viz. *N. rubidipinnis* and *N. semizonata*, are synonymous and that the differences noted between them are not of any specific value. The number of rays in the dorsal fin is, as is shown below, a variable character.

Vinciguerra, in 1890, recorded *N. rubidipinnis* from Mandalay (Upper Burma), Kokarit and Meetan (Lower Burma) and thus considerably extended the range of the species. Through the kindness of Dr. D. Vinciguerra I have with me three specimens from Fea's collection and with all this material in hand it seems worth while to redescribe this species here.

D. 3/13-17 ; P. 1/11-13 ; V 1/7 ; A. 3/5.

Nemachilus rubidipinnis is a long and slender species. The length of the head is contained 4.4 to 4.8 times and the depth of the body 5.1 to 6.1 times in the total length without the caudal. The eye is situated almost in the middle of the length of the head or somewhat in the posterior half of the head ; its diameter is contained 4 to 5 times in the length of the head, 1.5 to 2.1 times in the length of the snout and is greater than the interorbital width. The nostrils are close together and are situated nearer the eye than the tip of the snout ; the anterior nostril is tubular to a certain extent and the internarial membrane is prominent. The mouth is situated on the ventral surface behind the tip of the snout and is bordered by thick lips, the lower lip is interrupted in the middle and is raised into two button-like projections. The barbels are long and thread-like ; the inner rostral almost reaches the eye, while the outer rostral and the maxillary both extend beyond the eye. The upper jaw is produced into a beak-like process in the middle which, when the animal bites, comes in front of the lower jaw. There is a minute spinelet above the muzzle.

The body is entirely covered with distinct, imbricate scales and the lateral line is complete.

The dorsal fin originates considerably in advance of the ventral and its commencement is much nearer the snout than the base of the caudal. The base of the dorsal fin is much longer than the head. The pectoral

fin is long and pointed ; it is almost as long as or slightly shorter than the head ; it is separated from the ventral by a distance equal to a third of its length. The ventral fin is also long and pointed but is much shorter than the pectoral. It is separated from the anal opening by a considerable distance. The anal fin is small and does not extend to the base of the caudal. The caudal fin is almost as long as or slightly longer than the head ; its posterior margin is more or less entire. The caudal peduncle is fairly stout ; it is as long as or slightly longer than its depth.

The colouration according to Day is "reddish brown, with 12 to 16 irregular darkish bands descending from the back and ending in dark spots below the lateral line : 4 to 6 oblique bands on the dorsal fin : 6 to 8 irregularly vertical bars on the caudal, which has a black ocellus on the upper half of its base "

Locality.—Burma (Tenasserim, Meetan, Kokrait and Mandalay).

Measurements in millimetres.

	Tenasserim. ¹	Mandalay.		Meetan.
Total length without caudal	64.0	73.0	56.5	57.2
Length of head	14.3	15.0	12.3	12.4
Depth of body	12.5	13.4	10.0	9.3
Diameter of eye	3.2	3.0	3.0	3.2
Length of snout	5.6	6.3	5.0	4.7
Interorbital distance	3.0	2.6	2.3	2.3
Length of caudal peduncle	10.0	11.2	7.5	7.7
Least height of caudal peduncle	8.0	9.0	7.3	7.3
Length of pectoral	13.0	15.0	11.3	11.2
Length of ventral	10.1	12.3	10.5	9.5

Nemachilus botia (Ham. Buch.).

A very wide range of distribution has been assigned to *N. botia* and so far as I am aware the precise specific limits of this species have not been ascertained. In the "Gangetic Fishes" Buchanan mentions that the "Botia is found in the rivers of the north-eastern parts of Bengal" ² and his original notes concerning the "Gangetic Fishes" show that the types of his description were obtained from the Brahmaputra River at Goalpara. However, at the present moment I am not in a position to elucidate the precise diagnostic characters of the species and, therefore, recognize it here in its usually accepted sense.

Nemachilus botia has twice been recorded from Burma. Boulenger ³ recorded it from NampanDET in the Southern Shan States and according to Annandale ⁴ this species is common in small streams in the hills round about the Inlé Lake. Chaudhuri ⁵ recorded *N. botia* from Tanja on the North-Eastern frontier of Burma. In the collection there is a fine specimen from Shatu Jup, Myitkyina and Hukong Valley frontier,

¹ Type-specimen of *Nemachilus semizonata* (Blyth) figured by Day in *Fishes of India*.

² Hamilton-Buchanan, *An Account of the Fishes found in the River Ganges and its branches*, p. 350 (Edinburgh : 1822).

³ Boulenger, *Ann. Mag. Nat. Hist.* (6) XII, p. 203 (1893).

⁴ Annandale, *Rec. Ind. Mus.* XIV, p. 35 (1918).

⁵ Chaudhuri, *Rec. Ind. Mus.* XVI, p. 279 (1919).

collected by Dr. Murray Stuart. A number of young examples, probably referable to this species, were obtained by Dr. B. N. Chopra from the north end of the Indawgyi Lake and in small rocky streams round about Kamaing, Myitkyina District.

***Nemachilus zonalternans* (Blyth).**

1860. *Cobitis zonalternans*, Blyth, *Journ. As. Soc. Bengal*, XXIX, p. 172.
 1869. *Nemacheilus zonalternans*, Day, *Proc. Zool. Soc. London*, p. 551.
 1878. *Nemacheilus zonalternans*, Day, *Fish. India*, p. 618.
 1889. *Nemachilus zonalternans*, Day, *Faun. Brit. Ind. Fish.*, I, p. 232.
 1921. *Nemachilus zonalternans*, Hora, *Rec. Ind. Mus.* XXII, p. 199, pl. x, figs. 3, 3a.

This small loach was characterized by Blyth from two specimens obtained by Major Berdmore in the Tenasserim Provinces, but his diagnosis was considered insufficient by Günther and the species was, therefore, not included in his *Catalogue*. Later on Day examined the type-specimens and gave some further particulars about the diagnostic features of the species. In 1920, I collected a large number of specimens of this species in the Manipur Valley, Assam, and in the following year described it in detail from this fresh material. A few observations were also made on the type-specimens, which, unfortunately, are now missing from the collection.

From its general facies *N. zonalternans* appears to be an inhabitant of sluggish waters and in the Manipur Valley the specimens were obtained from muddy streams or from relatively deeper streams at the base of the hills. The species can be readily distinguished by its small size and characteristic *N. botia*-like colouration. The distribution of this species, as known at present, is discontinuous but this is mainly due to the fact that the fauna of the intermediate region has not been properly investigated so far.

***Nemachilus brevis* Boulenger.**

(Plate XV, fig. 10.)

1893. *Nemachilus brevis*, Boulenger, *Ann. Mag. Nat. Hist.* (6) XII, p. 203.
 1918. *Nemachilus brevis*, Annandale, *Rec. Ind. Mus.* XIV, p. 43, pl. ii, figs. 1, 1a.

Nemachilus brevis was described from 3 specimens collected from the Inlé Lake at Fort Stedman. Later, Annandale obtained a large number of specimens of this species from several localities in the Inlé basin and on the He-Ho plain. In 1922, I collected some further material from the Inlé Lake and from a stream flowing out of the "White-Crow Tank" at the base of the Tongyi Hill. The species has so far been found only in still and slow-running waters and is very well adapted for this type of habitat. Its large and bulging eyes, long barbels, deep body with rounded ventral surface and its tubular anterior nostrils are all characteristic modifications in response to its peculiar habitat.

