VI THE FAUNA OF CERTAIN SMALL STREAMS IN THE BOMBAY PRESIDENCY

By N. ANNANDALE, *D.Sc., F.A.S.B., Director, Zoological Survey of India.*

(With Plates I—VII.)

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INTRODUCTION.

The notes embodied in this paper are based primarily on collections made in the course of a tour in the Satara and Poona districts in February and March, 1918. The chief localities at which these collections were made were Medha in the Satara district (alt. *ca.* 2,000 feet) and Khandalla in the Poona district (alt. *ca.* 2,500 feet). The former place is situated on the river Yenna or Vena, a tributary of the Kistna or Krishna, in a valley among the easternmost spurs of the Western Ghats; the latter on the hillside about a mile and a half east of the well-known pass Bhor Ghat. From Medha the Zoological Survey of India already possessed large collections of aquatic invertebrates made by Dr. F. H. Gravely and Mr. S. P. Agharkar.

My main object in visiting Medha was to obtain further information about the freshwater medusa *Limnocnida indica*, which was originally discovered there by Mr. Agharkar; while Khandalla was selected as a suitable spot at which to study the fauna of the small mountain torrents of the Bombay Ghats. It is a locality well known to conchologists as the home of the interesting genera *Lithotis* (Succineidae) and *Cremnoconchus* (Littorinidae).

So far as *Limnocnida* was concerned the results of my tour were purely negative, but even so they are not devoid of interest, for they prove beyond doubt that the medusa must have a fixed

or resting stage in its life-history, perhaps with the structure of a minute hydroid, or more probably encysted in a form that would not be recognizable with our present knowledge.

The most interesting results obtained in the streamlets at Khandalla were those bearing on adaptation to environment in fish and molluscs.

Notes resulting from a tour of the kind cannot be exhaustive, but our knowledge of the bionomics and environment of the aquatic fauna of India is still in its preliminary stage, in which it is, in my opinion at any rate, worth while to publish notes of the kind, even at the risk of being superficial.

I must be held wholly responsible for all statements made in those sections of the paper in the superscription of which no author's name is given.

I. THE LIMNOCNIDA POOL IN THE YENNA RIVER AT MEDHA.

The Yenna or Vena is a stream of a type very common in hilly districts in Peninsular India. In the wet season it may be described as a small river in which deep pools alternate with rapids obstructed by rocks of irregular shape. In dry weather, however, the pools shrink considerably, while the rapids are reduced to a mere trickle of water or even disappear altogether leaving the pools completely isolated. The bed of the stream is for the most part rocky, with gravelly reaches; but in the pools it is covered with a layer of mud and vegetable debris. As in all the smaller tributaries near the source of the Kistna, the water contains an abundance of very finely divided silt never completely deposited, and is, therefore, opaque and brownish. After heavy rain it is further contaminated with red mud, from the Mahableshwar plateau, that seems to be particularly inimical to animal life. The pools are practically devoid of aquatic vegetation. The temperature of the water of the pools must rise to a considerable height in the hot season; at other times of year it is strictly temperate.

The pool in which *Limnocnida indica* was originally found is, including the gorge at its upper end, about 50 yards long and a stone's throw across; its width must vary slightly with the seasons. A photograph of it is published by Gravely and Agharkar in *Rec. Ind. Mus.* VII. In March the water is 7 to 12 metres deep, but must be considerably deeper in the "rains." In March there is very little current, as the rapid above the pool is then small and feeble. A tall man could stride across the outlet. The rocky bottom is very irregular; in the lower part of the pool it is covered with a fairly deep layer of gravel mixed with mud, but in the upper part, which is the deepest, there is only a sparse coating of small pebbles and vegetable debris. A large irregular rock rises far above the surface in the lower part and a foot-bridge spans the upper part at a considerable height above the water. It is impossible, owing to the opacity of the water, to see the

bottom of the pool. Except algae, which are scantily represented, there is no living vegetation.

The fauna of this pool is chiefly a bottom fauna. The bare rock of the sides is covered for considerable areas by the hard black encrusting sponge *Corvospongilla ultima* var. *spinosa* and by the much softer and rather thinner green species *Spongilla perviridis* and *S. sumatrensis* var. *rivularis*. The Polyzoa *Plumatella javanica* and *P. emarginata* occur sparingly on the cleaner parts of the rocky basin and also on the lower surface of loose stones. In the mud and dead vegetable matter a small white dipterous larva of the family Chironomidae is abundant, while in the more gravelly spots thick-shelled Unionids (*Parreyssia corrugata* and *P. cylindrica*, sp. nov.) are not uncommon. For some inches above the bottom Entomostraca, chiefly Copepods and Daphnids, are abundant and with them occur the larvae and pupae of the Corethrine Culicid *Chaoborus manillensis*.[1] None of these arthropods commonly rise to the surface, on which the only zooplancton taken in my nets consisted of the statoblasts of *Plumatella*. Surface-haunting fish such as *Barilius bendelesis* are scarce in the pool, but bottom-haunting forms, notably *Discognathus lamta* and *Gobius bombayensis*, are numerous; a large proportion of the fish bore the glochidia of Unionidae on their fins at the time of my visit. Small prawns of the genera *Caridina* and *Palaemon* are not uncommon, and the crab *Paratelphusa* (*Barytelphusa*) *jacquemonti* burrows in the mud at shallow points near the shore.[2]

The facts known about the life-history of *Limnocnida* are as follows:—they are taken mainly from the papers referred to in a footnote below.[3]

L. indica has been found only in the smaller streams of the upper Kistna river-system, and only in pools situated as described above. It has been observed only in the months of April and May; in places where it is abundant in these months it has been proved to be completely absent in February March and October,

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[1] Both larva and pupa of this fly are modified in correlation with life near the bottom instead of at the surface, the larva in its very small air-sacs, the pupa in several structures, particularly in its balloon-like breathing trumpets, which are sufficiently bouyant to keep it in an upright position but not to raise it to the surface. See Baini Prashad, *Rec. Ind. Mus.*, XV, pp. 154–156 (1918).

[2] I may refer briefly to two small but remarkable Orthopterous insects common at the edge of the pool, *viz. Scelimena harpago* (Serv.) and *Paranemobius pictus*, Sauss. The former is an Acridiid grasshopper of the subfamily Acrydiinae (or Tettiginae) and is amphibious in habits, flying, diving and swimming with equal ease. I hope on some future occasion to discuss the peculiar modification of its hind legs by means of which it can cling to rocks under water. The *Paranemobius* is a brachypterous, long-legged cricket which runs, as often sideways as forwards, with great agility on the shady sides of dry rocks at the edge of water. It is widely distributed in India (Kashmir to South India) and is always found in this position. I have to thank M. L. Chopard for this identification.

[3] See Annandale, "A Preliminary Description of a Freshwater Medusa from the Bombay Presidency," *Rec. Ind. Mus.*, VII, p. 253 (1912): Gravely & Agharkar, "Notes on the Habits and Distribution of *Limnocnida indica*," *Rec. Ind. Mus.*, VII, p. 399 (1912); Agharkar, "Further Notes on the Habits and Distribution of *Limnocnida indica*," *Rec. Ind. Mus.*, IX, p. 247.

and is stated by natives of these places (who are well acquainted with it under the names "water-wheels" or "water-flowers") to be absent at all other times of the year. In the pools it feeds on minute crustacea, which are probably always to be found in abundance at the bottom, near which the medusa spends most of its time. All attempts either to breed the animal in captivity or to discover what becomes of the species when the medusa is not present have hitherto failed. Investigation of the latter point is rendered difficult at Medha by the inequalities of the rocky basin of the pool. I found that a heavy dredge invariably caught in projections of the rock, but succeeded by careful manipulation in dragging a D-net over the bottom and in bringing up pebbles and vegetable debris from it. I could detect no organism of a coelenterate nature in this matter; nor could I find any trace of a parasitic or quasiparasitic stage on or in any of the fish, molluscs or crustaceans of the pool. The structure of the stream and of the surrounding country renders it almost impossible that the medusa could be introduced periodically; at other localities it appears in bodies of water completely isolated at the time of its appearance. We know that it is killed off annually by the red mud brought down from higher up stream in the first summer freshets. We know also that sexual reproduction is active immediately before this occurs, and evidence that asexual budding ever occurs is altogether lacking. I am sure no ordinary hydroid, if at all abundant, could have escaped my notice in the investigations I undertook at Medha, while Mr. Agharkar's experiments at the same place had equally negative results. The most probable explanation seems to me to be that the hydrozoon remains for the greater part of the year in an encysted condition and that the medusa becomes fully developed in favourable conditions of temperature, as soon as the hot season is fully established. The union of ova and spermatozoa probably gives rise to planulae of the type usual in hydroids. Probably those planulae which are produced in the earlier part of the brief season of activity develop directly into medusae, but there may be a short-lived hydroid generation. Those planulae, however, which have not undergone further development at the time when the water is rendered unfit for the activities of the medusa by the freshets, perhaps become encysted and lie on the bottom until conditions favourable for active life return Their cysts may be very minute and have no definite characters by which they could be recognized. I know of no case[1] in the Hydrozoa precisely parallel, but that of the encysted embryo of *Hydra* is similar and encystment is a phenomenon of such common occurrence in many diverse groups of freshwater invertebrates that it would not be at all surprising to find it in *Limnocnida*.

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[1] In *Annulella*, an anomalous hydroid from the brackish water of the Gangetic delta, an encysted resting stage has been described.. See Ritchie, *Rec. Ind. Mus.*, XI, p. 552, pl. xxx*a*, fig. 9 (1915).

II. THE FAUNA OF MOUNTAIN STREAMLETS AT KHANDALLA.

The hills at Khandalla are fairly steep and almost bare or at any rate devoid of heavy jungle. Numerous small streams rush down them, falling over many cliffs and rocks and thus forming cascades and waterfalls, some of which are of a considerable, even a great height. The streams are for the most part very small indeed, nowhere more than a yard or two across and in the deepest pools not more than a foot or two deep. This description applies to their conditions in the dry season; in the rainy season they must be small but raging torrents, the biological investigation of which would be difficult. In the following notes I discuss the true aquatic fauna of these streamlets; the fauna of damp rocks at the edge of the waterfalls will be considered separately.

It is impossible at present to give anything like a full account of the fauna of any body of water in India, because it inevitably includes among its members a large proportion of insect larvae even the adults of which are imperfectly known, if known at all. This is particularly unfortunate in the case of small torrents, the insect larvae of which are almost without exception highly modified and adapted forms. In present circumstances, however, it is perhaps best to ignore the curious flattened Ephemerid and other larvae that play an important part in the natural history of the streamlets at Khandalla, and also the aquatic and semi-aquatic beetles which, though never of large size, are by no means uncommon in the water or at the edge. Mr. Paiva's co-operation has made more satisfactory reference to the Rhynchota possible. I shall do no more than mention here that Anopheline larvae are abundant in small pools and that the adults rest in large numbers on damp rocks shaded from the sun and standing in the water. It will be remembered that my observations were made in March, when there was very little water in the streamlets.

Batrachia.—The only frogs observed at the edge of the streamlets were *Rana limnocharis syhadrensis* and *Ixalus bombayensis*, both of which were fairly common under stones. The *Ixalus* was also found in the cracks between the narrow strata of the rocks over which little cascades fall in the streamlets. These cracks often make it possible to strip off slabs of stone by the exercise of a little force, and when this is done the frogs appear flattened against the parent rock, with their pupils strongly contracted. With them there is abundant food, particularly in the form of earwigs (*Forcipula*), which greatly favour such situations. When the streamlets become broader owing to natural or artificial obstructions in comparatively level areas *Rana cyanophlyctis* is abundant round the margin. I found no tadpoles of any species.

Fish.—Three species of fish, all very small, make their way into the smallest pools in the streamlets. They are *Nemachilus evezardi*, *Discognathus nasutus* and *Psilorhynchus tentaculatus*. All of these, and especially the two last, are modified forms.

The loach resembles other small species of its genus in general structure but has the processes between the two nostrils on each side of the head prolonged into regular barbels. This feature does not occur in any other Indian species of *Nemachilus* but is present in the closely allied genus *Aborichthys*, which is found in hill streams in Assam and north-eastern Burma.

The modifications exhibited by the *Discognathus* and the *Psilorhynchus* are of a more extreme and more clearly adaptive nature. Many species of *Nemachilus*, with their ventral mouth, swollen suctorial lips, glandular skin, flat ventral surface and small size are well fitted to live in rapid-running water among rocks, to which they are able to adhere and over which they can crawl even when the surface is not entirely submerged; but other species of similar structure live in ordinary rivers. The two species of *Psilorhynchus* are inhabitants only of streams in or near Indian mountains, and are modified accordingly. The Bombay species does not differ from its Himalayan congeners to any important degree in this respect. It has been generally assumed that the genus

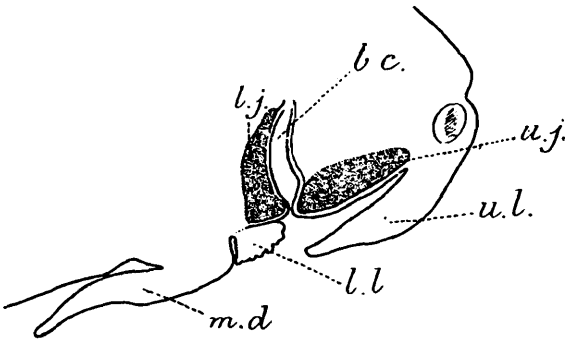

FIG. 1.—Vertical section through the mouth of *Discognathus lamta*.
b.c. = buccal cavity. *l.j.* = lower jaw. *l.l.* = anterior free portion of lower lip. *m.d.* = mental disk. *u.j.* = upper jaw. *u.l.* = upper lip.

Discognathus has had a similar history, but though *Psilorhynchus* may be a more primitive form of *Discognathus*, there is something to be said for another view.

The main if not the only generic peculiarities of *Discognathus* lie in the structure of its mouth and lips (fig. 1). The jaws are of semicircular shape, firm and bony, with blunt edges and covered with soft integument; they are directed downwards and can be tightly closed together with their margins in contact. The upper lip is a deep but delicate fold covered with minute papillae, mobile and probably sensitive. It entirely conceals the upper jaw, to which it is not attached. The lower lip bears much the same relation to the lower jaw so far as its anterior part is concerned, but the free portion is shorter; posteriorly it is much enlarged and flattened and bears in its centre a relatively large transversely oval or nearly circular pad, which can be elevated by muscular action and so produce a partial vacuum, thus forming an organ of adhesion. The mouth of *Psilorhynchus* is essentially similar, except that the pad is entirely absent or represented, as in *P. ten-*

taculatus, by a slight swelling. From the more normal species of *Discognathus* the genus is further separated by the structure of the pectoral fins, which are greatly expanded, entirely horizontal in position and with their rays broad, flat and sparingly branched. The chest is also flat, devoid of scales, highly muscular and, with the pectoral fins, capable of adhering tightly to flat or uneven surfaces. The other generic differences are trivial or inconstant: *Discognathus* may have two or four barbels or none, *Psilorhynchus* two or none; the two lips are joined together by a fold in *Discognathus*, separated by a groove in *Psilorhynchus*. In the Indian species there is no difficulty in separating the genera, but both in India and Africa forms occur that are intermediate in one way or another. Boulenger[1] in describing the Nilotic species of *Discognathus* says:

> "Aberrant Cyprininae adapted for living in torrents and mountain rivers. The mental disk by which they are enabled to fasten themselves to stones varies greatly in its degree of development, and is so reduced in some specimens of the species described below as *D. quadrimaculatus* as to be almost indistinguishable. Such specimens might be referred to the genus *Crossochilus*, Van Hasselt, were it not for the more reduced gill-openings, which do not extend to the lower surface of the head, the isthmus being much broader than in the related genera."