It was pointed out by Annandale that "the male differs from the female in colouration and also in the shape of the body; as a rule, instead of being merely spotted or mottled, it has on the sides a number of short black vertical bars, which sometimes fuse together to form an

irregular longitudinal bar. The bars are variable both in number and in size. The male has, further, a small cartilagenous pad immediately in front of the lowest quarter of the eye" Besides these points I find that the males are, as a rule, smaller in size and possess relatively longer fins. The black, longitudinal band along the lateral line is a striking feature of the male.

In *N. brevis* the mouth is bordered by thick lips which are continuous at the angles. The lower lip is interrupted in the middle line and its two halves are thrown into a number of folds. The upper lip is also somewhat pleated.

Measurements in millimetres.

	♀	♀	♂	♂
Total length including caudal	57.5	56.2	47.0	41.3
Length of caudal	9.0	9.2	8.0	7.7
Length of head	12.8	12.5	10.3	9.4
Depth of body	12.4	12.0	9.5	7.8
Length of snout	4.6	4.2	3.0	3.0
Diameter of eye	3.0	3.5	3.0	2.6
Interorbital distance	3.7	3.3	2.7	2.3
Length of caudal peduncle	6.5	6.0	5.5	5.3
Least height of caudal peduncle	5.3	5.0	4.2	3.4
Longest ray of dorsal	8.4	8.3	7.0	7.0
Length of pectoral	9.0	8.8	9.3	8.8
Length of ventral	7.3	7.4	7.0	6.3
Longest ray of anal	7.2	7.4	6.7	6.0

***Nemachilus peguensis*, sp. nov.**

(Plate XIV, figs. 1, 2.)

D. 3/9; P. 1/11; V 1/8; A. 9?

Nemachilus peguensis is a small and slender species in which both the dorsal and the ventral profiles are somewhat arched. The ventral surface is flattened in front of the ventrals and the tail is compressed from side to side.

The head is pointed and its length is contained 4 times in the total length without the caudal; its greatest width is equal to its length excluding the snout; its height at the occiput is equal to half of its length. The depth of the body is contained 6 times in the total length without the caudal. The eye is situated somewhat in the posterior half of the head and the snout is longer than the postorbital part of the head; the diameter of the eye is contained 4.5 times in the length of the head, 2 times in the length of the snout and 1.1 times in the interorbital distance. The eye is not visible from the ventral surface. The nostrils are situated close to the dorso-anterior border of the orbit. The mouth is situated in a cup-shaped structure formed by the lips; it is ventral in position and is placed considerably behind the tip of the snout. The anterior lip is greatly hypertrophied and its edges are raised, forming a funnel-shaped structure; on the inner side it is lined with a sort of horny substance. The posterior lip is represented by

two thick pads which are separated along the middle line by a deep and narrow groove. Both the lips are continuous at the angles. The three pairs of barbels are well-developed, the inner rostral extends to the nostrils, the outer rostral to below the middle of the eye and the maxillary, which is as long as the outer rostral, extends beyond the eye.

The body, except on its ventral surface, is covered with minute, imbricate scales and the lateral line is complete.

The dorsal fin originates in advance of the ventral and its commencement is almost equidistant between the tip of the snout and the base of the caudal fin; its height is considerably greater than the depth of the body below it. The pectoral fin is long and narrow and is pointed posteriorly; it is not as long as the head and is separated from the ventral by a distance equal to about half its length. The ventral is similar to the pectoral and extends considerably beyond the anal opening; it is provided with a sharp, scaly appendage to its base which is adnate to the body for the greater part of its length. The specimen is damaged in the region of the anal fin and, therefore, the characters of this fin cannot be given. The caudal fin is as long as the head and is sharply divided in the last third of its length; the two lobes are equal and are sharply pointed. The caudal peduncle is fairly stout; it is almost as long as high.

In the only preserved specimen the colour is very much faded, but a large number, about 18, indistinct, vertical, black bars can be made out on the body. The fins are without any markings.

Type-specimen.—F $\frac{11057}{1}$, Zoological Survey of India, Calcutta (*Ind. Mus.*).

Locality.—Pegu Yoma, a chain of hills in Burma to the east of the Irrawaddi running due north and south.

Remarks.—There is only a single specimen of this species in the collection and even this is partly damaged in the region of the anal fin. The specimen was collected by Mr. J. P. Cook and unfortunately no information is available as to the precise habitat of the species. *N. peguensis* is remarkable in the modification of its lips, especially the anterior, which is produced upwards and forms a funnel-like structure. I am unable, at present, to discuss the exact significance of this remarkable structural modification, which alone has induced me to describe it as a new species based on a single, partly damaged, specimen.

Measurements in millimetres.

Total length excluding caudal	51.0
Length of head	12.6
Depth of body	8.2
Diameter of eye	2.8
Length of snout	5.6
Interorbital distance	3.2
Height of dorsal	11.0
Length of pectoral	11.0
Length of ventral	9.0

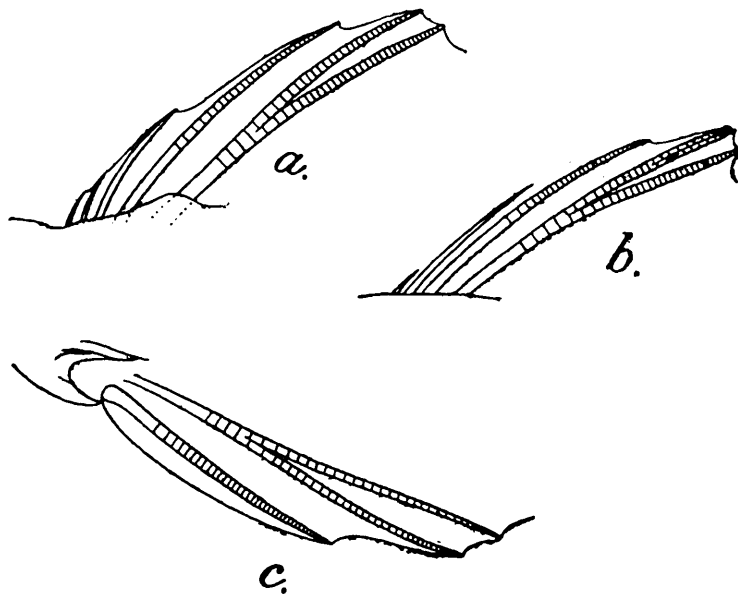
Nemachilus shanensis, sp. nov.

(Plate XV, figs. 5, 6.)

D. $\frac{4}{9}$; P. $\frac{1}{8}$; V $\frac{1}{6}$; A. $\frac{3}{6}$.

In *Nemachilus shanensis* the head and the anterior part of the body are somewhat depressed and the under surface is flattened. The paired fins are horizontally placed and are specially modified to serve as adhesive organs. The fish is stout, muscular and well-built.

The head is short and globular ; its length decreases proportionately with the growth of the fish as does also the depth of the body. The length of the head is contained from 4.5 to 5 times and the depth of the body 5.1 to 6 times in the length without the caudal. The eye is situated almost in the middle of the length of the head and its upper margin is slightly raised above the dorsal profile of the head ; its diameter is contained 4 to 4.2 times in the length of the head, 1.7 to 1.9 times in the length of the snout and is almost equal to the interorbital distance. The eye is not visible from the ventral surface. The nostrils are situated close together and are much nearer to the eye than to the tip of the snout. The barbels are short and stumpy ; the inner rostrals are shorter than the diameter of the eye, while the other two pairs are somewhat longer. The mouth is ventral, placed slightly behind the tip of the snout ; the lips are thick and continuous at the angle but the lower lip is interrupted in the middle line by a narrow channel. The lips leave the lower jaw and the middle portion of the upper jaw free and exposed ; the exposed portions of the jaws are covered with a thick horny layer.