The resemblance between *D. quadrimaculatus* and *Psilorhynchus* seems to me to be very close indeed, both in the structure of the mouth and as regards general facies. There is no resemblance, however, in the structure of the pectoral fins, and the lips are continuous in the African fish.

If we have in this African species a close approximation to *Psilorhynchus*, we have among Indian forms a still closer resemblance in the modification of the pectoral fins and chest in one or possibly two species of *Discognathus*. This is the case in *D. nasutus*. Here again, however, we have a difference as well as a resemblance, for the pectoral fins in *D. nasutus* differ from those of all species of *Psilorhynchus* in that all the rays except the outermost ones are branched, though sparingly so, whereas in *Psilorhynchus* several of the outer rays are simple or nearly so.

Resemblances between the mouth-parts in these fish are perhaps more important genetically than those between the fins, both because they are more exact and because we find similar modifications in the fins of other unrelated genera (such as *Homaloptera* and even some Siluridae) that also live in mountain streams. The latter resemblances are, therefore, without doubt convergent. It will be as well, however, to inquire a little further, before coming to any conclusion, what are the normal modifications in the

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[1] *The Fishes of the Nile*, p. 180 (1907). See also the same author's *Fresh-Water Fishes of Africa*, I, p. 343 (1909).

clearly specialized genus *Discognathus* and in what way these modifications are actually utilized.

With the structure of the mouth in *Discognathus* I have dealt to some extent. The Western Asiatic forms (*D. variabilis* and *D. lamta* var. *rufus*) closely resemble the Indian forms in this respect, and so does the one species (*D. borneensis*) known from the Malay Archipelago. I have been able myself to observe both the typical *D. lamta* and its Syrian race under natural conditions in exceptionally favourable circumstances. Neither of these forms lives habitually in mountain streams; both affect the pools of streams and rivers and even isolated masses of still water; they are what we may call normal forms of the genus with well-developed mental suckers and with the pectoral fins and chest comparatively little modified. My observations on the Syrian fish were made in a walled fountain at the Lake of Tiberias, those on the Indian form in the Inlé Lake in the Southern Shan States. Moreover, in the literature on other species of the genus I can find no statement that would justify, so far as most species are concerned, the belief that the genus is like *Psilorhynchus*, essentially a mountain one. Blanford [1] took the types of *D. blanfordii* in a stream which he describes as a torrent, and Max Weber [2] states that *D. borneensis* lives in mountain streams. All the other species are recorded from rivers or lakes. *Discognathus lamta*, in both its races, feeds on small organisms that are tightly fixed to rocks or other hard objects. Its manner of feeding is this. Having fastened itself, usually in a more or less vertical position with the head uppermost, to a rock or post by means of its mental disk, it selects suitable food with its lips, bites it off with its jaws and sucks it into its almost horizontal buccal cavity. When the food in its reach is exhausted, it relaxes its adhesive organ and by means of an almost imperceptible movement of its tail, thrusts itself slightly upwards. The disk then takes hold again. In Palestine I experienced this process by bodily sensation on placing my bare feet in the water of the fountain. The fish invariably attached themselves and it was possible to feel the action of the disk fixing itself, the movements of the lips and the nibblings of the jaws, which were not sharp enough to pierce the human skin. *Psilorhynchus* apparently feeds in the same way but clings rather by means of its pectoral fins and flattened, highly muscular chest, which can probably be rendered concave by muscular action. *Discognathus nasutus* has both means of attachment strongly developed.

It is noteworthy that in *D. blanfordii*, so far as can be seen from Boulenger's figures, the fins and chest have a considerable resemblance to those of *D. nasutus*, while those of the other African species, which apparently live in comparatively still water, resemble those of *D. lamta*. The Bornean species also

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[1] *Discognathus lamta*, Blanford, *Geol. Zool. Abyssinia*, pp. 460-461 (1870).

[2] *Indo-Australian Fish*, III, p. 228 (1916); see also Vaillant, *Notes Leyden Mus.*, XXIV p. 9, figs. 25, 26 (1902).

resembles *D. nasutus* in this respect, so far as can be judged from published figures.

Taking all these facts into consideration and further remembering that the peculiar structure of the pectoral fins found in *Psilorhynchus* is also found in *Homaloptera* and to a still greater degree of specialization in the Bornean genus *Gastromyzon*,[1] I am of the opinion that the resemblance between *Psilorhynchus* and *Discognathus* is to a large extent due to parallel evolution. In the species of the latter genus that live in comparatively still water (*i.e.* in the majority of species) it is superficial, while in those species that live in hill torrents convergence has certainly taken place. I am inclined to think, therefore, that both *Psilorhynchus* and *Discognathus* have been derived from a genus like *Crossochilus* or probably *Labeo*, but that their evolution took place independently, and that whereas the chief factor in the case of *Psilorhynchus* was rapid-running water in a rocky stream-bed, in *Discognathus* the primary factor was a peculiar mode of feeding. The close resemblance between such forms as *P. tentaculatus* and *D. nasutus* is due, if this be so, to secondary convergence. The resemblance between *D. quadrimaculatus* and *Crossochilus* may or may not be due to a real genetic relationship, while that between the former and *Psilorhynchus*, close though it seems at first sight, cannot be closer at most than that between distant cousins, so far as descent is concerned.

Molluscs.—The only mollusc found in the upper parts of the streams at Khandalla was *Ampullaria nux*. As we have pointed out in our systematic notes on the Mollusca collected on my tour, this species is modified for its peculiar habitat in respect to two characters: (1) its small size and (2) the curious development of the inner lip of the aperture of the shell. It is the only species of *Ampullaria* that I have seen in anything but still or at most very sluggish water. The columellar callus of the shell is a flattened ridge nearly two millemetres broad, and this ridge forms with the outer lip a continuous margin of attachment, enabling the shell to come into much closer contact with the rocks to which the animal attaches itself than is the case with the shells of more normal species that crawl on water-weeds. Only one living individual was seen, though broken shells were not uncommon in the streamlets and it is probable that *A. nux*, like many other species of its genus, conceals itself in the dry season. The one individual was attached to the rocky margin of a small pool densly shaded at all times of day and supplied by a small but perennial waterfall.

Paludomus obesa was found in some abundance in the same streams, but in a small plain where it was not shaded and had lost for a short distance its peculiar character as a mountain streamlet. It was feeding on algae covering stones.

Insects.—As I have already stated I can deal only with the Rhynchota of the streamlets. These fall from a bionomical point

[1] See Weber, *Indo-Australian Fishes*, III, p. 3, fig 1 (1916).

of view into three categories: (1) surface forms, (2) mid-water forms confined to still pools, and (3) bottom forms that can live in rapid running water. The list of species collected in the streamlets at Khandalla is as follows; I have distinguished the names of those that belong to the first category with an *, those of the species of the second category with a † and those of the species of the third category with a §.

*Rhagovelia nigricans.**	*Heleocoris elongatus.*§
*Ptilomera laticaudata.**	*Naucoris sordidus.*§
*Metrocoris ståli.**	*Erithares templetoni.*†

Even in dealing with the Rhynchota I think it will be better to defer a detailed discussion until it has been possible to investigate the structure of Indian aquatic insects more completely. I shall merely point out that the Hydrometridae of running water, in India at any rate, usually differ from those that live on the surface of pools and have either extremely long legs and bodies, as in *Cylindrostethus*, or else have the body short and rounded like that of the marine species, as in *Metrocoris*; while the species of *Heleocoris* are flattened and smooth and are thus well adapted to cling tightly to stones or to make their way beneath and between them. Such small, short-legged surface forms as *Rhagovelia* live at the edge of the stiller parts of the streamlets and are not perceptibly modified.

III. The Fauna of Damp Rocks at the Edge of Waterfalls at Khandalla.

Where the small streamlets near Khandalla are precipitated over the sheer basaltic cliffs that abound in the neighbourhood waterfalls of different heights are formed. The larger of these, where the water drops for some hundreds of feet, are practically inaccessible, but many smaller ones can be readily investigated in which hundreds of feet are represented by tens and the amount of water is by no means great.

The fauna of these waterfalls is of considerable bionomic interest, but what I have said in reference to insects of small streams has even greater force here. The fauna of the actual falls is perhaps exclusively entomological, its most conspicuous members being certain moth-larvae that spin their flattened cocoons on the rocks and certain caddis-worms that make bag-shaped reticulate snares of such strength that the water pours right through without breaking them. At the edge of the falls, however, at any rate in the dry season, a much larger and more varied fauna has established itself where the rock is kept wet with spray and the growth of algae is thus encouraged.

Here again insects predominate, but other animals also occur.

Batrachia.—Ixalus bombayensis is not uncommon in cracks in the damp rock, and *Rana limnocharis syhadrensis* may be found under stones at the bottom of the falls.

Molluscs.—Two species of molluscs, both belonging to highly peculiar genera probably of very limited range, have been described from the edge of the waterfalls at Khandalla. These are *Cremnoconchus* of the almost exclusively marine family Littorinidae and *Lithotis* of the semi-terrestrial pulmonate family Succineidae. Our knowledge of both these interesting genera is due primarily to the work of the late Dr W. T. Blanford.[1] In March *Lithotis* was entirely absent from the cliffs from which it was described. Its absence in the dry season is additional evidence for the belief that, like other members of its family, it is an air-breathing mollusc that can only exist in damp surroundings. In dry weather it probably conceals itself and aestivates. *Cremnoconchus syhadrensis*, on the other hand, was found in great abundance, but only at places where the cliff was shaded from the midday sun and supported a growth of the peculiar dull green filamentous alga on which it feeds. Some individuals were in an active condition, crawling and feeding in the spray of the falls; others, in drier places, were apparently quite torpid and had their opercula tightly closed. A number of individuals in both states were placed in jars of water. Some were prevented from reaching the surface. These were drowned in 24 hours, dying partially expanded. Others, placed in a jar with flat sides and only half full of water, crawled out after a short time. Their movements could be observed with great nicety through the glass. They moved upwards slowly. When out of the water the shell was closely applied to the glass except where the tentacles protruded in front, the ventral surface of the body-whorl being in contact with it as well as the rim of the aperture. The opening of the branchial cavity was patent, but was relatively small and had a somewhat lunate form. It could be easily seen that this cavity was full of water, and the animal took with it a film of water that surrounded the shell on the glass. After it had been moving about for some hours this film grew smaller and finally disappeared. The orifice of the branchial cavity was then shut, the foot retracted and the operculum closed. The mollusc remained for days in this condition, absolutely immobile, and probably would have so remained until it had been soaked with water. Although the glass on which it crawled was quite clean, it opened its mouth and thrust out its radula from time to time, as though trying to scrape off its food, so long as it remained active. Fig. 3, pl. IV, which shows the film of water, the open branchial orifice, etc., was drawn from a specimen brought alive but torpid to Calcutta and revivified by being placed in water.

Cremnoconchus seems, therefore, to be in a sense a water-breather, incapable of obtaining its oxygen direct from the air, but also incapable of obtaining it from water in the manner usual

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[1] Blanford, *Ann. Mag. Nat. Hist.*, (3) XII, p. 184 (1863), and (4) III, p. 343 (1869). For *Lithotis* see also Gude, *Faun. Brit. Ind. Moll.*, II, p. 457 (1914); for *Cremnoconchus*, Stoliczka, *Proc. As. Soc. Bengal*, 1871, p. 108.

in aquatic Prosobranchiate molluscs. It possesses both a gill and a branchial chamber with a small orifice that can be completely closed. The branchial chamber, however, is not transformed into a lung and is apparently never filled with air; breathing is effected by the absorbtion of atmospheric oxygen through a thin film of water. *Cremnoconchus* belongs to a family (the Littorinidae) of which other forms are maritime, rupicolous or even arboricolous and more or less amphibious. According to Pilseneer,[1] the branchial cavity of some species of *Littorina*, though not transformed into a lung like that of Pulmonates and though containing a gill, is filled with air when the animals are out of the water, and with water when they are submerged; while other species of the same genus "ménent ordinairement une véritable existence de Pulmoné." The physical modifications of the breathing apparatus found in *Cremnoconchus* are not very greatly different from those found in *Littorina*, but they *are* different and have a different function. In the former genus the branchial cavity is more of a closed chamber; the structure of the gill,[2] though essentially similar, is somewhat more simplified, its vascular outgrowths are less developed and the osphradium is still more reduced, having become papilliform instead of ridge-like. The small size of the branchial orifice and the completeness with which it can be closed are adaptations correlated with life in circumstances in which prolonged periods of desiccation occur. In these periods the animal is in a state of coma and probably requires little fresh oxygen, but the gill must be kept wet.

Insects.—The insect fauna of damp rocks at Khandalla is a rich one. In little ledges in which masses of damp algae grow or dead leaves accumulate numerous dipterous larvae of the families Tipulidae,[3] Chironomidae and Stratiomyidae occur, with small beetles belonging to the Staphylinidae, the Clavicornia and other groups. In cracks in the rocks the earwig *Forcipula quadrispinosa* and the Reduviid bug *Pirates arcuatus* are not uncommon, while Tettigine grasshoppers frequently alight on the algae coating smooth surfaces. I shall, however, say nothing of these, but merely draw attention to the great abundance of two species of water-bugs, *Hebrus bombayensis* and *Onychotrechus rhexenor*. The former runs about on the damp alga and takes readily to flight. It was also found on the surface of water at Medha, and exhibits no particular modification for life on rocks. *Onychotrechus* is a genus which, so far as my experience goes, is always found either on damp rocks or on the surface of small rocky streams.[4] It differs from its nearest ally *Gerris*, which always

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[1] Pelseneer, *Arch. de Biol.*, XIV, p. 356 (1895).

[2] Stoliczka, *Proc. As. Soc. Bengal*, 1871, p. 108, fig. 1.

[3] An adult fly of this family found beneath a stone on a ledge in one of the waterfalls has been identified by Mr. Brunetti as a new species of *Antocha*.

[4] Mr. Green's remarks on *O. vadda*, Dist. (quoted by Distant on p. 147 of Vol. V of the "Fauna" volumes on the Rhynchota) would apply equally well to *O. rhexenor* at Khandalla.

lives on the surface of water, and as a rule, though not invariably, of still water, in the structure of its feet, more particularly of those of the two hinder pairs of legs. On these feet there is in *Gerris* a pair of slender, almost bristle-like claws, which are situated at the tip of the limb; some distance in front of them, on the lower surface, there is a large bristle, but there is no definite empodium and the whole structure is degenerate. In *Onychotrechus* the claws are real claws, of a horny consistency, curved towards the tips, sharply pointed and flattened from side to side; they are separated from the extremity of the limb by several strong bristles and small processes perhaps of a sensory nature; similar processes also occur just behind the claws, and between them protrudes a coiled band-like empodium. These structures deserve a more detailed examination. I refer to them here merely to indicate that the foot is modified in this genus to enable it to cling to slippery surfaces, while in *Gerris*,[1] which apparently does not use the claws of its hinder legs at all, they are degenerate. There is less difference between the anterior feet of the two genera, both of which probably use them for grasping prey, but even in these feet the claws of *Onychotrechus* are much stronger and larger than those of *Gerris*. These facts are illustrated in figures 8 and 9 on plate III, drawn on the same scale from insects of approximately the same size.

Oligochaeta.—Small white worms of the family Naiadae are abundant in damp algae on the cliffs.

The fauna of these cliffs, where they are wet with the spray of waterfalls, includes, therefore, highly modified forms among both the Mollusca and the insects. The latter are still imperfectly known, but there is every reason to think that a proper entomological investigation of the waterfalls would have great biological interest.

IV. SOME FROGS FROM STREAMS IN THE BOMBAY PRESIDENCY.

Only three species of frogs were found at the edge of the streams investigated at Medha and Khandalla. They are *Rana cyanophlyctis*, an undescribed race of *R. limnocharis* for which I propose the subspecific name *syhadrensis*, and an undescribed species of *Ixalus*, which I have called *I bombayensis*. Both new race and new species are abundant in the Bombay Ghats. The *Ixalus* has been found in the North Canara, Satara and Poona districts, the race of *R. limnocharis* in the two latter and also in the Nasik district; neither form is known to occur at altitudes below 2,000 or above 4,000 feet.

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[1] I have seen a species of *Gerris* clinging to rocks at the edge of the Bhavani river by means of its anterior claws. It could not, however, run about on the slippery surface.

Rana cyanophlyctis, Schneider.

This frog, one of the commonest species in the plains of India, is found only in the immediate neighbourhood of water. It is equally at home in puddles of rain-water, ponds and streams, but does not frequent the smaller mountain streamlets. So far as my own observations go, it is the only species that skips over the surface of the water as *R. limnocharis* is sometimes stated, I believed incorrectly, to do. The habit was first noted in literature by the Emperor Bābur[1] in the year 1525-1526. *R. hexadactyla* may have the same habit when young, but when full grown is probably, as Dr. Henderson points out in a letter, too heavy an animal.[2] *R. cyanophlyctis* is frequently seen in wells and in pools with a steep margin. In such conditions it floats on the surface of the water, but when a resting place is available it usually sits at the edge. When disturbed it gives a short leap, horizontally

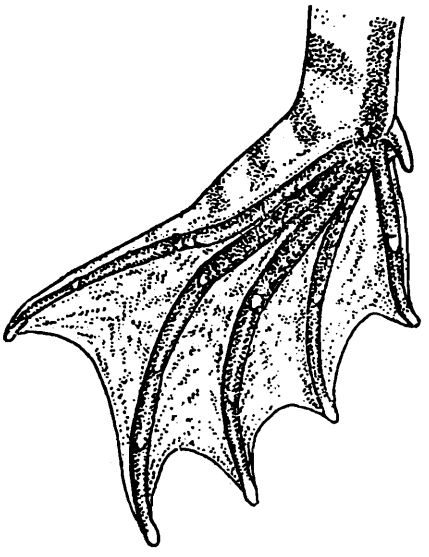

FIG. 2.—Hind foot of *R. cyanophlyctis* (enlarged).

rather than upwards, and strikes the surface of the water with its short, broad, slightly cup-shaped and stoutly webbed hind feet (fig. 2) at such an angle that it is again propelled forwards through the air for some inches; it then again strikes the water in the same way, and the manoeuvre may be repeated as many as seven times. When the impetus is exhausted, as it usually is after a couple of yards or at most 10 feet—the Emperor's observation was not strictly accurate—the frog dives obliquely forwards to the

[1] He says in his "Memoirs," "The frogs of Hindustan, though otherwise like those others (Tramontane) run 6 or 7 yards on the face of the water." See *The Memoirs of Emperor Bābur*, translated by Annette S. Beveridge, fasc. III, p. 503 (1918).

[2] Since this was written I have been able to observe *R. hexadactyla* in Madras. The adult usually sits among weeds in the water, where its bright green colour conceals it to some extent. When disturbed it dives through the weeds but if they are too thick it skips feebly two or three times.

bottom. If this be soft it burrows into it with its fore feet, impelling itself forwards at the same time by vigorous kicks of its hind legs. It makes its way more or less completely into the mud or sand but does not attempt to go downwards. After remaining buried or half buried for a few minutes, it backs from its temporary burrow and rises cautiously to the surface. If no danger threatens it then swims ashore. I have often seen a frog dive direct into the water from a stone or rock and then leap out and skip two or three times. When living at the edge of a stream it dives against the current, and often has difficulty in reaching the bottom. Its swimming stroke is, however, very powerful; it is the only frog with the habits of which I am acquainted that habitually swims upstream.

R. cyanophlyctis is abundant at the edge of the Yenna at Medha and also at that of ponds and of the larger streams, where they traverse fairly level ground, at Khandalla. It evidently prefers pools or streams of which the bottom is soft. It appears rapidly in isolated temporary pools and must make its way overland by night; I have never seen it except at the edge of water by day.

Rana limnocharis, subsp. syhadrensis, nov.

This is a dwarfed race akin to the subsp. *niligiraca* but of much smaller stature and with the hind limbs as a rule shorter. The first finger hardly extends beyond the second; the hind feet are as in the typical form except that the webbing is slightly less extensive and the tibio tarsal articulation reaches the anterior border of the eye or a point between it and the tip of the snout. The dorsal surface is grey with black spots sometimes with a reddish suffusion; a narrow pale mid-dorsal line is often present; the ventral surface is white; with the whole of the throat black in the adult male. The length does not exceed 3·5 cm.

Measurements in millemetres.

	(type) ♂	♀
Snout to vent	27	31·5
Length of head	11	12·5
Width of head	9·5	11
Snout	4 5	6
Eye	3·4	3·4
Interorbital breadth	2·8	3
Tympanum	1·7	2
Fore limb	13·2	16
1st finger	4	5
2nd finger	3·8	4·5
Hind limb	42·7	45·8
Inner metatarsal tubercle	2	2·3
Middle toe	11	12

Type-specimen.—Rept. No. 19764, Z.S.I. (*Ind. Mus.*).

Geographical Range.—This little frog is abundant in the hills and elevated valleys of the middle region of the Bombay Presidency. I have examined specimens from several places in the Satara district at altitudes between 2,000 and 4,000 feet; also from Khandalla (2-3,000 feet) in the Poona district and from Igatpuri (2,000 feet) in the Nasik district. Apparently the typical *R. limnocharis* is absent from these localities.

Ixalus bombayensis, sp. nov.

(Plate I, fig. 1).

Tongue with a free pointed papilla, often inconspicuous, in the anterior part of the median line. Snout rounded, as long as or a little longer than the orbital diameter; canthus rostralis distinct; loreal region concave; nostril much nearer the tip of the snout than the eye; eye very large and prominent; *interorbital space broader than the upper eyelid*; tympanum small, hidden. Fingers free; *toes not more than one third webbed*; disks and subarticular tubercles moderate; a fairly large but by no means prominent oval inner metatarsal tubercle; outer toes slightly fringed. The hind limb being carried forward along the body, the tibio-tarsal articulation reaches the eye. *Skin more or less distinctly rugose*[1] *above, bearing small, scattered pointed warts or tubercles*; *upper eyelid tubercular*; throat and chest smooth; belly coarsely granular; a fold from the eye to the shoulder; a low ridge, sometimes broken up into a series of tubercles, on the mid-dorsal line of the head. The adult male with a very large gular pouch.

Colouration variable; dorsal surface dark brown or grey speckled with black, sometimes almost entirely occupied by a large dicebox-shaped mark of pinkish buff edged and speckled with black; a dark pale-edged cross-bar often present between eyes; sides dark, spotted and blotched with dull yellow; a large black and lemon-yellow mark in front of the groin in adults; limbs pale grey more or less irregularly cross-barred with black; hind part of thighs mottled with black and dull yellow; ventral surface greenish-yellow suffused with black.

Length not exceeding 3 cm.

Type-specimen.—Rept. No. 18782, Zool. Survey of India (*Ind. Mus.*), from Castle Rock.

Geographical Range.—Hills of the Bombay Presidency from N. Canara (Castle Rock) to the Satara (Khas) and Poona (Khandalla) districts at altitudes between 2,500 and 4,000 feet.

The species is closely allied to *I flaviventris*, Boulenger,

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[1] In the specimen figured on pl. I it is smoother than usual. This specimen is the only fully developed adult male in the series examined.

whose description of that species I have followed closely, italicizing the more important differences. I have examined a large series of specimens.

I. bombayensis is common at Khas (where it occurs with *I glandulosus*) and Khandalla; Mr. Kemp found a single specimen at Castle Rock. It is evidently nocturnal in habits and in the daytime its pupil is often reduced to a very narrow transverse slit. It hides under stones in damp places at the edge of small streams and in cracks in rocks kept wet by the spray of waterfalls.

V NOTES ON FRESHWATER FISH MOSTLY FROM THE SATARA AND POONA DISTRICTS.

Fish of the following species were collected in the Yenna at Medha in February and March:—

Euglyptosternum saisii (Jenkins).
Lepidocephalus thermalis (C. & V.)
Nemachilus botia (Ham. Buch.).
Nemachilus savona (Ham. Buch.).
Nemachilus anguilla, sp. nov.
Psilorhynchus tentaculatus, sp. nov.
Discognathus lamta (Ham. Buch.), Day.
Cirrhina reba (Ham. Buch.).
Barbus malabaricus, Jerdon.
Barbus kolus, Sykes.
Barbus ticto, Day.
Rasbora daniconius (Ham. Buch.).
Barilius bendelisis (Ham. Buch.).
Danio aequipinnatus (McCl.).
Chela boopis, Day.
Mastacembelus armatus (Lacép.).
Ophiocephalus gachua, Ham. Buch.
Gobius bombayensis, sp. nov.

About several of these fish, having put on record their occurrence in the head waters of the Kistna, I have nothing further to say.

In small hill streamlets at Khandalla I obtained three species of fish:—*Nemachilus evezardi*, Day; *Psilorhynchus tentaculatus*, sp. nov. and *Discognathus nasutus* (McCl.). These I have already discussed at some length (pp. 113–117).

In addition to my own collection I have before me some interesting specimens of *Barbus* from the Satara district, sent me by Mr. C. D. McIver of the Public Works Department, a very keen student of the local fish-fauna. To these I shall refer, and with them to an interesting specimen of the same genus recently sent to the Indian Museum from Gauhati on the Brahmaputra by Mr. T. R. Phookun on behalf of the late Chief Commissioner of Assam.

I shall also discuss the Indian species of the genus *Discognathus*, so far as the material at my disposal permits me to do so.

Family SILURIDAE.

Euglyptosternum saisii (Jenkins).

1910. *Glyptosternum saisii*, Jenkins, *Rec. Ind. Mus.* V, p. 128, pl. vi, fig. 6.

A specimen from the Yenna (Vena) River at Medha in the Satara district agrees well with the type-specimens from Paresnath in Bihar except in being much larger; its total length is 121 mm.

In general facies the species resemble *Euglyptosternum* rather than *Glyptosternum* and I find that both in Dr. Jenkin's specimens and in my own microscopic horny teeth are scattered on the palate. They are, however, attached to skin and not to the bone and are not arranged in any definite manner. The tooth-band on the upper jaw is narrow as in *Glyptosternum*. I have examined the palate of *E. lineatum* and of several species of *Glyptosternum* and cannot discover any trace of scattered teeth.

Family CYPRINIDAE.

Lepidocephalus thermalis (C. and V.).

1889. *Lepidocephalicththys thermalis*, Day, *Faun. Brit. Ind., Fishes*, I, p. 221.

Weber[1] has shown that the clumsy generic name by which this fish and its congeners were known to Day may be abbreviated to *Lepidocephalus*.

L. thermalis is characteristic of Peninsular India and Ceylon as distinct from the Indo-Gangetic river-systems. It is not uncommon in the Yenna River

Nemachilus evezardi, Day.

(Plate I, figs. 2, 2*a*).

1878. *Nemachilus evezardi*, Day; *Fishes of India*, II, p. 613, pl. cliii, fig. 11.

1889. *Nemachilus evezardi*, Day, *op. cit.*, p. 226.

Hitherto known from a single specimen (now in the Indian Museum) from a stream near Poona, this little loach is actually one of the commonest species in small streamlets in the Bombay Ghats. I obtained numerous specimens at Khandalla in the Poona district and my assistant Mr. J W Caunter collected others at Khas in the Satara district, while Mr. E. A. D'Abreu of the Nagpur Museum has recently sent me one from Pachmhari in the Central Provinces. All these places lie between 2,000 and 4,500 feet above sea level.

The species is stated by Day to differ from all other Indian species of its genus in possessing a pair of nasal barbels. These

[1] *Indo-Australian Fishes*, III, p. 27 (1916).

are merely prolongations of the processes that always occur between the two nostrils on either side of the head. The colouration of the fish varies considerably in different parts of the same streamlet. When the bottom is sandy the dark bars or spots on the sides are much less strongly marked than where it is of a dark colour.

At Khandalla I found *N evezardi* with *Discognathus nasutus* and a new species of *Psilorhynchus* in hill streamlets nowhere more than a few feet in breadth. It frequented small pools, taking the place occupied by *N montanus* in similar streamlets in the Eastern Himalayas.

Nemachilus savona (Ham. Buch.).

This loach is common in many of the smaller rivers of Peninsular India and the Indo Gangetic plain. I obtained several specimens from the Yenna River at Medha.

In fresh specimens the head and forequarters are of a rather bright olivaceous green, obscurely mottled; the posterior part of the body is of the same colour but with a variable number of pale vertical bars, which vary greatly in breadth but are always narrower than the green interspaces. A purplish black band embraces the posterior extremity of the caudal peduncle and there is a black spot at the root of the dorsal fin in front. This fin is opaque white with seven longitudinal rows of small black spots, while the caudal has similar rows of black spots arranged vertically.

Nemachilus botia (Ham. Buch.).

1878. *Nemachilus botia*, Day, *op. cit.*, p. 614, pl. clvi, fig. 5.
1889. *Nemachilus botius*, Day, *op. cit.*, p. 227.

This fish is perhaps the most widely distributed of the Indian species of the genus. It occurs in small streams all over northern and central India and also on the Shan Plateau, and is not absent from the Kistna as Day thought.