TEXT-FIG. 2.—Nature and arrangement of the spines in the fins of *Nemachilus shanensis*, sp. nov. a = Spines of dorsal ; b = spines of anal ; c = spine of pectoral.

There are minute, indistinct scales covering the entire body. The lateral line is complete.

The dorsal fin is fairly extensive and is fan-shaped in outline; it originates in advance of the ventral and its commencement is equidistant between the tip of the snout and the base of the caudal fin. The height of the dorsal fin is less than the length of the head, but the length of its base almost equals the length of the head. The 4 spines of the dorsal fin are enclosed in a thick membrane and appear as a single spine. The last dorsal spine is segmented distally for a greater part of its length. The membranes in between the rays are provided with skin pads. The anal fin is as high as the dorsal and its three spines are enclosed in a thick membrane, so that superficially they appear as one, the last spine is segmented distally for the greater part of its length. The anal fin is considerably removed from the anal opening and its commencement is nearer to the base of the caudal than to the origin of the ventral fin. The membranes in between the rays are thickened in their proximal halves. The pectoral fin is considerably longer than the head and extends for about two-thirds of the distance to the base of the ventral. The pectoral is pointed in the middle and the rays according to their lengths are so arranged along the outer border that the outline becomes indented. The outermost ray is simple and bears a broad and thick pad of skin anteriorly; it is segmented for a greater portion of its length distally. The ventral fin is shorter than the pectoral and just misses the vent; its outermost ray is modified in the same way as that of the pectoral. There is a fleshy appendage at the base of the ventral. Both the paired fins are horizontally placed, and the membranes between the rays are provided with pads of skin which are used for purposes of adhesion. The caudal fin is longer than the head and is deeply forked; both the lobes are rounded at their extremities. The upper lobe of the caudal fin is longer and better developed than the lower. The caudal peduncle is $1\frac{1}{4}$ times as long as high.

The colouration, in spirit specimens, is characteristic of the species. There are about 8 to 9 short, broad bars along the lateral line and a few similar markings on the dorsal surface in the tail region. Anteriorly the upper surface of the body is irrorated with black spots. The upper surface and the sides of the head are gray and there is a black streak along the lateral line. The ventral surface is pale. The rays of the dorsal fin are provided with two rows of black spots; there is also a black blotch at the base of the spines and the anteriormost ray. The caudal fin is provided with a number of vertical, black bands composed of longitudinal short bars.

Type-specimen.—F $\frac{11058}{1}$, Zoological Survey of India, Calcutta (*Ind. Mus.*).

Locality.—Thale-ú Stream near Fort Stedman, Southern Shan States, Burma.

Remarks.—There are 5 specimens of this species in the collection. They were collected by me from a rapid-running, rocky stream in March 1922. *N. shanensis* is highly modified for life in swift currents and has a very characteristic facies. It can be readily distinguished by the form of its fins and by its characteristic colouration.

Measurements in millimetres.

Total length including caudal	63.0	60.0	48.0
Length of caudal	11.5	11.5	9.8
Length of head	10.2	9.8	8.5
Depth of body	8.6	9.5	6.8
Length of snout	4.5	4.5	3.6
Diameter of eye	2.5	2.3	2.1
Interorbital distance	2.5	2.2	2.2
Length of caudal peduncle	7.0	6.6	5.5
Least height of caudal peduncle	5.5	5.5	4.2

Nemachilus sikmaiensis Hora.

1921. *Nemachilus sikmaiensis*, Hora, *Rec. Ind. Mus.* XXII, p. 201, pl. ix, fig. 4; pl. x, figs. 1, 1a.

Nemachilus sikmaiensis is a small loach of slender build. It inhabits shallow, rocky streams with clear and rapid-running water. The species was described from 9 specimens collected by me in the Manipur Valley (Sikmai Stream near Palel on the Burma Road) and recently Dr. B. N. Chopra obtained a large number of specimens from the Myitkyina District, Upper Burma (streams in the neighbourhood of Kamaing). The Burmese examples differ from the Assamese in having fewer bars on the body and in the markings being of a much deeper colour. The specimens collected by Dr. Chopra do not exceed 3.5 cm. in length and in none of them I have been able to distinguish the secondary sexual characters of the male.

Measurements in millimetres of Burmese examples.

Total length including caudal	33.6	32.3	30.0
Length of caudal	7.0	6.5	5.8
Length of head	6.4	6.5	5.8
Depth of body	4.3	4.1	3.6
Length of snout.	2.4	2.6	2.0
Diameter of eye	1.4	1.3	1.3
Interorbital distance	1.5	1.5	1.3
Length of caudal peduncle	2.7	2.7	2.2
Length of pectoral	5.6	6.0	5.5
Length of ventral	5.3	5.0	4.6

Nemachilus rivulicola, sp. nov.

(Plate XV, figs. 3, 4.)

D. 4/8; P. 1/10; V 1/6; A. 3/5-6.

Nemachilus rivulicola is a small and slender species which replaces *N. brunneanus* Annandale in the clear, rapid-running streams of the Inlé Basin. Annandale's *N. brunneanus*, as remarked elsewhere, is a typical sluggish water form and can be readily distinguished from the new species by its large eyes and long paired fins.

In *N. rivulicola* the head and the anterior part of the body are slightly depressed and the ventral surface in this region is flattened. The tail is compressed from side to side. The head is almost as broad as high at the occiput, its length is contained 4.1 to 4.3 times in the total length without the caudal. The eye is situated somewhat in the anterior half of the head, and is not visible from the ventral surface; its diameter is contained 3.6 to 4 times in the length of the head and 1.4 to 1.7 times

in the length of the snout. The eyes are relatively larger in the young individuals. The nostrils are situated close together, nearer to the eye than to the tip of the snout. The mouth is situated on the ventral surface slightly behind the tip of the snout and is bordered by thick lips which are continuous at the angles. The lower lip is somewhat corrugated and slightly interrupted in the middle line. There are two pairs of rostrals and a pair of maxillary barbels; the inner rostral does not reach the eye, the outer rostral reaches to the middle of the eye, while the maxillary barbel, which is almost as long as the outer rostral, extends beyond the eye.

The body is covered with small indistinct scales. The lateral line is well-marked up to the middle of the base of the anal fin, beyond which it is not clear or is absent.

The dorsal fin originates in advance of the ventrals and its commencement is nearer the tip of the snout than the base of the caudal. The height of the dorsal fin is less than the length of the head, but is greater than the depth of the body below it. The four spines of the dorsal fin are enveloped in a thick membrane and can be made out only after a careful dissection. The pectoral fin is pointed in the middle and is almost as long as the head; it is separated from the ventral by a distance equal to half of its length. The ventrals are considerably smaller than the pectorals and extend as far back as the anal opening; they are provided with fleshy appendages at their bases. The anal fin commences at a distance of one and a half diameters of the eye from the anal opening and does not reach the base of the caudal fin; it is not as high as the dorsal fin. The caudal fin is longer than the head and is forked in the last third of its length; both the lobes are of equal size and are bluntly pointed. The least height of the caudal peduncle is contained 1.2 to 1.4 times in its length.