Specimens from Medha agree with Day's var. *aureus* in that the lateral line disappears behind the dorsal fin, but the number of rays in that fin seems to be variable.

Nemachilus anguilla, sp. nov.

(Plate I, fig. 3; plate III, fig. 1).

D. 10 (2/8). P. 13. V 8. A 6 (2/4).

Habit elongate, shallow and somewhat compressed; total length $5\frac{1}{3}$ to $5\frac{1}{2}$ times that of head, $4\frac{3}{4}$ that of caudal fin, about 9 times the greatest depth of the body. Head narrow, conical; snout bluntly pointed, with 6 slender and rather short barbels, the rostral pair of which extend backwards almost as far as the anterior border of the eyes, while the outer maxillary pair almost

reach their posterior border. Lips greatly swollen, corrugated; the upper lip with two short, stout digitiform processes in front; the lower lip interrupted in the middle line, with two or three longitudinal ridges on either side; mouth entirely ventral. Eye large and prominent, situated dorsally near the middle of the length of the head.

Pectoral fins long and narrow, extending backwards about $\frac{2}{3}$ the distance between their own roots and those of the ventrals; ventrals narrow, extending backwards about the same distance towards the anal; anal very short, a little deeper than the body; dorsal short, a little higher than the body, with its upper margin nearly straight but sloping rapidly downwards and backwards; caudal very long, deeply emarginate, with the two halves pointed. Scales small, absent from the head, hardly distinguishable on the ventral surface of the body. Lateral line complete or nearly so.

Natural colouration.—Head and body dull golden yellow; tip of snout scarlet; numerous transverse bars of dark olive green, usually broader than the interspaces, across the back; a row of large blackish spots or blotches running along the mid-lateral line and sometimes coalescing, extended on to the caudal fin. Fins yellowish; dorsal with an anterior scarlet border and caudal broadly edged both above and below with the same colour. Red markings evanescent.

I have examined three specimens, the largest of which is 57 mm. long.

Type-specimen.—F $\frac{9692}{1}$, *Zool. Survey of India* (*Ind. Mus.*).

Locality.—Yenna River at Medha, Satara district, Bombay Presidency.

Psilorhynchus tentaculatus, sp. nov.

(Plate I, figs. 4, 4*a*; plate III, fig. 2).

D. 9-10 (3/6-7). P. 15. V. 9. A. 6 (2/4). L. l. 37. L. t. 6/3½.

A very distinct species, distinguished from *Ps. balitora* by the possession of a pair of rostral barbels, by the fact that the dorsal fin commences immediately above the ventrals, etc.

Size small; back moderately elevated; ventral surface flat. Total length 5 to 5½ times length of head, about 5 times length of caudal fin and 4½ to 5 times greatest depth of body. Eye 2¾ to 3½ times in length of head. A pair of short barbels on the snout. Upper lip long, fringed, plicate; lower lip bilobed, covered with minute tubercles. Five outer pectoral rays undivided, flattened; pectoral not nearly reaching root of ventral when adpressed; ventral a little longer than in *P. balitora*, with a small fleshy appendage at its root in the male; anterior border of dorsal immediately above that of ventral; the last undivided dorsal ray considerably shorter than the first branched ray; caudal bilobed, the lobes rounded. Lateral line complete, running along caudal peduncle. The pharyngeal bones very slender; their teeth long,

narrow and pointed, 11 in number, arranged in three rows, 2 in the outer row, 5 in the middle row and 4 in the inner row, grouped close together on a very distinct outward protuberance of the bone; the two outer teeth less sharply pointed than the others. The air-bladder well developed and distinctly divided into two parts.

Head and body dark purplish-grey or black, paler immediately above and below mid-lateral region; ventral surface white; operculum strongly iridescent, edged with white behind; a black horizontal bar or spot on the caudal peduncle edged with white posteriorly; fins whitish; dorsal more or less infuscated and with a black spot on each branched ray, caudal with its central part infuscated and with a vertically oval black spot at its base.

My largest specimen is less than 45 mm. long.

Type-specimen —F. 9695/1, *Zool. Survey of India* (*Ind. Mus.*).

Distribution.—Abundant in small hill-streamlets at Khandalla in the Poona district (2-3,000 feet), less common in the Yenna River at Medha in the Satara district (2,000 feet).

Genus **Discognathus**, Heckel.

(Plate II, figs. 1-3).

1868. *Discognathus*, Günther, *Cat. Fishes Brit. Mus.* VII, p. 68.

Both the name and the species of this genus have been subjected to many vicissitudes and the Indian forms are still imperfectly known The earlier writers on Indian ichthyology, notably Buchanan and McClelland, described a considerable number of so-called species that would now be placed in the genus, but they paid little attention to sexual differences or individual variation and their descriptions were too brief to be definitive. Day in his *Fishes of India* (1878) and his volume in the *Fauna of British India* (1889) recognized three species, *D. lamta* (Ham. Buch.), *D. jerdoni* and *D. modestus*. Günther, however, in his British Museum Catalogue (1868), though he also recognized three Indian species, gave them different names and different definitions: he called them *D. lamta*, *D. macrochir* and *D. nasutus*. Jenkins (*Rec. Ind. Mus.* III, p. 291: 1909), with Day's specimens before him, was of the opinion that they represented a single species, possibly with local varieties, while I pointed out in 1913 (*Journ. As. Soc. Bengal*, n. s. IX, p. 36) that a considerable number of forms occurred in different parts of the Indian Empire that were at least worthy of racial distinction. In the meanwhile Vinciguerra [1] had not only discussed the form he believed to be Buchanan's *Cyprinus lamta* but had also described a very distinct Burmese species under the name *D. imberbis*. Finally, in the early part of the present year, I was able to provide evidence that two distinct species occurred in the Southern Shan States and that one of them was the *D. lamta* of Day (*Rec. Ind. Mus.* XIV, p. 45).

[1] *Ann. Mus. Stor. Nat. Genova* (2) IX (XXIX), pp. 275-280, figs. (1889).

Since I discussed the collection from the Inlé Lake I have had an opportunity of examining a large series of fresh and well preserved specimens of the two commonest Indian forms from the Deccan and elsewhere. The names most convenient for these two forms are *D. lamta*, Day and *D. nasutus* (McClelland). I give Day and not Buchanan as the author of the former, because it is impossible to be sure as to the species to which Buchanan first applied the name *Cyprinus lamta*; his original figures in the library of the Asiatic Society of Bengal cast no light on the subject.

A great deal of the uncertainty about the Indian species of the genus has arisen from the fact that the marked and constant structural characters which separate these two forms are to some extent concealed by bad preservation of specimens. The essential differences between *D. lamta* and *D. nasutus* (= *D. modestus*, Day) are correlated with the fact that whereas the former lives in the pools of larger streams in or near the plains or even in upland lakes, the latter is an inhabitant of mountain torrents. In *D. lamta*, although the fish can cling to vertical surfaces by means of its mental disk, the abdomen is not flattened, the pectoral fins are set obliquely on the sides of the body and the rays are not greatly flattened or expanded. In *D. nasutus* on the other hand the fins and chest are modified to form an organ of adhesion, as is well shown in fig. 2*a*, pl. II. Unless great care is exercised in preserving specimens of *D. lamta*, however, the ventral surface collapses and though the structure of the pectoral fins remains of course unchanged, their relations to the chest and to one another are distorted. The form I describe here as *D. gravelyi* is allied to *D. lamta*, from which it differs in outline, in the shape of the head and in the form of the mental disk.

The form Day called *D. jerdoni* seems to me to be distinguished from *D. lamta* by characters which are quite apparent when adult specimens are compared.[1] They lie mainly in the shape and proportions of the body and the relative size of the head and eye.

D. macrochir (McCl.) from Assam is evidently allied to *D. nasutus*, but may be distinct.

Two forms of the genus occur in Syria and Mesopotamia. One of these (*D. rufus*, Heckel) I regard as a variety of *D. lamta*, while the other (*D. variabilis*,[2] Heckel) differs from all the Indian forms in having only one pair of barbels. A form has been described from Southern Arabia and the Punjab Salt Range the male of which bears a forwardly directed tubercular appendage on the

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[1] Since this paper was written I have examined a good series of fresh specimens from the Bhavani River at the base of the Nilghiris. They fall definitely into three species, two of which are distinguished from all those included in my key by the possession by the adult male of a conical tuberculate process between the nostril. I hope to discuss this new material shortly.

[2] This species also occurs in the Helmand basin, possibly within the limits of the Indian Empire. See Tate Regan, *Journ. As. Soc. Bengal*, (n.s.) II, p. 8 (1906).

head, but no specimens of this form are at present in Calcutta. The only species known from the Malay Archipelago is *D. borneensis*, Vaillant, which has larger scales than any Indian species.

Key to the Asiatic forms of Discognathus *at present described.*

I. No barbels. L.L. 44 ... ... *D. imberbis.*
II. Two barbels. L.L. 38-40 ... ... *D. variabilis.*
III. Four barbels. L.L. 28 ... ... *D. borneensis.*
IV. Four barbels. L.L. 32-36.
A. Pectoral fins entirely horizontal, with their rays broad and flat; chest flat, without scales.
1. Pectoral fins longer than head, their tips extending nearly to base of ventrals ... *D. macrochir.*
2. Pectorals hardly longer than head, their tips not approaching the base of the ventrals ... ... *D. nasutus.*
B. Pectoral fins set obliquely on the sides of the body; chest convex, with scales.
1. Pectoral fins longer than head, their tips approaching the base of the ventrals; eye much nearer margin of opercle than tip of snout; 2nd dorsal fin-ray slender ... *D. gravelyi.*
2 Pectoral no longer than head, not approaching base of ventrals; eye near middle of head; 2nd dorsal fin-ray stout.
a. Posterior barbels longer than anterior; pectorals directed backwards and upwards, arising some distance from ventral surface .. ... *D. lamta* var. *rufus.*
b. Barbels subequal, anterior pair usually a little longer; pectorals directed backwards and a little downwards, arising immediately above ventral surface.
i. Length of head 5 to 5½ times in total length; dorsal profile convex in adult male ... *D. lamta (s.s.)*
ii. Length of head 6 to 6½ times in total length; dorsal profile nearly straight in adult male ... ... *D. jerdoni.*

Discognathus lamta (Ham. Buch.), Day.

(Plate II, figs. 1, 1*a*).

1841. *Chondrostoma mullya*, Sykes, *Trans. Zool. Soc. London*, II, p. 359.
1889. *Discognathus lamta*, Day, *Faun. Brit. Ind. Fish.*, I, p. 246, fig. 87.
1909. *Discognathus lamta*, Jenkins, *Rec. Ind. Mus.*, III, p. 291 (in part).
1913. *Discognathus lamta*, Annandale, *Journ. As. Soc. Bengal*, (n.s.) IX, p. 36, fig. 1.
1918. *Discognathus lamta, id., Rec. Ind. Mus.*, XIV p. 45.

The form to which I give this name is certainly the *D. lamta* of Day, but there is some doubt as to whether Buchanan's *Cyprinus lamta* was not rather the form called *D. modestus* by Day and *Platycara nasuta* by McClelland. In any case, as the point cannot be settled satisfactorily, it is best to accept Day's nomenclature so far as *D. lamta* is concerned.

In this species the abdomen is naturally convex (it is apt to collapse in preserved specimens) and the pectoral fins are set on the sides of the body a short distance above the ventral surface and somewhat obliquely. These fins, though sometimes as long as the head, are usually a little shorter; the distance between their tips and the base of the ventrals is about ½ their own length; they are not greatly expanded and only the outermost ray is simple and flattened. The eye is variable in size even in specimens from precisely the same locality, but its length is usually contained at least very nearly 5 times in the length of the head; its upper border is situated considerably below the upper profile of the head. The upper profile of the body is arched. A broad but shallow depression runs across the snout of the adult male a little in front of the eyes and the region immediately in front of and behind it is covered with prominent tubercles.

D. lamta is common in the river at Medha, where it is captured in considerable numbers for food by fishermen using cast-nets. Specimens are very similar to those recently obtained in the Shan States (*op. cit.*, 1918), but perhaps a little darker in colour. The largest collected is 152 mm. long. The sides and back of the head and body are dark olivaceous green. Traces of a darker mid-lateral stripe extending on to the caudal fin can be detected, and of a small dark spot just behind the upper angle of the opercle. The free border of the opercle is paler and the ventral surface yellowish. The fins are pale olivaceous.

Discognathus jerdoni, Day.

1889. *Discognathus jerdoni*, Day, *op. cit.*, p. 247.

This species is distinguished from the former by the following characters:—

(*a*) The head is relatively smaller.
(*b*) The eye is as a rule larger in proportion to the head.
(*c*) The pectoral fin is much shorter than the head and its tip is further removed from the root of the ventral fin.
(*d*) The body is less elevated, the dorsal and ventral profiles being nearly parallel in the adult male.

I can detect no real difference in the scales and fin-rays.

Discognathus nasutus (McClelland).

(Plate II, figs. 2. 2*a*).

1839. *Platycara nasuta*, McClelland, *As. Res.* IX(2) (*Ind. Cypr.*), p. 300, pl. lvii, fig. 2.
1871. *Mayoa modesta*, Day, *Journ. As. Soc. Bengal* (2)XL, p. 108, pl. ix, fig. 2.
1889. *Discognathus modestus*, Day, *op. cit.*, p. 247.
1890. *Discognathus lamta*, Vinciguerra, *Ann. Mus. St. Nat. Genova* (2)IX, p. 270, fig.

McClelland's figure is a somewhat exaggerated presentiment of an adult male of this form, which must be accepted as specifically distinct in that it exhibits quite definite and constant structural modifications. It differs from *D. lamta* in the following characters :—

(*a*) The head is flattened and depressed in such a way that the upper border of the eye is practically co-terminous with the upper profile. The whole of the upper profile is straight and horizontal.

(*b*) The abdomen is flat, and the chest is both flattened and expanded.

(*c*) The adhesive organ on the lower lip is much larger.

(*d*) The pectoral fins are enlarged and expanded, being always longer than the head and separated when adpressed from the ventrals by a distance less than half their own length. They are set on the body horizontally at the junction of the ventral and lateral surfaces and form with the chest an organ of adhesion.

(*e*) Several of the outer pectoral rays are simple and flattened.

(*f*) The whole of the dorsal and lateral surfaces is nearly black, the ventral surface dead white.

(*g*) The length rarely if ever exceeds 110 mm.

This species is found only in small hill streamlets. It occurs in the Himalayas, the hills of Assam, the Western Ghats, the hills of the Central Provinces and probably those of Burma. Vinciguerra's figure cited above seems to represent this species rather than *D. lamta*, but probably he had examined specimens of both.

Discognathus gravelyi, sp. nov.

(Plate II, figs. 3, 3*a*).

Having now been able to compare good series of well-preserved specimens of *D. lamta* from districts so far apart as the Shan States and the Deccan, and having found certain differential characters quite constant, I no longer hesitate to describe the new species referred to in my recent account of the fish of the Inlé Lake (*Rec. Ind. Mus.* XIV, p. 45 : 1918). It is distinguished from *D. lamta* by the different shape and the larger size of its mental disk, by the different shape of the head, by its larger scales and apparently also by difference in the formulae of the fin-rays.