The colouration of the specimens before me does not vary much. The ground colour of the head and body is pale olivaceous. The dorsal surface of the head is mottled and spotted with black. There is a variable number of dark horizontal bars on the sides of the body, fairly broad behind the dorsal and anteriorly broken up into a number of narrower bars. Even in the posterior region there are indications of these bars breaking up. The dorsal fin is provided with a dark spot at its base in front and with two rows of dotted longitudinal lines on its rays. The caudal fin bears two or three faint V-shaped markings and a narrow, black, somewhat interrupted band at its base. The other fins are generally without any markings.

Type-specimen.—F $\frac{11060}{1}$, Zoological Survey of India, Calcutta (*Ind. Mus.*).

Locality.—Clear, rocky streams in the Yawnghwe Valley and the He-Ho plain, S. Shan States, Burma. I collected several specimens in a stream flowing out of a small spring near Fort Stedman.

Remarks.—It seems likely that *N. rivulicola* and *N. brunneanus* are derived from a common ancestral stock and the specific differences now noticeable between them are probably due to the divergence in their habitats. The distinctive features of both the species can be correlated with the types of environment they now inhabit.

Measurements in millimetres.

Total length including caudal	58.0	58.0	48.5
Length of caudal	12.0	12.0	10.0
Length of head	11.2	10.6	9.0
Depth of body	8.6	8.8	7.5
Length of snout	5.0	4.0	4.0
Diameter of eye	2.8	2.8	2.5
Interorbital distance	3.3	4.0	2.2
Length of caudal peduncle	6.8	7.0	6.0
Least height of caudal peduncle	5.7	5.0	4.5
Length of pectoral	10.8	11.3	9.0
Length of ventral	8.5	8.8	7.4

Nemachilus cincticauda (Blyth).

(Plate XIV, figs. 3, 4.)

1860. *Cobitis cincticauda*, Blyth, *Journ. As. Soc. Bengal*, XXIX, p. 172.1869. *Nemacheilus cincticauda*, Day, *Proc. Zool. Soc. London*, p. 552.1890. *Nemachilus savona*, Vinciguerra (nec Hamilton-Buchanan), *Ann. Mus. Civ. Stor. Nat. Genova*, (2) IX, p. 211.

Blyth characterised *Nemachilus cincticauda* as follows: "Very like *C. scaturiginea*, B. H., but with fewer rays to the dorsal and anal (*viz.* seven and six respectively), and the body more regularly banded; shewing about ten dorsal transverse bands which are broader than the alternating yellowish bands, and a strongly marked black transverse bar at base of tail,—also a dark bar between the eyes and mouth, crossing the muzzle. Two black spots on base of dorsal, and above them a black speck on each ray; the other fins without markings. Length 2 in. Tenasserim Provinces." Günther considered the above description insufficient and did not include this species in his *Catalogue*. Day, 1869, examined the type-specimen in the collection of the Indian Museum and redescribed the species in greater detail. He mentioned that the specimen, "2 inches long", was "received from Major Berdmore, who obtained it at Pegu" Later on Day described and figured a specimen from Prome as *N. cincticauda* in his *Fishes of India* and repeated this description in the *Fauna*. There are several important differences between the two descriptions and it seems certain that Day was not dealing with the same species in the two cases. Some of the salient points distinguishing the two forms are given below:—

<i>N. cincticauda</i> (<i>P. Z. S.</i> , p. 552; 1869).	<i>N. cincticauda</i> (<i>Fish. Ind.</i> , p. 619, 1878).
1. D. 2/7.	D. 2/8.
2. Eyes "nearly 3 diameters from the end of the snout, 1½ diameters apart".	Eyes "2 diameters from end of snout, 1¼ diameters apart".
3. "No projection on the preorbital."	"Preorbital projecting and with a free lower edge in some but not in all examples."
4. Dorsal "commences midway between the posterior margin of the orbit and the base of the caudal fin", which "is slightly emarginate".	Dorsal "arises nearer the snout than the base of the caudal, which last is slightly forked with pointed lobes". In the figure, however, the caudal fin is deeply forked.

Besides these points there are differences in proportions, etc., of the various parts of the body. Unfortunately there is neither the type-specimen nor any other old specimen of this species in our collection and I am, therefore, unable to comment any further on the specimen described by Day as *N. cincticauda* from Prome. There are, however, two examples (Nos. 89-2-1—1666-7) in the collection of the British Museum presented by Day and stated to have been collected at Prome. These specimens are labelled *N. subfuscus?* and are not in a very good state of preservation, but so far as can be judged they resemble *N. blythii* Day and differ considerably from *N. cincticauda* (Blyth). In the same collection there are thirteen specimens (Nos. 80-12-1—50-63) from Tenasserim presented by J. Wood Mason. They are labelled *N. savona*, but they very probably represent *N. cincticauda* Blyth.

In the collection of the Zoological Survey of India there are 6 specimens collected by Dr. F. H. Gravely at Sukli on the east side of the Dawna Hills in November, 1911. These examples agree very closely with Blyth's description of *N. cincticauda* and with Day's description of this species from the type-specimen. There is no doubt in my mind that these examples represent Blyth's *N. cincticauda* and as this species has not so far been properly understood, I take this opportunity to redescribe it in detail.

D. 2/7 ; P. 1/8 ; V 1/8 ; A. 2-3/5.

Nemachilus cincticauda is a small, but strongly built species. The head and the anterior part of the body are greatly depressed and the tail, which is very muscular, is compressed from side to side. The dorsal profile is slightly arched and the ventral is almost straight and horizontal. The ventral surface of the head and the body is flattened.

The head is considerably broader than its height and its length is contained 4.1 to 4.5 times in the total length without the caudal. The body is narrow and its depth is contained 6.1 to 7 times in the total length without the caudal. The eyes are small, dorso-laterally directed and are situated in the middle of the length of the head ; they are not visible from the ventral surface. The diameter of the eye is contained 4.6 to 6 times in the length of the head, 2 to 2.5 times in the length of the snout and 1.2 to 1.7 times in the interorbital distance. The nostrils are situated close together only a short distance anterior to the eye. The membrane between the nostrils is produced into a short, but well-marked barbel-like process. The mouth is situated on the ventral surface slightly behind the tip of the snout ; the mouth opening is lunate and is twice as wide as the diameter of the orbit. It is bordered by fleshy, crenulated lips which are continuous at the angles ; the lower lip is partly divided in the middle line. The three pairs of barbels are well developed and are of equal length ; the inner rostral extends to the front margin of the eye, the outer rostral to the middle of the eye and the maxillary extends considerably beyond the eye. There are rows of open pores on the head.

The body is covered with minute, non-imbricate scales and the lateral line is incomplete, ending before the termination of the pectoral fin.

The dorsal fin is small and originates slightly behind the ventral; its commencement is considerably nearer to the base of the caudal than to the tip of the snout; its height is greater than the depth of the body below it. The paired fins are more or less horizontally placed, the pectoral is shorter than the head and extends for about two-thirds of the distance to the ventral, which is shorter than the pectoral and extends considerably beyond the anal opening. The ventral is separated from the anal fin by a distance equal to twice the diameter of the orbit. The anal just misses the caudal, which is slightly emarginate and is almost as long as the head. The caudal peduncle is short and stout; it is almost as long as deep.

The colouration in spirit agrees with that given by Blyth. There are about 10 to 11 broad, black bands on the body, broader than the pale olivaceous interspaces between them. The base of the caudal fin is provided with a black vertical streak and there is a black blotch at the base of the anterior rays of the dorsal fin. There is an indication of a row of black spots in the middle of the dorsal fin. The other fins are without any markings. The upper surface of the head is dusky and the ventral surface dull-white.

Locality.—Lower Burma (Dawna Hills and Tenasserim Province).

Remarks.—At my request Dr. D. Vinciguerra sent me for examination the two specimens from "Thagata Juva" referred by him to *N. savona*. After a careful study I have determined them as *N. cincticauda*, but it is unfortunate that both these examples were badly damaged during transit when the material was sent to the British Museum, London, for my examination.

Measurements in millimetres.

Total length excluding caudal	46.0	43.0	38.5	35.5
Length of head	10.1	9.6	9.2	8.3
Depth of body	6.3	6.8	6.0	5.8
Diameter of eye	2.2	1.6	1.8	1.6
Length of snout	4.5	4.0	4.0	3.5
Interorbital distance	3.5	2.8	2.2	2.3
Length of caudal peduncle	7.3	5.2	6.0	5.0
Least height of caudal peduncle	5.6	5.8	5.0	5.0
Longest ray of dorsal	7.8	7.2	6.5	6.2
Longest ray of anal	7.0	6.0	5.5	5.5
Longest ray of pectoral	9.8	8.8	8.3	7.5
Length of ventral	8.8	8.0	7.0	6.7

***Nemachilus acuticephalus*, sp. nov.**

(Plate XIV, figs. 5, 6.)

D. 3/7; P. 1/8; V 1/6; A. 2/5.

Nemachilus acuticephalus is a remarkable species as regards its general facies. It is a small and slender loach in which both the profiles are slightly arched and the ventral surface is rounded.

The head is almost cylindrical and pointed anteriorly. When the fish rests on the ground it seems probable that the ventral surface of

the head does not come in contact with the substratum. The length of the head is contained 4.5 to 4.9 times in the total length without the caudal, its greatest width equals its height at the occiput which is slightly less than the postorbital part of the head. The depth of the body in female specimens full of eggs is contained 5.3 to 5.9 times in the total length without the caudal. The eyes are minute and are situated in the anterior half of the head; they are not visible from the ventral surface. The mouth is small and is situated on the ventral surface slightly behind the tip of the snout, it is bordered by thin lips which are continuous at the angle. The lower lip is interrupted in the middle line. The nostrils are placed close together and their situation is much nearer to the eye than to the tip of the snout. The membrane between the nostrils is well developed; it lies over and entirely covers the posterior nostril and is distally produced into a short process in the middle. The barbels are thread-like, two pairs rostrals and one pair maxillary. The inner rostral extends to the nostril, the outer rostral to the middle of the eye and the maxillary extends beyond the eye.

The body is covered with small, rudimentary scales which are embedded in the skin and are hardly distinguishable. The lateral line is incomplete, it terminates in between the pectoral and the dorsal fins.

The dorsal fin is small; it originates slightly in advance of the ventral and its commencement is much nearer the base of the caudal than the tip of the snout; its height is less than the length of the head. The pectoral is much shorter than the head and extends about half way to the base of the ventral. The ventral is even shorter than the pectoral and is separated from the anal opening by a considerable distance; it is provided with a fleshy appendage at its base. The anal fin is very small and does not extend to the base of the caudal fin, which is as long as the head. The caudal fin is forked in the last third of its length, the two lobes are pointed and are almost of equal length. The rays in all the fins are cramped together and it is only with difficulty that their number in each fin can be counted. Along the dorsal surface between the bases of the dorsal and the caudal fin the skin is raised into a low ridge forming a semi-transparent adipose fin such as is found in fishes of the genus *Adiposia*.¹ A similar but much less extensive ridge occurs along the ventral surface also between the anal and the caudal fins. The least height of the caudal peduncle is contained 1.2 to 1.3 times in its length.

In the preserved specimens before me the colour is considerably faded, but still 11-13 vertical bars can be made out on the body. These bars are wider than the interspaces between them. The dorsal fin possesses a black spot at the base of its anterior rays and there is a distinctive black blotch on either side of the caudal peduncle at the base of the caudal fin. The general colouration of the preserved specimens is pale olivaceous.

Type-specimen.—F $\frac{6675}{1}$, Zoological Survey of India, Calcutta (*Ind. Mus.*).

¹ Annandale & Hora, *Rec. Ind. Mus.* XVIII, p. 182, fig. 10 (1920).

Locality.—Hwe-gna-sang River, in the Pazi Township, of the Mong-long Sub-division of Hsipaw State, Northern Shan States, Burma. The Hwe-gna-sang stream is one of the branches of the upper waters of the Madeya river, which runs into the Irrawaddi a short distance above Mandalay.

Remarks.—There are only five specimens of this species in the collection. They were obtained in May, 1911, by Dr. J. Coggin Brown of the Geological Survey of India. Of the 5 specimens 4 are females full of eggs which are of a large size, each being a little over a millimeter in diameter. The rounded and tapering head, the small and compact fins and the general facies of the species indicate that it is adapted to a burrowing mode of life. Moreover all the specimens are covered with a brownish mud which lends further support to its burrowing habits. There can be no doubt that *Nemachilus acuticephalus* is not an inhabitant of swift currents and even if it frequents such habitats it probably lives burrowed in sand or among shingles at the bottom of the stream.

Measurements in millimetres.

	♀	♀	♀
Total length including caudal	40.0	39.0	36.0
Length of caudal	6.7	7.0	6.5
Length of head	6.7	7.0	6.3
Depth of body	6.0	6.0	5.0
Length of snout	2.8	2.8	2.5
Interorbital distance	2.0	2.1	1.8
Length of caudal peduncle	4.3	3.6	4.0
Least height of caudal peduncle	3.5	3.0	3.0
Length of pectoral .	6.0	5.2	5.0
Length of ventral .	5.3	5.0	4.7

***Nemachilus paucifasciatus*, sp. nov.**

(Plate XV, figs. 1, 2.)

D. 3/6-7; P. 1/7; V. 1/5; A. 3/5.

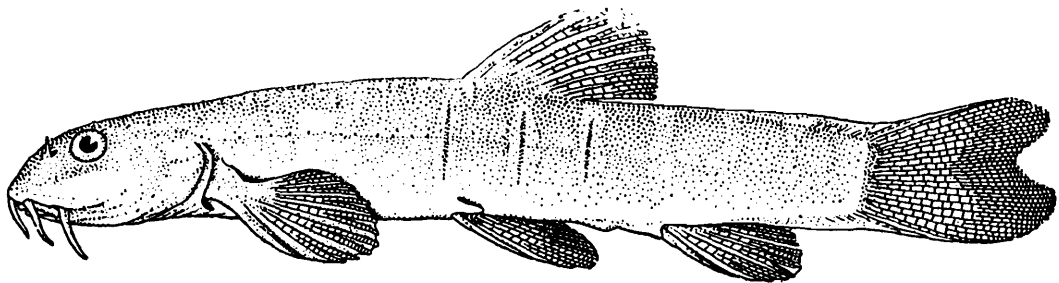
In *Nemachilus paucifasciatus* the head is depressed and the ventral surface is flat. The anterior part of the body is also somewhat depressed, but the posterior part is greatly compressed. Both the dorsal and the ventral profiles are slightly arched.