D. 10(2/8). P. 14. V 8. A 7(2/5). L. tr. $3\frac{1}{2}/3$.

The total length is $5\frac{3}{5}$ times the greatest depth of the body and a little more than 5 times the length of the head. The length of the eye, which is large and prominent, is contained a little more than $4\frac{1}{2}$ times in that of the head. The snout is somewhat produced and in the adult male there is a deep but narrow

transverse groove just behind the tip. The dorsal profile slopes abruptly from a point a little in front of the dorsal fin to the tip of the snout and, although the head is not flattened, the upper border of the orbit is practically co-terminous with its upper surface; behind the dorsal fin the profile is highly convex. The upper lip is very broad, the lower lip greatly enlarged, the mental disk large and subcircular; the fringe of the lower lip broad, with the margin semieircular. In the adult male there is a semicircle of glandular openings beneath and behind the eye. There are four short barbels, those at the angle of the mouth being particularly small. The ventral surface is convex and the scales extend all over the chest. The pectoral fins are longer than the head and broad in proportion, but they are lateral and oblique. They extend backwards almost as far as the base of the ventrals, but their rays are not flattened and expanded The ventrals are also large and almost reach the anal when adpressed. The caudal is deeply forked and the upper lobe is a little smaller than the lower. The dorsal is short; its unbranched rays are slender and not at all ossified, but the second is longer than the head.

Colouration.—Head and body purplish-brown, with a darker mid-lateral streak and a dark horizontal lunate mark on the caudal peduncle; ventral surface slightly paler; pectoral fins infuscated, with pale edges; other fins pale yellowish clouded towards the base with a dusky brown.

The only specimen I have seen, an adult male, is 112 mm. long.

Type-specimen.—F 9694/1, *Zool. Survey of India* (*Ind. Mus.*).

Locality.—Stream at He-Ho, Yawnghwe State, Southern Shan States, Burma: alt. 3,800 feet.

The type-specimen was taken with typical specimens of *D. lamta.*

Genus **Barbus**, Cuvier.

There are few genera among the freshwater fish that have received greater difference of treatment from different ichthyologists than this. Day in his works on Indian ichthyology recognizes three subgenera or groups of species, while Boulenger in his "Fishes of the Nile" and in his recent monograph of the freshwater fishes of Africa divides the genus into a number of sections for which he does not provide names. Weber, on the other hand, in the third volume of his "Indo-Australian Fishes" recognizes a number of distinct genera among the species placed in *Barbus* by other authors, but denies the occurrence of *Barbus s.s.* in the Malay Archipelago. So far as specific limits and definitions are concerned there is still much confusion among the Indian species, and this is the case not only with rare and inconpicuous forms but even with some of the largest and most conpicuous. Indeed, there is no group in which confusion is greater than that of the Mahseer so familiar to Indian sportsmen.

I have not the material to attempt a revision of the Mahseer group, specimens of which are difficult to preserve in large series on account of their size, but two species have recently come to my notice which it seems justifiable to rescue from the oblivion of synonymy as they possess differential characters of a marked nature and likely to be constant. These species are *Barbus putitora* (Ham. Buch.) and *Barbus mussullah*, Sykes. That Hamilton's *mossul* and Jerdon's *hamiltonii* differ in some respects from the *forma typica* of *Barbus tor* the collection in the Indian Museum provides abundant evidence, while specimens from the upper Kistna seem to differ from any of these; but the question whether the differences should be considered specific or merely racial must be left to be answered with more extensive experience.

Another group of species in which confusion exists so far as the Indian forms are concerned is that popularly called Carnatic Carp. It is, indeed, doubtful how far this designation has any scientific basis, for certain species so called have no more than a distant resemblance to *Barbus carnaticus* (Jerdon).

I have nothing particular to say about the species of *Barbus* (*B. malabaricus*, *B. kolus* and *B. ticto*) that I obtained at Medha myself, but Mr. McIver has sent me specimens of three species from the Kistna near Satara that are of considerable interest. Two of these may be called Mahseer, while the third is known locally as the Carnatic Carp.

Barbus tor (Ham. Buch.).

(Plate III, figs. 3, 3*a*).

It is not yet possible to discuss the races or species of the Mahseer, of which six or seven probably exist in different parts of the Indian Empire, in a satisfactory manner. Specimens sent me from the Kistna River near Satara by Mr. McIver certainly differ both from the north Indian and the south Indian forms and probably represent an undescribed race, which has only 3 rows of scales above the lateral line and 12(3/9) dorsal fin-rays. Mr. McIver informs me that it grows to a large size.

Barbus mussullah, Sykes.

(Plate III, figs. 4, 4*a*).

1841. *Barbus mussullah*, Sykes, *Trans. Zool. Soc., London* II, p. 356, pl. lxi, fig. 4.

Sykes's description of this fish is inadequate and his figure inaccurate, but he refers to and illustrates one trivial but apparently constant character that gives me confidence in identifying specimens sent by Mr. McIver. This character is the presence under the eye of a group of small tubercles not confined to one sex and visible with the aid of a lens in quite young fish.

A more important differential character, not recognized by Sykes but shown in his figure, is, however, to be found in the

structure of the mouth, the opening of which is much more oblique than in any race of *Barbus tor*. The extremity of the maxillary lies directly under the middle part of the eye. This feature is well shown on plate III. There are 13 (3/10) dorsal and 8 (3/5) anal fin-rays; 25-26 scales in the lateral line, 4 rows of scales above it and 3 below.

B. mussullah is common in the upper Kistna, where it occurs with the local race of *B. tor*. The Maharatta fishermen of Satara never fail to distinguish the two species. *B. tor* they call *Kudis*; *B. mussullah*, *Masundi*. Mr. McIver, to whom I am indebted for this information, has caught a specimen of the *Masundi* 21 lbs. in weight.

Barbus putitora (Ham Buch.).

(Plate III, fig. 5).

1822. *Cyprinus putitora*, Hamilton, *Fishes of the Ganges*, p. 303.

Having received some time ago a large *Barbus* from Gauhati in Assam that was evidently related to but distinct from any of the races or species at present included under the name *Barbus tor*, I have made a careful examination of it and have compared it with the specimens labelled by that name in the collection of the Indian Museum. From these specimens it differs not only in shape and proportions but also in having only two undivided rays in the dorsal fin and only 15 rays in the pectoral fins. As these characters are given by Hamilton among those proper to his *Cyprinus putitora*, I have little doubt that our specimen is identical with that form and must be called *Barbus putitora*. It may be redescribed as follows:—

D 10-11 (2/8-9). P. 15. V. 9. A 7 (2/5). L. l 27. L. tr. $3\frac{1}{2}/2\frac{1}{2}$.

The habit is stout and though the body is somewhat compressed it may almost be described as subcylindrical; its depth is contained only a little more than 4 times in the total length. The length of the head is contained between $4\frac{1}{2}$ and $4\frac{3}{4}$ times in the total length and is thus distinctly less than the greatest depth of the body. The snout is blunt and very little declivous; the length of the part of the head in front of the eye is about $\frac{2}{3}$ of that of the part behind the eye. The upper profile of the head and body is feebly arched, the curve of the lower profile a little more marked. The mouth is protrusible and nearly horizontal the posterior end of the maxilla is in front of the eye; the lower jaw is shorter than the upper. The lips are thick and fleshy but not produced forwards; the lower lip is slightly retroverted in the middle line. There are 4 barbels; the anterior pair is much shorter than the posterior; the latter extend backwards to a point under the middle of the eyes. The nostrils are a little nearer the eyes than the tip of the snout. The eyes are rather small, their diameter being contained about $7\frac{3}{4}$ in the length of the head. The cheeks are quite smooth. All the fins are relatively small. The dorsal is short and about $\frac{2}{3}$ as deep as the

body. The first dorsal ray is stout and bony but short, the second, which is also bony, tapers to a fine point and is about $\frac{2}{5}$ as long as the head; it is quite smooth. The anterior root of this fin lies immediately above that of the ventrals. The pectorals are particularly small, their length is between $\frac{2}{3}$ and $\frac{3}{4}$ that of the head. The ventrals, from which they are widely separated, are considerably shorter; their tips do not quite reach the vent. The anal is distinctly pedunculate. The caudal peduncle is well differentiated but less than twice as long as deep; it is strongly compressed. The caudal fin is short; its upper lobe is distinctly sharper and more produced than the lower lobe. The scales are very large; sometimes notched in front. Their exposed parts are marked with delicate longitudinal striae. The lateral line is rather obscure.

The only specimen of this fish that I have seen was sent from Gauhati on the Brahmaputra by Mr. T. R. Phookun. It is 115 cm. long and is preserved stuffed, its number in our register being F 9654/1.

Barbus jerdoni, Day.

(Plate II, fig. 4, var. *maciveri*, nov.).

1889. *Barbus jerdoni*, Day, *op. cit.*, p. 312.
1889. *Barbus dobsoni*, *id.*, *ibid.*

As Day himself suggests in his *Fishes of India* (p. 568), the two forms included in the above synonymy are merely varieties or local races of the same species. The only constant difference that I can find between the specimens in his own collection are that the body is considerably deeper in *B. dobsoni* than in *B. jerdoni* and that there are more scales below the lateral line in the former Mr. McIver has sent me specimens from the Kistna River near Satara that represent a third variety, which has the following differential characters:—

D. 13 (4/9). A. 8 (3/5). L. l. 31-33. L. tr. $5\frac{1}{2}/3\frac{1}{2}$.

Depth of body $3\frac{2}{3}$ to 4 times in total length; length of head about $5\frac{2}{5}$ times in total length; diameter of eyes $3\frac{1}{2}$ times in length of head. The body is brownish above and the caudal, dorsal and anal fins are tipped with black. The specimens I have examined are small (not more than 151 mm. long), but Mr. McIver tells me that the form attains a weight of 20 to 25 lbs. I propose for it the name var. *maciveri*. The Maharatta name at Satara is *purgi*; Mr. McIver refers to the fish as the "Carnatic Carp of the Krishna."

Type-specimen of variety.—F 9576/1, *Zool. Survey of India* (*Ind. Mus*).

Family OPHIOCEPHALIDAE.

Ophicephalus gachua, Ham. Buch.

This widely distributed species, of which specimens were taken in the river at Medha and in artificial ponds at Khandalla,

is much more variable in the number of its dorsal and anal fin-rays than published descriptions indicate. The Assamese form *O. stewarti*, Playfair, and my own recently described *O. harcourt-butleri* from the Southern Shan States may ultimately prove to be no more than local races. In both of these the number of vertical fin-rays is variable. In *O. harcourt-butleri* [1] there are from 28 to 38 in the dorsal fin and from 16 to 25 in the anal. Dr. Chaudhuri tells me that in a series of *O. stewarti* from Shillong he finds the corresponding numbers to be 34 to 39 and 22-27. In the typical *O. gachua* the variation is at least as great as in the latter, but it will be better to defer a more precise statement until good series are examined from numerous localities.

Family GOBIIDAE.

Gobius bombayensis, sp. nov.

(Plate I, fig. 5).

A small species resembling *G. viridipunctatus*, Day, but with fewer vertical fin-rays and without enlarged canine teeth; allied to *G. chilkensis*, Jenkins,[2] but with a much longer snout and smaller caudal fin.

D. 6-1/7-8. P. 17-18. A. 1/7. L.e. 28-29. L. tr. 7.

Size small; habit slender, slightly compressed. Total length about $4\frac{1}{4}$ the length of the head and about $5\frac{1}{4}$ the greatest depth of the body. Dorsal profile slightly arched. Caudal peduncle distinct, rather more than twice as long as deep. Head coarse; snout blunt, rather short, less than $\frac{1}{2}$ as long as the part of the head behind the eye, nearly twice as long as the eye. Mouth large, slightly oblique; the posterior extremity of the maxilla situated below the middle of the eye; lower jaw very slightly longer than the upper; teeth small; tongue notched in front, without teeth. Eye large and prominent, its length contained 5 times in the length of the head. Dorsal fin low, with none of the rays elongate.

Colouration.—Pale yellowish, irregularly blotched with black. Anterior dorsal fin infuscated, with a rather deep whitish border; posterior dorsal with three longitudinal rows of small dark spots; other fins irregularly infuscated, the caudal with obscure and irregular vertical dark bars.

The largest specimen examined is 42 mm. long.

Type-specimen.—F 9698/1, *Zool. Survey of India* (*Ind. Mus.*).

Locality.—The species is not uncommon in the Medha river at Satara.

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[1] *Rec. Ind. Mus.*, XIV p. 54, fig. 2, pl. ii, fig. 7, pl. iv, figs. 16, 17 (1918).
[2] *Rec. Ind. Mus.*, V, p. 137, pl. vi, fig. 2.

VI. SOME FRESHWATER MOLLUSCS FROM THE BOMBAY PRESIDENCY.

By N. ANNANDALE, *D.Sc., C.M.Z.S., Director, Zoological Survey of India, and* B. PRASHAD, *D.Sc., Superintendent of Fisheries, Bengal, Bihar and Orissa.*

The molluscs discussed in these notes are for the most part common species of wide geographical range. This makes it the more necessary that their differential characters should be understood, exact localities put on record and the precise environment which each affects described. Unfortunately nothing was known as to the anatomy of the commonest Indian freshwater molluscs when Preston's volume in the official *Fauna of British India* was written, and very little attention was paid by him even to published records of locality. Two of the species we have to consider are of particular interest on account of their habitat. They are *Cremnoconchus syhadrensis*, a Littorinid which lives on inland cliffs at the edge of waterfalls, and *Ampullaria nux*, which, unlike other Indian species of its genus, frequents small hill-streams.

The following species were taken in the river at Medha:—*Melania tuberculata*, *M scabra*, *Parreyssia cylindrica*, *P. corrugata* and *Lamellidens marginalis*. *Ampullaria nux* and *Cremnoconchus syhadrensis* were found on the hill-side at Khandalla.

We also discuss specimens from ponds at Khandalla, and from reservoirs in the Satara fort, at Karla in the Poona district and at Igatpuri in the Nasik district.

We may note here, though the fact is perhaps of archaeological rather than malacological interest, that single valves of *Arca granosa* are occasionally found in the Yenna. They are invariably pierced in the umbonal region and probably served as ornaments for some jungle tribe which has now disappeared or become civilized and ceased to affect such primitive decorations.

Family LIMNAEIDAE.

Genus **Limnaea**, Lamarck.

Preston, in his volume in the official *Fauna of British India*, gives descriptions of twenty-eight Indian species and varieties of this genus, but (although he describes *L. bowelli*, a Tibetan mollusc not found within the limits of the Indian Empire), he makes no reference to the peculiar forms of *L. lagotis*[1] long known to occur in Kashmir, the Kangra Valley and Baluchistan, or to *L. andersoniana*,[2] which Nevill reported from the Shan States of Burma as well as from Western China. One of us has recently added two

[1] See Nevill's *Hand List*, pt. I, pp. 234, 237, 239 (1889); also Hanley and Theobald's *Conch. Ind.*, pl. lviii, fig. 7 (1876).