The head is broad and spatulate, its breadth equals the length of the head behind the anterior nostril and its height equals the postorbital portion of the head. The length of the head is contained from 4.2 to 4.6 times and the depth of the body 6.4 to 8 times in the length without the caudal. The eye is small and is situated nearer to the tip of the snout than to the posterior margin of the operculum; its diameter is contained from 5 to 7 times in the length of the head. The eye is not visible from the ventral surface. The nostrils are situated close together and are placed much nearer to the eye than to the tip of the snout. The membrane between the two nostrils is produced into a small, blunt projection. The three pairs of barbels are well-developed; the inner rostrals just extend as far as the nasal openings, the outer rostrals extend

to below the middle of the eyes and the maxillary barbels are slightly longer than the outer rostrals. The mouth is situated on the ventral surface slightly behind the tip of the snout. It is bordered by thick and crenulated lips which are continuous at the angles of the mouth; the lower lip is divided in the middle. For the greater part of their lengths the lips are free from the jaws, which are covered with a horny substance. In older specimens the upper jaw is produced into a beak-like process in the middle and the lower jaw is grooved in the corresponding position for its reception. Behind the lower lip the skin is raised into a pad-like structure which probably serves as an adhesive device. There are open pores on the head arranged in definite rows. Those above and below the eyes and across the nape are continued into the lateral line, while the row on the pre-opercular and inter-opercular border ends abruptly on the side of the head.

There are small, inconspicuous scales on the body specially in its posterior half. The lateral line is fairly distinct up to the base of the ventral fin, beyond which it is absent.

The dorsal fin originates opposite the ventral and its commencement is nearer to the base of the caudal than to the tip of the snout. The height of the dorsal fin is less than the length of the head. The anal fin is not as high as the dorsal and its commencement is midway between the origin of the ventral and the base of the caudal; it does not extend as far back as the caudal fin and is considerably removed from the anal opening. The pectoral is shorter than the head and is separated from the ventral by a distance almost equal to its own length. The ventral fin is slightly shorter than the pectoral and bears a short fleshy appendage at its base; in young examples it just reaches the anal-opening but in older specimens it does not extend so far back. The caudal fin is shorter than the head and is notched at the end; both the lobes are rounded. The caudal peduncle is stout and in adult specimens it is almost as high as long.



TEXT-FIG. 3.—A young specimen of *Nemachilus paucifasciatus*, sp. nov.: lateral view to show the primary colouration with indications of the bars which are so characteristic of the adult examples.

The colour varies considerably in the young and grown-up specimens. In young examples there are about 8 broad, gray bands running from the dorsal surface to the sides; these bands are separated by dull-white, narrow interspaces. A dark band of a deep colour is invariably present at the base of the caudal fin. The dorsal surface of the head is dusky. The cheeks and the ventral surface of the head and body are pale olivaceous. A dark spot is present at the commencement of the dorsal fin. With the growth of the fish the broad bands on the

body gradually fade away and the fish takes up a uniform reddish-brown tint. In the middle of the body, in the region of the interspaces, there appear narrow vertical bars of a deep reddish-brown colour. There are usually 3 or 4 such bars and they impart a very characteristic colouration to the fish. The colour band at the base of the caudal does not undergo any change and the fins do not show any markings.

Type-specimen.—F $\frac{6314}{1}$, Zoological Survey of India, Calcutta (*Ind. Mus.*).

Locality.—Hwe-gna-sang River, in the Pazi Township, of the Mong-long Sub-division of Hsipaw State, Northern Shan States, Burma.

Remarks.—There are 15 specimens of this species in the collection. They were obtained by Dr. J. Coggin Brown of the Geological Survey of India in May, 1911. The adult specimens of *Nemachilus paucifasciatus* can be readily distinguished by their very characteristic colour.

Measurements in millimetres.

Total length including caudal	66.0	56.5	53.6	48.0	40.6	39.0
Length of caudal	11.7	9.2	9.5	8.2	7.0	6.8
Length of head	12.0	10.2	9.7	9.0	8.0	7.5
Depth of body	8.6	5.9	6.6	5.5	4.8	5.0
Length of snout	4.3	4.0	4.2	3.5	3.0	3.0
Diameter of eye	1.8	2.0	1.4	1.6	1.6	1.5
Interorbital distance	3.3	2.3	2.6	2.4	2.1	1.6
Length of caudal peduncle	8.8	7.0	7.3	6.3	4.8	5.8
Least height of caudal peduncle	7.8	4.9	4.8	4.8	4.0	3.8

***Nemachilus raoe*, sp. nov.**

(Plate XV, figs. 7, 8.)

D. 4/9; P. 1/10; V 1/7; A. 3/6.

Nemachilus raoe is a small and slender species resembling *N. brunneanus* both in its general facies and in its body markings. The head and the anterior part of the body are somewhat depressed and the ventral surface is flattened. The tail is compressed.

The head is proportionately larger in young specimens, its length being contained 4 to 4.3 times in the total length without the caudal. The depth of the body is much less than the length of the head and is contained 5.1 to 6 times in the total length without the caudal. The eye is situated almost in the middle of the length of the head or somewhat in the posterior half; its diameter is contained 3.9 to 4.3 times in the length of the head. The eyes become proportionately larger with the growth of the fish, a rather unusual occurrence. The snout is considerably longer than the diameter of the orbit but the interorbital width is only slightly longer than the diameter of the eye. The eye is not visible from the ventral surface. The nostrils are situated close together and are much nearer to the eye than to the tip of the snout. The anterior nostril is somewhat tubular; the tube is produced posteriorly into a flap-like projection. The three pairs of barbels are well-marked, the inner rostrals extend to the nostrils, the outer rostrals to the eyes and the maxillaries, which are as long as the outer rostrals, extend slightly beyond the eye. The mouth is on the ventral surface, slightly behind the tip of the snout and is bordered by thick lips which

are continuous at the angles, the lower lip is papillated and corrugated and is interrupted in the middle line.

The scales are rudimentary and the body appears to be naked. The lateral line is incomplete and terminates in most cases opposite the commencement of the dorsal.

The dorsal fin is almost as high as or higher than the length of the head; it originates in advance of the ventral and its commencement is either equidistant between the tip of the snout and the base of the caudal or is nearer to the former than to the latter. The pectoral fins are longer than the head, are pointed in the middle and are separated from the ventrals by a short distance. The ventrals are much shorter than the pectorals and reach the anal opening; they are provided with fleshy appendages at their bases. The anal fin is much shorter than the dorsal and just reaches the base of the caudal fin. The caudal fin is longer than the head and is deeply forked in the last third of its length, the upper lobe is better developed than the lower. The least height of the caudal peduncle is contained 1.1 to 1.2 times in its length.

The ground colour of the head and body is pale olivaceous. The dorsal surface of the head is mottled and spotted with black. The body is marked with about 22 dark horizontal bars on the sides separated from one another by narrow interspaces. At the base of the caudal fin there are two deeply coloured short black bars on each side of the caudal peduncle. There is a black blotch at the base of the dorsal fin in front and a row of short black lines across its middle. The caudal fin is indistinctly marked in its proximal half with two or three V-shaped dark bands. The other fins are white. The outer rostral is finely dotted with black.

Type-specimen.—F $\frac{11062}{1}$, Zoological Survey of India, Calcutta (*Ind. Mus.*).

Locality.—Mongyai, N. Shan States, Burma.

Remarks.—Drs. H. S. Rao and B. N. Chopra collected six specimens of this species from a large tank full of weeds near the Inspection Bungalow at Mongvai. *N. raoe*, like its nearest ally *N. brunneanus* from the S. Shan States, is an inhabitant of sluggish waters, and it seems probable that the markings on the body adapt these species to life among weeds (protective colouration). *N. brunneanus* differs from the new species in having larger eyes, a larger and narrower caudal peduncle and in having the entire body covered with distinct scales. There are also differences in the colouration of the caudal and the dorsal fins of the two species.

Measurements in millimetres.

Total length including caudal	42.4	39.4	35.8
Length of caudal ¹	8.9	8.8	8.0
Length of head	7.8	7.5	7.0
Depth of body	5.6	5.8	5.4
Length of snout	3.2	2.8	3.0
Diameter of eye	2.0	1.8	1.6
Interorbital distance	2.2	2.1	2.0
Length of caudal peduncle	5.8	4.1	4.0
Least height of caudal peduncle	4.7	3.8	3.4
Length of pectoral	9.0	8.1	7.4
Length of ventral	6.5	6.2	5.2

Nemachilus brunneanus Annandale.

(Plate XV, fig. 9.)

1918. *Nemachilus brunneanus*, Annandale, *Rec. Ind. Mus.* XIV, p. 44, pl. ii, fig. 2.

Annandale described this slender species from the Yawnghwe Valley and remarked that "this little loach is abundant in the waters of the Yawnghwe valley and seems to be equally at home in clear hill-streams, in muddy rivers and among the weed-thickets of the Inlé Lake, in which it occurs both in the central region and in the marginal zone" I have examined Annandale's material and find that the single specimen collected by him from the Hsin Daung Chaung stream has been erroneously referred to *N. brunneanus*; it belongs to my new species—*N. rivulicola*. *Nemachilus brunneanus* is an inhabitant of sluggish waters; its large eyes, complete lepidosis, long and pointed paired fins and the lateral line restricted to a short distance are some of its salient features.

Measurements in millimetres.

Total length including caudal	46.7	45.0	44.6	42.0
Length of caudal	9.0	9.0	9.5	8.5
Length of head	8.0	8.7	8.3	7.5
Depth of body	7.2	7.2	7.0	6.8
Length of snout	2.8	3.3	3.0	2.6
Diameter of eye	2.5	2.5	2.6	2.5
Interorbital distance	1.8	2.0	1.3	1.7
Length of caudal peduncle	5.6	5.5	6.0	5.0
Least height of caudal peduncle	3.2	3.6	3.7	3.2
Length of pectoral	9.2	9.0	9.3	8.6
Length of ventral	6.2	6.3	6.4	5.6

EXPLANATION OF PLATE XIV.

Nemachilus peguensis, sp. nov.

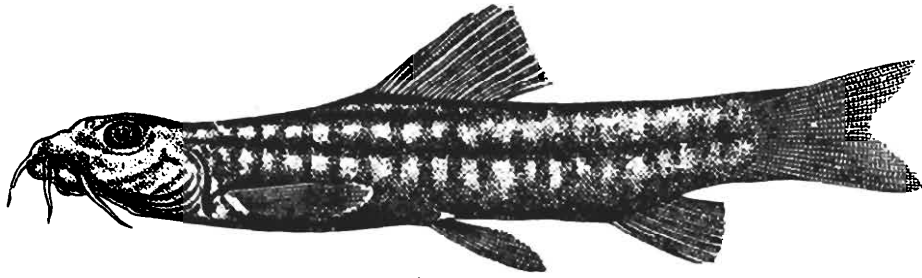
- FIG. 1.—Lateral view of type-specimen, $\times 1\frac{1}{2}$.
,, 2.—Ventral surface of head and anterior region of body of same,
 $\times 2\frac{1}{2}$.

Nemachilus cincticauda (Blyth).

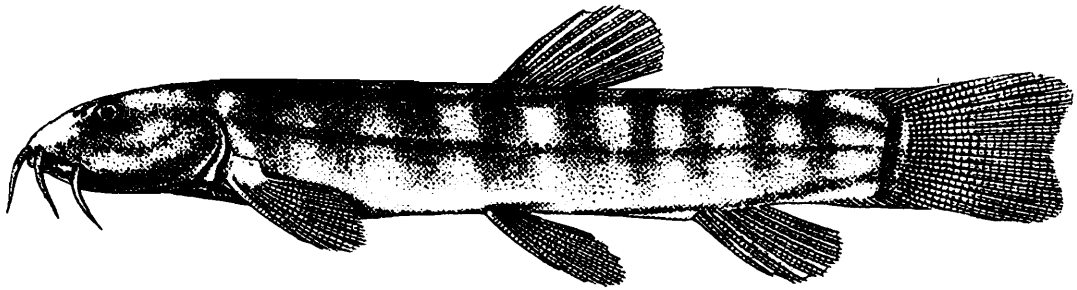
- FIG. 3.—Lateral view, $\times 2\frac{1}{2}$.
,, 4.—Ventral surface of head and anterior region of body, $\times 3$.

Nemachilus acuticephalus, sp. nov.

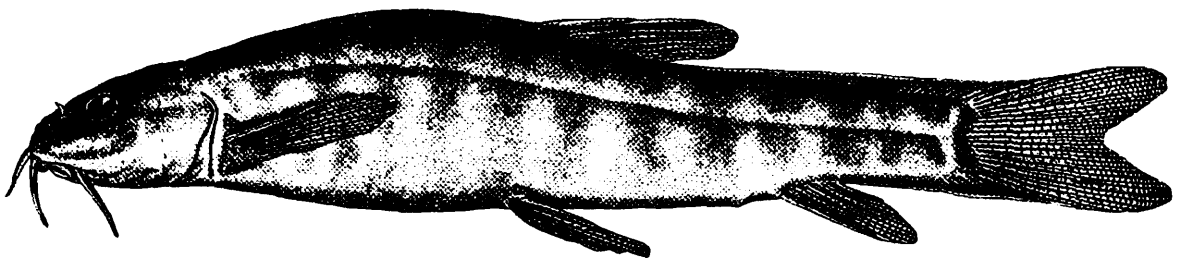
- FIG. 5.—Lateral view of type-specimen, $\times 3$.
,, 6.—Ventral surface of head and anterior region of body of same,
 $\times 4$.



1



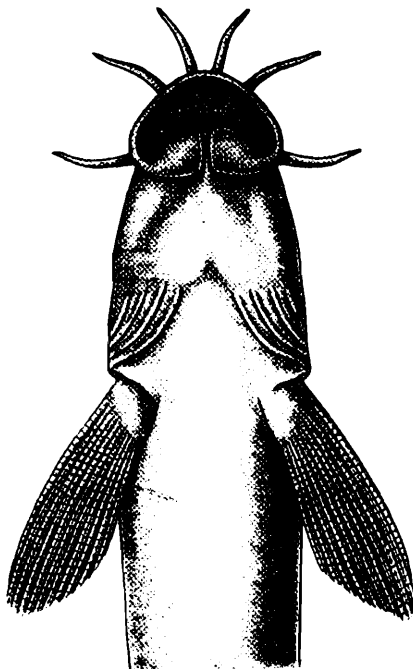
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6



2



4

S. O. Mondul & D. Bagchi, del.

Nemachilus from Burma.

EXPLANATION OF PLATE XV.