[2] Nevill, *Journ. As. Soc. Bengal*, (ii) XLVI, p. 26 (1877), and I., p. 142, pl. v, fig. 9.

further species[1] from the Shan States to the Indian fauna, namely *L. shanensis* of which several extinct phases as well as the living form have been described; and the highly peculiar *L. mimetica.*

The shell is extraordinarily plastic in *Limnaea* and it is of great importance that the genitalia, the radula and the structure of the upper jaw should, whenever possible, be examined in the identification of the species. In the genitalia we find the most constant differences in the relative lengths of the different parts of the main ducts, in the form of the penis-sheath and in the presence or absence of the spermathecal duct.

Limnaea acuminata, Lamarck.

(Plate V, fig. 1).

1890. *Limnaea acuminata* varr. *patula* and *rufescens*, Von Martens, *Conch. Mitth.* I, pp. 75, 76, pl. xiv, figs. 1-3.

We confine this name to the forms in which the outer margin of the aperture of the shell is regularly curved, thus excluding both *L. chlamys*, Benson and *L. amygdalum*, Troschel.

The radula (fig. 1) is rather broad. The lateral teeth have three distinct cusps; there are about nine rows of lateral teeth on each side of the central tooth, but there is no very abrupt difference between the lateral and the marginal teeth, of which there are at least twenty rows on each side. The central tooth is practically unicuspid, and the single cusp is narrowly produced. The lateral teeth are very broad, their central cusp is not much larger than the two lateral ones, which are subequal; the outer lateral cusp is considerably nearer the base of the projecting part of the tooth than the inner one. The marginal teeth have from three to six rather short and blunt cusps, the outermost of which is situated near the base of the projecting part.

The central piece of the horny upper jaw is broad and strongly convex, but hardly beak-like; it is of a dark brown colour.

The genitalia are of normal type. The duct of the hermaphrodite gland is short and coarse, never much longer than the gland itself, it does not appear to be swollen at the point at which the male and female ducts diverge. In the male duct the part between the prostate and this point of divergence is slightly longer than that between the prostate and the proximal end of the penis-sheath, which is of considerable length, sausage-shaped and rather narrow. The albumen and accessory glands are rather large in the specimens examined; they arise close together and are situated much nearer to the uterus than to the hermaphrodite gland. The oviduct is very short; the uterus is elongate and narrow; and the spermatheca, which is pear-shaped when fully mature, is almost sessile.

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[1] Annandale, *Rec. Ind. Mus.*, XIV, pp. 107-109, pl. x, figs. 5, 8, 9, pl. xi, figs. 2, 3, 4 (1918).

This species was found in considerable abundance at Khandalla in pools containing an abundant aquatic vegetation but largely of artificial origin and formed by the damming of small hill-streams.

The shells bear a close general resemblance to Von Marten's figure of the var. *patula*, but vary considerably in the breadth of the body-whorl. Most of the adult specimens are not more than about 19 mm. long and about 10 mm. broad. Occasionally, however, very much larger and broader individuals occur in the ponds. The shells of such individuals are always eroded on the surface and have the apex more or less eaten away; if complete they would be about 30 mm. long and 18 mm. broad. The aperture of the shell is relatively large (about 21 mm. by 11 mm.). Such shells are evidently those of aged individuals which have survived the vicissitudes to which most of their contemporaries have succumbed.

The Oligochaete worm *Chaetogaster* was frequently observed on this mollusc at Khandalla.

The species is one of the commonest of the Indian *Limnaeae*, and has been found in many parts of Peninsular India and the Indo-Gangetic Plain.

Limnaea acuminata var. **nana**, nov.

(Plate IV, fig. i; pl. V, fig. 2).

The shell of this form (pl. IV, fig. 1) is very small, rather thick, of a blackish colour and with the longitudinal striae very strongly developed. In outline it somewhat resembles the var. *rufescens*, Gray, as figured by Von Martens in the paper cited above, but the spire is relatively longer, the body-whorl more swollen, the columellar callus coarser and the aperture narrower and somewhat curved inwards posteriorly.

Measurements of type-specimen.

Length	9·3 mm.
Breadth	.. 5·6 mm.
Length of aperture	. 6 mm.
Breadth of aperture	3 mm.

Shells of this size are sexually mature. The radula (fig. 2, pl. V) differs from that of the typical form mainly in the greater irregularity of the shape of the teeth. Even in parts which are quite unworn the cusp of the central tooth is irregular and often asymmetrical. The cusps of the lateral teeth are shorter and the inner cusp is relatively smaller. In the marginal teeth the second and the innermost cusps are considerably enlarged.

The central piece of the horny upper jaw is narrower, paler in colour and apparently less convex than in the *forma typica*.

The genitalia (text-fig. 3) agree precisely with those of the typical form.

Type-specimen.—No. M 11397/2 in the register of the Zoological Survey of India (*Indian Museum*).

Locality.—Khandalla, Poona district, Bombay Presidency; altitude 2,500 ft., March, 1918.

We have thought it convenient to give this form a varietal name as the characters are constant in the series we have examined. We believe, however, that its peculiarities are due to the unfavourable conditions in which the individuals were living. They were found at the side of the railway line in a small ditch not more than a couple of feet wide and three or four inches deep. The bottom was muddy and there was a considerable but ephemeral vegetation of semi-aquatic plants. Some of the shells possess a kind of varix (pl. iv, fig. 1) across the middle of the body-whorl; this we believe to be probably due to a temporary cessation in shell-production at a time when the water in the ditch had completely

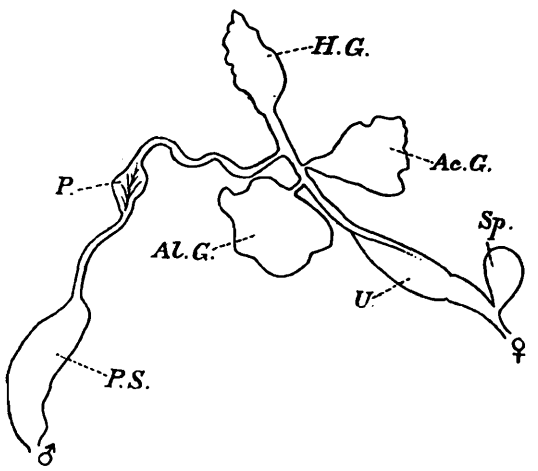

FIG. 3.—Genitalia of *Limnaea acuminata* var. *nana*.

Ac. G.=accessory gland. Al. G.=albumen gland. H. G.=hermaphrodite gland. P.=prostate. P. S.=penis-sheath. Sp.=spermatheca. U.=uterus.

dried up, and the animal had buried itself deeply in the mud, as molluscs of this genus do in periods of drought. The ditch was situated within a few hundred yards of the ponds in which the typical form of the species was found.

Limnaea chlamys, Benson.

(Plate V, fig. 3).

1836. *Limnaea chlamys*, Benson, *Journ. As. Soc. Bengal*, V, p. 744.
1876. *Limnaea chlamys*, Hanley and Theobald. *Conch. Ind.*, pl. lxix, figs. 5, 6.

The radula and genitalia of this form seem to us sufficiently different from those of *L. acuminata* to justify specific separation. The shell may be distinguished by the obliquity of the body-whorl and by the peculiar curvature of the outer margin of the aperture.

The measurements of a specimen are as follows:—

Length	15 mm.
Breadth	9 mm.
Length of aperture	9 mm.
Breadth of aperture	6 mm.

The radula (pl. V, fig. 3) is very similar to that of *L. acuminata*, except that the central cusp of the lateral teeth is considerably longer, all the cusps of these teeth sharper, and in there being a second internal cusp resulting in four cusps in all; the fourth cusp is situated at a lower level than the others. The cusps of the marginal teeth are more regular and have a distinctly pectinate appearance. The central tooth is trilobed and distinctly asymmetrical.

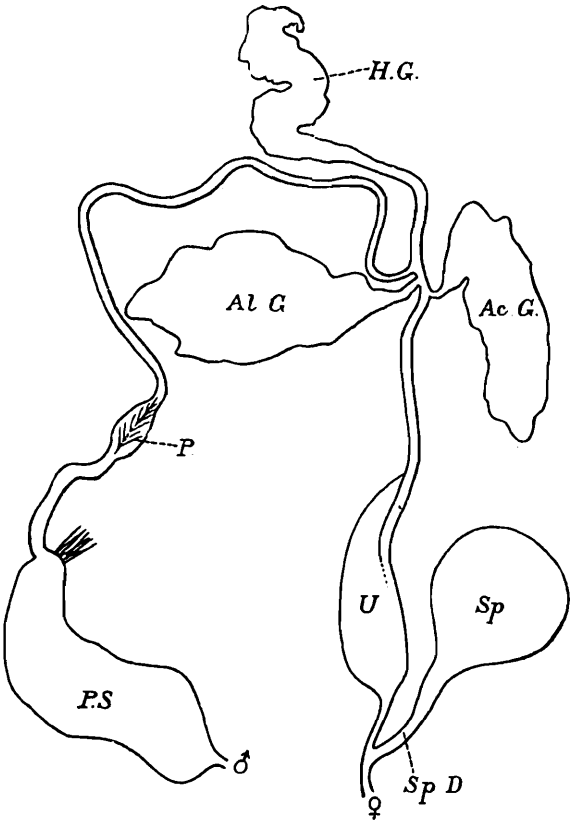

FIG. 4.—Genitalia of *Limnaea chlamys*, Benson.
Lettering as in fig. 3, p. 142. Sp. D.=spermathecal duct.

The central part of the horny upper jaw is broad, but the outer margin is less convex than in *L. acuminata*; its colour is paler than in that species.

The genitalia (text-fig. 4) of this species differ from those of *L. acuminata* mainly in the much greater length of the proximal part of the male duct and the hermaphrodite duct; in the position of the accessory and the albumen glands, which are situated close to the junction of the male and female systems rather nearer the hermaphrodite gland than the uterus, and in the considerable length of the spermathecal duct, which is as long or nearly as long as the spermatheca. The penis-sheath is also thicker.

A large series of specimens was obtained in one of the artificial ponds in the old fort on the hill-top immediately above the town of Satara. The bottom of this pond, which is shallow, is rocky but covered with a growth of minute green algae on which the molluscs were apparently feeding. The shells are all small and fragile, of a pale but bright yellowish colour, and with the microscopic sculpture less marked than is usually the case. The Oligochaete worm *Chaetogaster* was abundant on these molluscs also.

Limnaea pinguis, Dorhn.

(Plate V, fig. 4).

1876. *Limnaea pinguis*, Hanley and Theobald, *Conch. Ind.*, pl. lxx, figs. 7, 8, 10.

Two individuals of this form were found among a large series of *L. acuminata* from the ponds at Khandalla. The shells of

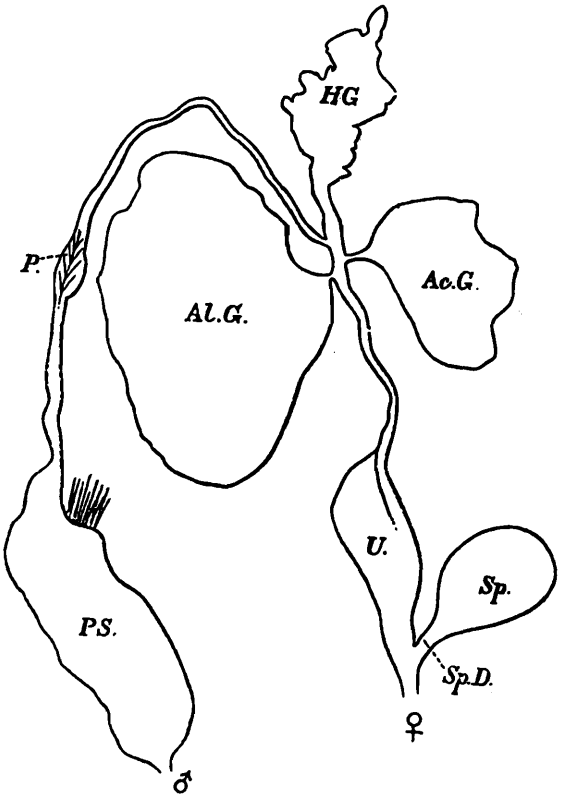

FIG. 5.—Genitalia of *Limnaea pinguis*, Dorhn.
Lettering as in figs. 3, 4, pp. 142, 143.

these two specimens are rather narrow and of small size; the longitudinal striae are very well developed and the shell is very pale in colour. *L. pinguis* may prove synonymous with *L. succinea*, Desh.

The measurements of one of the specimens are as follows :—

Length	21 mm.
Breadth ..	11 mm.
Length of aperture	12·5 mm.
Breadth of aperture	6·5 mm.

The radular teeth (fig. 4, pl. V) are coarser in this species than in the other two we have discussed. The central tooth is small, often distinctly asymmetrical and with either two or three lobes. The lateral teeth have three distinct cusps, but the innermost is strongly curved and bends outwards towards or even beneath the median cusp[1] in a very characteristic fashion; the central cusp is much larger than the outer one. There are only about six rows of lateral teeth. The marginal teeth have a considerable number of cusps the outermost of which is much coarser and nearer to the base than the others, especially towards the edge of the radula.

The middle piece of the horny upper jaw is broad and coarse and of a dark brown colour; the cutting edge is nearly straight.

In this species the genitalia (fig. 5) closely resemble those of *L. chlamys*, but all the ducts are shorter and the distal part of the male duct is hardly longer than the proximal part. The spermathecal duct, although distinctly present, is much shorter than the spermatheca.

Genus **Planorbis**, Geoffroy.

The Indian species of this genus are still very imperfectly known. The large collection of shells belonging to the Indian Museum has recently been examined by M. L. Germain of the Paris Museum but the transmission of the manuscript of his report upon it has been delayed by the war.

Planorbis exustus, Desh.

1918. *Planorbis exustus*, Annandale, *Rec. Ind. Mus.* XIV, p. 111, pl. xi, figs. 1, 1*a*.

This is certainly the most abundant species as well as the largest commonly found in the plains of India. It is, however, scarcer as a rule in hilly country. A young specimen was obtained in the ponds at Khandalla.

Planorbis labiatus, Benson.

1915. *Planorbis* (*Gyraulus*) *labiatus*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 119, fig. 5.

A specimen from the ponds at Khandalla agrees well with Preston's figures of the type-specimen.

Family MELANIIDAE.

Genus **Melania**, Lamarck.

Two species of this genus were found in abundance at the edge of the Yenna River at Medha, and at other places in the

[1] The innermost cusp is much larger and more distinct from the median cusp in a specimen from Madras (presented by the late Prof. Gwatkin) than in the one we have figured. Its outward curvature is, however, just as strongly marked and characteristic.

Satara and Poona districts. They are *M tuberculata* and *M scabra*, perhaps the two commonest and the most widely distributed of the Indian species.

Melania tuberculata (Müller).

(Plate V, fig. 5).

1918. *Melania tuberculata*, Annandale, *Rec. Ind. Mus.* XIV pp. 114, 115, pl. xii, figs. 1, 2.

In the paper cited one of us has recently discussed the variation and plasticity of the species. Shells from the Yenna River are of the typical form but pale in colour, with the reddish markings very conspicuous. Specimens from the Igatpuri Lake, an artificial reservoir situated at about the same altitude in the Nasik district, are a little stouter and have the sculpture deeper; they are as a rule still paler and have the reddish marks even more conspicuous, but there is a tendency for the older whorls to be blackened. Several individuals of a dwarfed type were found living in a small ditch at Khandalla with *L. acuminata* var *nana*, they resemble the form from the pools of brackish water at Port Canning figured (fig. 6*f*) in the paper cited above. They are darker in colour than others from the same district, but this appears to be due largely to a deposit formed on their surface. Most of the Medha shells are not more than 25 mm. long, but occasionally larger individuals of a somewhat more elongate type occur.

We give measurements of the largest shells from each of the three localities; none of them are much eroded.

	Length.	Breadth.	Length of aperture.	Breadth of aperture.
Medha	25 mm.	8·7 mm.	8·8 mm.	4·3 mm.
	31·4 mm.	10·3 mm.	9 mm.	5 mm.
Igatpuri	22 mm.	8 mm.	7·8 mm.	4·2 mm.
Khandalla	16 mm.	5·4 mm.	5·2 mm.	3 mm.

We figure the radular teeth (fig. 5, pl. v) of a specimen from Igatpuri. They are of the type normal in the genus, and differ (according to Heude's figure) from those of *M jacquetiana*, Heude,[1] a closely allied species if not a mere variety from China, in having more numerous denticulations on the central tooth. They also show minor differences from Jickeli's figure of a North African specimen.[2]

The species was found with *M scabra* in the Yenna River on mud in still pools. It was particularly abundant on shelves of rock covered with mud.

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[1] Heude; *Mem. Hist. Nat. Chinois*, I. *Moll. D'Eau Douce*, p. 163, pl. xliii, fig. 5*r* (1890).

[2] Jickeli, *N. A. K. Leop-Carol. Ak. Naturf.* XXXVII (1), pl. iii, fig. 7 (1874).

Melania scabra (Müller).

(Plate V, fig. 6).

1874. *Melania scabra*, Brot, *Melaniaceen* in Martini und Chemitz, *Conch.-Cab.* (*Ed. Kuster*), p. 266, figs. 14, 15.

Brot places this species in the group or subgenus *Plotia*, in the definition of which he writes "Anfractibus superne angulatis et spinulosis." This applies exactly enough to most young shells, but, as Brot's own figures show, the spines and even the angulation of the whorls disappear with age, and are not equally developed even in all young specimens. In our series from the Medha River all intermediate stages are represented. In this locality the shells reach a large size, but at Karla in the Poona district a series of dwarfed shells was collected at the edge of a small partially artificial reservoir situated at the base of the hill in which is the well-known Buddhist cave monastery. Shells from the two localities do not differ in shape or sculpture.

We give measurements of two fully developed specimens from each locality. In all cases the apices are somewhat eroded.

	Length.	Breadth.	Length of aperture.	Breadth of aperture.
Medha	29·3 mm.	13·2 mm.	12·6 mm.	8·2 mm.
	28·2 mm.	12·1 mm.	11 mm.	7 mm.
Karla	17 mm.	8·6 mm.	8·3 mm.	5·4 mm.
	16·6 mm.	8·5 mm.	8·1 mm.	5·3 mm.

The radula (fig. 6, pl. v) differs little from that of *M tuberculata*.

Though rarely as abundant as *M. tuberculata* and *M variabilis*, this species has a wide range in the Indian Empire and as far east as New Guinea. There are specimens of the typical form in the collection of the Zoological Survey of India from Calcutta; Chaibassa, Chota Nagpur; the foot of the Garo Hills, Assam; Madras (many localities in the eastern districts), Bangalore (3,000 feet); Nemunangad, Travancore; Simla; Matelle, Ceylon; Kawkareik, Amherst District, Tenasserim, etc.

Genus **Paludomus**, Swainson.

The distribution of the genus in Peninsular India is somewhat peculiar. Numerous species have been described from the hill-streams of South India, and also from those of Ceylon on the one hand, and of Assam and Burma on the other. From the central and northern part of the Peninsula, however, only one species (*P. obesa*) is known, though many apparently suitable streams are to be found.

Paludomus obesa (Phillipi).

(Plate V, fig. 7).

This mollusc was found in considerable abundance on stones covered with algae in a small stream at Khandalla. The stream

was one of those which rushes down the hill-side, but the mollusc only occurred where it broadened out and its currents became less strong as it crossed a small plain. We figure (fig. 7, pl. v) the radular teeth of a specimen from Khandalla.

P. obesa seems to be the most widely distributed of the Indian species. It was described from the Bombay Deccan, but one of us collected a large series some years ago at Courtallum in South India. These specimens were examined by Mr. Preston, who, however, with his habitual indifference to geography, makes no reference to them. It was noted at the time that they replaced *P. annandalei*, Preston, an abundant species on the ledges above waterfalls on the western side of the Western Ghats at Tenmalai, where the railway crosses that range, as soon as the eastern watershed was reached. The range of *P. obesa* may, therefore, be described as consisting of the western part of the Indian Peninsular area, properly so called, as distinct from the Malabar Zone to the west and the Indo-Gangetic Plain to the north. Khandalla, however, lies technically within the limits of the Malabar Zone. We regard this species provisionally as distinct from *P. tanjoriensis*, etc., see Blanford, *Trans. Linn. Soc.*, XXIV, p. 173 (1863).

Family Littorinidae.

Genus **Cremnoconchus** (Blanford).

1863. *Cremnobates*, Blanford, *Ann. Mag. Nat. Hist.* (3) XII, p. 184, pl. iv.
1869. *Cremnoconchus*, Blanford, *Ann. Mag. Nat. Hist.* (4) III, p. 343.
1871. *Cremnoconchus*, Stoliczka, *Proc. Asiat. Soc. Bengal*, p. 108, figs. 1-4.
1878. *Cremnoconchus*, Blanford, *Journ. As. Soc. Bengal*, XXXIX (ii), p. 10.
1887. *Cremnoconchus*, Fischer, *Conchyliologie*, pp. 708-709.

We have no doubt that Blanford and Stoliczka were right in referring this genus to the family Littorinidae. Blanford says (*loc. cit.* 1863): "Every character of shell, operculum and animal with the one exception of the pulmoniferous sac admits of the position I have assigned to it amongst the Littorinidae." As Stoliczka has shown, the gill is present, and the branchial chamber is less like that of the Pulmonata than Blanford imagined. The osphradium is present, but much reduced and almost papilliform (pl. iv, fig. 3). As to the origin of the genus, which lives on inland cliffs kept moist by the spray from waterfalls, we can add nothing to Blanford's statement. "No question can exist as to the Western Ghats having been formed from a marine cliff in comparatively recent geological times. Whether *Cremnobates* be a lineal descendant of the Littorinas or Fossars then inhabiting the coast may perhaps not be an unfair subject for speculation."

A species has since been described from French Indo-China,[1] but the shell differs considerably from that of the Western Indian forms, and nothing is known of the soft parts.

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[1] Bavay et Dautzenberg, *Journ. de Conchyliologie*, XLVIII, pp. 116, 449, pl. x, fig. 10 (1900).

Cremnoconchus syhadrensis (Blanford).

(Plate IV, figs. 2-4).

Two types of shells occur in a large series from the cliffs at Khandalla. The commoner of these agrees well with Blanford's figure (*op. cit.*, 1863, pl. iv), but in a few specimens the upper surface of the body-whorl is flattened and grooved much as in the same author's var. *canaliculatus* of *C. conicus*.

We have nothing to add to Blanford's description of the external characters, but his account of the branchial chamber is incorrect. As shown in fig. 3, a well developed gill is present. The orifice of the chamber bears a certain resemblance to that of the Pulmonates and can be completely closed. It appears, however, that the cavity is always filled with water and not air (see p. 119), and the roof is not highly vascular.

The radula (fig. 4, pl. iv) is that of a typical Littorinid. It is very long and narrow, but the tooth-formula is in our opinion 1. 2. 1. 2. 1. All the denticulations are very broad and rather blunt.

Khandalla appears to be the original locality of this species, and Blanford states that it is only found in the Western Ghats, in the neighbourhood of Bombay.

Family AMPULLARIDAE.

Genus **Ampullaria**, Lamarck.

Only a single species is represented in the collection.

Ampullaria nux, Reeve.

(Plate V, fig. 8).

1856. *Ampullaria nux*, Reeve, *Con. Icon.*, X, *Ampullaria*, pl. xxviii, figs. 132*a*, *b*.

Reeve in describing this species noted the peculiar development of the columellar callus, which forms a flat ridge nearly 2 mm. in diameter. This and the small size of the shell are probably correlated with the unusual habitat, for *A. nux*, unlike any other species of the genus with which we are acquainted, inhabits small mountain streamlets, in which it is important for it to be able to cling as tightly as possible to smooth rocks in rapid-running water. A single living specimen was obtained on the hill above Khandalla; it was clinging to the rocky margin of a small pool immediately below a waterfall. Numerous more or less broken shells were observed in the same streamlets. We figure the radular teeth of this specimen (fig. 8).

The operculum is long, rather narrow (13·3 mm. long by 8·5 mm. in a shell with the apex eroded 21 mm. long), thin and slightly transluscent. The inner margin is practically straight, the outer margin strongly convex; its horny epidermis is thin and of a

brownish colour; the nacre outside the muscular scar is tinged with lilac. The sculpture of the scar somewhat resembles that on the operculum of *A. winkleyi* (Pilsbry),[1] being concentrically striate on the columellar side.

Hanley and Theobald record this species from Bhor Ghat, which is within two miles of Khandalla; we have seen a series of dead shells from a small stream at Igatpuri in the Nasik district.

Family UNIONIDAE.

A large number of fish, belonging to several distinct species, from the *Limnocnida* pool at Medha were found to have glochidia of this family embedded in their fins. Unfortunately in the present state of our knowledge it is not possible, except in a few cases recently dealt with by one of the present authors, to identify larval Indian Unionidae.

Genus **Parreyssia**, Simpson.

This genus is represented in our collection by two species from Medha, one of them a common form, the other apparently new.

Parreyssia cylindrica, sp. nov.

(Plate IV, figs. 6, 7).

A small species closely allied to *P. favidens* (Benson), but with a much broader and lower shell than any of the varieties of the latter.

Shell moderately small and thick, transverse-ovate, sub-cylindrical, with the umbo rounded and by no means prominent in unworn shells; dorsal margin nearly straight, anterior margin broadly rounded. Umbonal region sculptured with numerous low corrugated ridges which tend to run together to form V-shaped prominences; towards the posterior margin of the shell these ridges are transverse and curved; they extend downwards in a more or less distinct fashion, and even in old shells can be traced almost to the lower margin. Periostracum coarse, irregularly striate transversely, of a brownish colour, darker in older shells than in young ones, not at all polished. Nacre with a strong rosy-pink tinge. Hinges much as in *P. favidens* but less strongly developed. Pseudocardinal teeth prominent, strongly ridged, divided on both valves by a deep groove which slopes forwards and downwards. Lateral teeth slender but prominent, of considerable length, oblique, slightly arched; two on each valve, a vestigial tooth present in the form of a low ridge below the anterior part of the main lateral tooth on the right valve. Muscular impressions strongly developed, oval or sub-circular.

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[1] *Proc. Acad. Nat. Sci. Philadelphia*, LIII, p. 189, pl. v, figs. 2, 3 (1901).

The measurements of four specimens are as follows :—

	Length.	Height.	Thickness.
1	44 mm.	25·5 mm.	18·4 mm.
2	35·1 mm	21 mm.	13·2 mm.
3	22·5 mm.	13·6 mm.	9·4 mm.
4	17·2 mm.	10 mm.	6·9 mm.

Type-specimen.—No. M 11398/2 in the register of the Zoological Survey of India (*Indian Museum*).

Locality.—Yenna River, Upper Kistna watershed, at Medha; common, with *P. corrugata*, in the pool in which *Limnocnida indica* occurs.

Parreyssia corrugata (Müller).

This species is even commoner in the Yenna River at Medha than the former one. The shells, which are much eroded, vary greatly in shape, some being much broader and less tumid than others. The external sculpture is always strongly but irregularly developed. The colour of the periostracum is dull brownish or greenish, and the nacre has a strong salmon-pink tinge.

The measurements of three specimens from Medha are as follows :—

	Length.	Height.	Thickness.
1	43·2 mm.	19·1 mm.	29·5 mm.
2	37 mm.	17·4 mm.	28·4 mm.
3	30 mm.	14·6 mm.	23·1 mm.

Genus **Lamellidens**, Simpson.

This genus is represented in the collection by two varieties of the commonest Indian species, *L. marginalis*.

Lamellidens marginalis (Lamarck).

There is a single small valve of this species, in rather bad condition, from the Medha River.

Lamellidens marginalis var. **cylindrica** (H. and T.).

(Plate IV, fig. 5).

1876. (*Unio marginalis* var. *cylindrica*, Hanley and Theobald, *Conch. Ind.*, p. 20, pl. xliv, fig. 1.

We assign to this variety with some doubt a series of shells from the Igatpuri reservoir in the Nasik district (alt. 2,000 feet). On the whole they resemble the figure in the *Conch. Ind.*, but are considerably smaller and have the anterior margin less broadly rounded and the posterior dorsal margin a little more elevated. The shell-substance has a distinct salmon-pink tinge and the epidermal membrane is translucent olivaceous with obsolescent dark radiating lines. The outline is very like that of *L. mainwaringii*, Preston, but the valves are much more inflated, there are differ-

ences in the dentition and the colour of the nacre is totally different. The outline is broader than that of *L. consobrina* (Lea), the shell much thinner, the epidermis paler, the pseudo-cardinal teeth smaller and less prominent and the laterals straighter.

The measurements of four shells are as follows:—

	Length.	Height.	Thickness.
1	56·5 mm.	30 mm.	18·7 mm.
2	53·4 mm.	28·6 mm.	18 mm.
3	52 mm.	27·6 mm.	18 mm.
4 ..	51·8 mm.	27·5 mm.	17·8 mm.

" Not uncommon in shallow muddy bays,many specimens found in damp mud (after a night's light rain) in a drying creek. Some of these were a considerable distance from water, but they were in an active condition. These individuals were observed lying horizontally dorsal side uppermost in shallow and narrow grooves in the mud some four or five inches long and not quite deep enough to contain their shells. Probably they had been buried deeper in the mud and had come to the surface owing to the rain. When placed in a jar of mud they sank to the bottom and there lay horizontally" (*field notes*).

VII. AQUATIC AND SEMI-AQUATIC RHYNCHOTA FROM THE SATARA AND POONA DISTRICTS.

By C. A. PAIVA, *Assistant, Zoological Survey of India.*

Specimens of the following species were collected by Dr. N. Annandale in the course of his tour :—

FAM. HEBRIDAE.