Nemachilus paucifasciatus, sp. nov.

- FIG. 1.—Lateral view of type-specimen, $\times 2\frac{2}{5}$.
,, 2.—Ventral surface of head and anterior region of body of same,
 $\times 1\frac{3}{5}$.

Nemachilus rivulicola, sp. nov.

- FIG. 3.—Lateral view of type-specimen, $\times 1\frac{3}{5}$.
,, 4.—Ventral surface of head and anterior region of body of same,
 $\times 1\frac{3}{5}$.

Nemachilus shanensis, sp. nov.

- FIG. 5.—Lateral view of type-specimen, $\times 1\frac{3}{5}$.
,, 6.—Ventral surface of head and anterior region of body of same,
 $\times 1\frac{3}{5}$.

Nemachilus raoe, sp. nov.

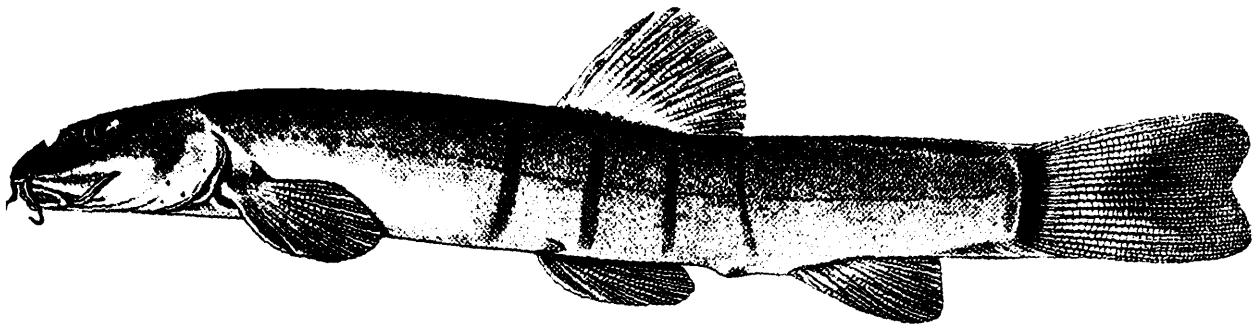
- FIG. 7.—Lateral view of type-specimen, $\times 2\frac{2}{5}$.
,, 8.—Ventral surface of head and anterior region of body of same,
 $\times 3\frac{1}{5}$.

Nemachilus brunneanus Annandale.

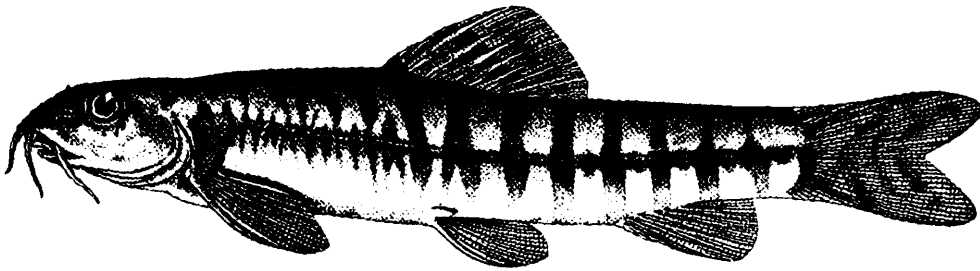
- FIG. 9.—Ventral surface of head and anterior region of body, $\times 1\frac{3}{5}$.

Nemachilus brevis Boulenger.

- FIG. 10.—Ventral surface of head, $\times 3\frac{1}{5}$.



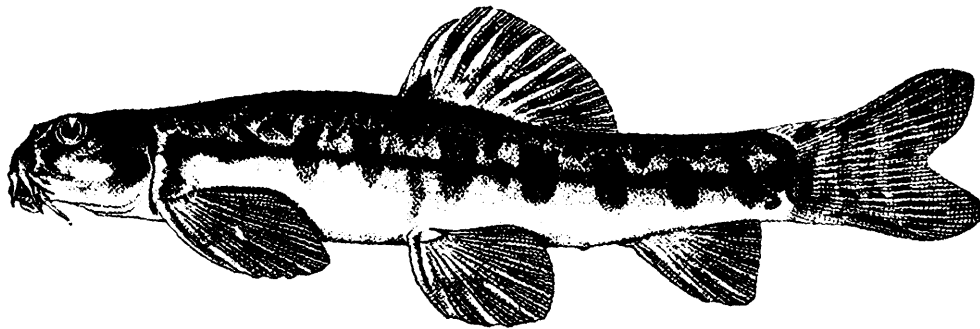
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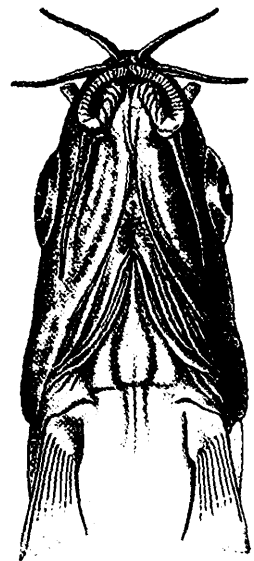
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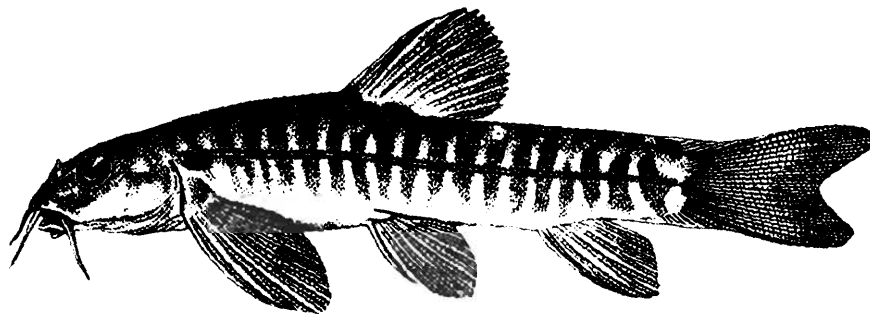
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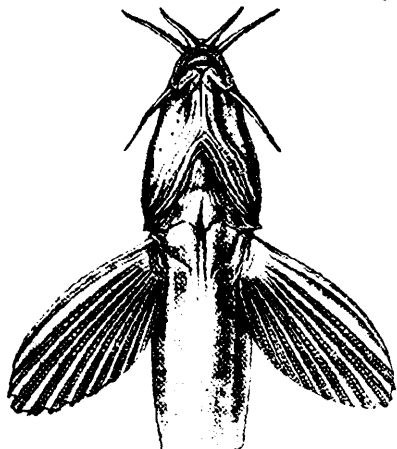
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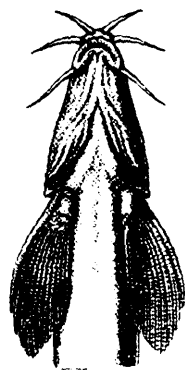
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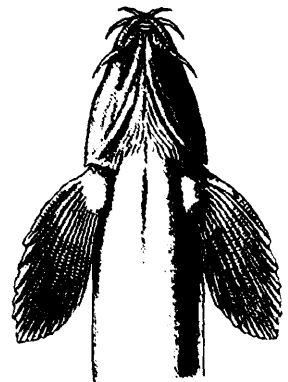
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4



2



6

D. Bagchi del.

Nemachilus from Burma.