Hebrus bombayensis, sp. nov.

FAM. HYDROMETRIDAE.

Hydrometra vittata, Stål
Rhagovelia nigricans (Burm.).
Onychotrechus rhexenor, Kirk.
Ptilomera laticaudata (Hardw.).
Metrocoris stali (Dohrn.).

FAM. REDUVIIDAE.

Pirates arcuatus (Stål).

FAM. PELOGONIDAE.

Pelogonus marginatus (Latr.).

FAM. NEPIDAE.

Laccotrephes ruber (Linn.).
Laccotrephes griseus, Guer.

FAM. NAUCORIDAE.

Heleocoris elongatus, Montand.
Heleocoris obliquatus (Spin.).
Naucoris sordidus, Dist.

FAM. NOTONECTIDAE.

Enithares templetoni (Kirby).
Enithares lactea, sp. nov.

FAM. CORIXIDAE.

Corixa hieroglyphica, Duf

Family HEBRIDAE.

Hebrus bombayensis, sp. nov.

(Plate III, fig. 6).

One specimen from surface of a small pool at the edge of the river at Medha, *ca.* 2,200 feet, Yenna Valley, Satara district, 27-ii-4-iii-1918 and five specimens found running and flying on vertical

rocks covered with damp algae at the edge of a waterfall at Khandalla, *ca.* 2,500 feet, Poona district, 6-10-iii-1918.

The description is taken from two carded specimens from the latter locality.

Black with greyish-white and golden pubescence; apical margin of head, a spot before each eye and the basal margin more or less greyishly pubescent; antennae ochraceous, apically darker, first joint stout, longest, shorter than any two joints together, second joint shortest, widened at apex and tapering towards base, third and fifth joints subequal, longer than fourth, the three apical joints slender; head slightly tumid above, gently sloping towards the apex; lateral projections at bases of antennae pointed; disk of vertex with two shallow longitudinal grooves united posteriorly and extended as one to basal margin of head; pronotum with two shallow depressions on each anterior lateral area, and a central longitudinal depression on disk; a line of deep punctures on each side of the central depression and also on the basal margin of the pronotum; the depressed portions of the pronotum in fresh specimens are greyishly pubescent; scutellum with its basal area gibbous, beyond which it is foveate as far as apex; a short central longitudinal carina on depressed portion; clavus and corium covered with short golden pubescence; a large subtriangular patch at base of clavus and three spots on membrane arranged in a triangle, white or greyish-white; the outer spot on the membrane transverse, widening inwardly, the other two near the inner margin are rounded; legs ochraceous.

Length 1·75—2 mm.

Type. No. 8048/H.I. in the collection of the Zoological Survey of India.

Family HYDROMETRIDAE.

Hydrometra vittata, Stål.

One specimen from a small pool at the edge of the river at Medha and another from the edge of a waterfall at Khandalla.

A very common species and probably found all over India.

Rhagovelia nigricans (Burm.).

Two apterous specimens from under a rock at the edge of a stream at Khandalla.

As far as the Indian fauna is concerned this species has been recorded from Travancore and Ceylon and it is represented in our collection from Pinjore, Patiala State, base of Simla Hills, W Himalayas; Tura and Ganool River, Damalgiri, Garo Hills, Assam; Sanjai River, Chakradharpur, Chota Nagpur, 8-10-ii-18, "In large numbers under the shelter of a rock in the stream. N. A." We have also specimens from the mouth of the Jordan, Tiberias, and the plains of Gennesaret, Palestine, collected by Dr. Annandale. It appears to be very widely distributed.

Onychotrechus rhexenor, Kirk.

(Plate III, figs. 8, 8*a*)

A number of specimens were found running and leaping on vertical rocks covered with damp algae at the edge of a waterfall, and two specimens were taken from a rocky stream at Khandalla.

This species has hitherto been recorded only from S. India; Kanara (*colln.* Distant).

Ptilomera laticaudata (Hardw.).

Three specimens from the surface of small streams at Khandalla.

Metrocoris stali (Dohrn).

A number of specimens from the surface of small pools at the edge of the river at Medha and two from small rocky streams at Khandalla.

This and the preceding species are widely distributed.

Family REDUVIIDAE.

Pirates arcuatus (Stål).

Three specimens from under stones at the edge of a stream, Khandalla.

Not an uncommon species.

Family PELOGONIDAE.

Pelogonus marginatus (Latr.).

One specimen from the edge of a stream at Khandalla. Within our limits the distribution of this species extends from Nepal to Ceylon and from Bombay to Burma.

Family NEPIDAE.

Laccotrephes ruber (Linn.).

One specimen from a small pool at the edge of the river at Medha.

Laccotrephes griseus (Guer.).

One specimen from same position and locality as the last. Both these species have a very wide distribution.

Family NAUCORIDAE.

Heleocoris elongatus, Montand.

A number of specimens from small rocky streams at Khandalla. "Very abundant, running about on and under stones below water and swimming when disturbed. N. A."

Recorded from Paresnath, 2,500 feet, iv-09, Bihar; Matheran, Bombay and "Indes Orientales." Also obtained by Dr. Gravely from the following localities in the Bombay Presidency:— Pophli, Vashishti Valley, Ratnagiri district, c. 400 ft., 1-2-v-1912; Tambi, Koyna Valley, Satara district, c. 2,100 ft., 24-26-iv-1912; and Nechal, W Ghats, Satara district, c. 2,000 ft., 30-iv-1912.

Heleocoris obliquatus, Montand.

A number of specimens in various stages of development from small pools at the edge of the river at Medha. Also found clinging to the lower surface of stones in stream, Sanjai River Chakradharpur, Chota Nagpur. Previously recorded from Bombay and Lower Burma. This species was also obtained by Dr. Gravely at Medha in April, 1912.

Naucoris sordidus, Dist.

A single specimen from a small rocky stream at Khandalla. This species has been recorded from the Calcutta tanks, and from Kerumaadi, S. end of Vembanaad Lake, Travancore, 6-xi-08 (N. A.).

Family NOTONECTIDAE.

Enithares lactea, sp. nov.

(Plate III, fig. 7.)

Described from a single specimen from a small pool at the edge of the river at Medha, Satara district.

Head, pronotum, scutellum and hemelytra milky white; vertex of head tinged with pale orange yellow a somewhat large orange yellow spot just below apical margin of vertex; a faint, shallow, longitudinal groove within the margin of each eye, not extending beyond the middle of the vertex; eyes greyish, with light purplish reflections, converging towards their bases; length of vertex about equal to its greatest breadth at apex, shorter than the pronotum, which is shining almost smooth and with a few, very minute, scattered punctures; foveately excavate anterior pronotal angles more or less fuscous; length of pronotum at centre less than half its greatest breadth; scutellum much broader at base than long, with a distinct transversely impressed line near basal margin; corium nearly as long as head, pronotum and scutellum together; embolium tinged with very pale yellow, a dull fuscous spot at its basal angle; body beneath dull white; two small contiguous spots on centre of face, lateral margins of face below eyes, margins of clypeus, linear markings on trochanters and on the hind femora beneath, and segmental spots on underside of connexivum dark castaneous; ventral longitudinal carina of abdomen fringed with long black hairs, a fringe of paler hairs on lateral margin of abdomen; intermediate femora with a

strong tooth near apex, hind tibiae about twice the length of the hind tarsi, deeply grooved beneath with a fringe of fine black hairs inside groove; hind tarsi also fringed with black hairs beneath.

Type. No. 8064/H.I. in the collection of the Zoological Survey of India.

This species is very closely related to *E. indica* and *E. paivana* from which it differs chiefly in the total absence of any black markings on its upperside; the transversely impressed line near the base of the scutellum is sufficient to differentiate it structurally from any allied form.

Enithares templetoni (Kirby).

Three specimens from small pools at the edge of the river at Medha, and three from small rocky streams at Khandalla. "Dives under water and clings to stones some inches below the surface. N. A." Evidently a very widely distributed species. Represented in the collection of the Zoological Survey of India from various localities in the Western Himalayas, Bombay Presidency, Ceylon and Southern Shan States.

Family CORIXIDAE.

Corixa hieroglyphica, Duf.

A number of specimens from small pools at the edge of the river at Medha.

VIII. SPONGES FROM THE SATARA AND POONA DISTRICTS AND FROM CHOTA (CHUTIA) NAGPUR.

I have already discussed Spongillidae from the Satara district in my paper on the sponges of the Malabar Zone (*Rec. Ind. Mus.* VII, pp. 383-397: 1912) and have referred to specimens from the Poona district in an earlier paper (*ibid*, VI, pp. 225, 226: 1911); but when I wrote these papers I had not visited the districts myself, and observation of sponges in the natural surroundings is always important. The species that inhabit the beds of rocky streams are of particular interest, and I am now able to compare those that do so at Medha with those found in a very similar stream at Chakradharpur in Chota Nagpur near the centre of Peninsular India. I have not yet found any sponge in a small mountain torrent such as those at Khandalla, in which food is probably deficient; but when these streams are dammed to form ponds in which aquatic vegetation grows up, sponges soon make their appearance.

So far as my experience goes, Spongillidae that grow on the rocks of Indian streams are always encrusting forms. Massive sponges would be in danger of destruction in floods, and although

the lax branches of *Spongilla lacustris* may be observed hanging in the water of placid streams such as the Isis at Oxford, the only branched form from running water that I can call to mind in the tropics is the South American *Uruguaya*, in which the skeleton is of coralline hardness. In the creeks of the Gangetic delta *Spongilla alba* may seem to be a branched form even when the water is moved by sluggish currents. It is not really so, but an encrusting sponge covering the roots or stems of grasses.

The sponges of Indian streams vary considerably both in external appearance and in internal structure. As a rule they are either of a vivid leaf-green colour or of a dense purplish-brown or black. They may be either soft or extremely hard; they usually spread over considerable areas, but are sometimes confined to pockets in the rock. Their colour, whether black or green, is due to the presence of large numbers of minute organized bodies in their cells. These bodies probably represent in all cases a stage in the life history of a microscopic alga, but whether the green corpuscles are all specifically identical we do not know, and no investigation has been made of the purple corpuscles which cause the darker colour. Black or brown sponges occur together with green ones and though their colour has no generic significance, it appears to be, in spite of its quasi-parasitic origin, of specific importance.

All the green sponges from rocky streams with which I am acquainted have a peculiar type of circulatory system that is often to be found in thin encrusting sponges, not only among the Spongillidae but also in several marine Tetraxonid families. In this type the pores, which are usually of relatively large size, are arranged in more or less circular groups immediately over the mouths of relatively wide inhalent canals, which run vertically downwards to near the base of the sponge, giving off lateral channels which convey the incoming water to the ciliated chambers. The exhausted water returns through other channels of similar calibre to the surface of the parenchyma, where it enters relatively wide horizontal canals that ramify immediately below the dermal membrane, which forms their roof. Each system has an osculum situated near the centre of these ramifying channels. It is never of large size and is always protected by a conical dermal collar, which is highly contractile and disappears in preserved specimens. This type of circulatory system is found among marine sponges that encrust rocks in shallow water and is by no means peculiar to green species; among the Spongillidae it is also found in almost colourless lacustrine species that grow near the edge of lakes on the lower surface of stones. Its development has no taxonomic significance but appears to be correlated with growth in the form of a thin layer on smooth surfaces in situations in which there is considerable movement in the water and danger from the accumulation of silt.

I collected specimens of the following species in the Satara and Poona districts and in Chota Nagpur:—

Spongilla lacustris var. *proliferens*, Annand.	Artificial pond at Khandalla
S. cinerea, Carter	Streams near Chakradharpur
S. perviridis, sp. nov.	Stream at Medha; rocky artificial pools in Satara fort and at Karla in the Poona district.
S. crateriformis, Potts .	Artificial pond at Khandalla.
S. sumatrana, Weber .	Well at Medha.
S. sumatrana var. *rivularis*, nov. .	Stream at Medha.
S. sumatrana var. *centralis*, nov.	Stream at Chakradharpur.
S. carteri, Carter	Reservoir in the Satara fort.
Corvospongilla ultima var. *spinosa*, Annand. .	Stream at Medha.

Of these species I need only discuss *S. cinerea*, *S. perviridis*, and *S. sumatrana* with its varieties.

Spongilla (Euspongilla) cinerea, Carter.

(Plate VI, figs. 1, 1*a*, 1*b*).

1911. *Spongilla cinerea*, Annandale, *Faun. Brit. Ind., Freshw. Sponges*, etc., p. 79, fig. 10.

This sponge, which appears to be very rare, has been known to me until recently merely from Carter's description, from a dried schizotype of the original specimen from a tank at Bombay and from some very imperfect material from Nasik. Living specimens were, however, obtained by Dr. Gravely and myself in Chota Nagpur some months ago and I am now able to differentiate from Carter's species a closely allied form (here described under the name *S. perviridis*) that I formerly believed to be a mountain phase of it.

S. cinerea may be distinguished from all other species of the subgenus *Euspongilla* yet known by three characters:—

(1) Its dense purplish-brown or black colour.
(2) Its very finely spinose or subspinose skeleton-spicules.
(3) The great regularity of its skeletal structure.

To take these characters in order. The colour is due to the presence in the cells of both the parenchyma and the dermal membrane[1] of minute organized bodies resembling the green

[1] This is also the case in *Corvospongilla ultima* var. *spinosa*.

corpuscles of many freshwater sponges in structure but of a deep purple colour, which is not soluble in spirit.

The spinosity of the megascleres is so faint that it is apt to escape notice altogether unless they are examined under a very high power of the microscope. The tips are smooth.

The regularity of the skeleton is due mainly to the compact formation and large number of the primary radiating or vertical spicule-fibres, which run upwards through the sponge for considerable distances without branching and are joined together by much less regular cross-fibres or by groups of spicules. The vertical fibres contain a considerable amount of binding substance.

The gemmules are small and very numerous in all the specimens I have examined. They have a thick pneumatic layer in which the air-spaces are very minute, and a slender, straight, projecting foraminal tubule.

In February, 1918 Dr. Gravely and I found specimens at two localities in the Singbhum district of Chota Nagpur, in a rocky stream close to Chakradharpur and in a pool of muddy water, evidently part of a sluggish stream in the rains, on the road between that place and Chaibassa.

At Chakradharpur the sponge was growing on the rocky bed of the stream in clear running water. It was essentially of encrusting habit but in little pockets in the rock showed a tendency to adopt a cushion-like form and was then a centimetre or more thick. The oscula were small on the flat rock but in the pockets become larger (about 5 mm. in diameter). In all cases they opened into wide vertical exhalent canals and horizontal subdermal exhalent canals were absent. The sponge was very soft and of a deep purple-brown colour. Our specimens from a pool on the Chaibassa road were attached to the lower surface of bricks at the base of the piers of a bridge. They had a cushion-like form and were harder and blacker than those from the stream. Their oscula were small and branching horizontal exhalent channels were conspicuous on the surface of the parenchyma.

Spongilla (Euspongilla) perviridis, sp. nov.

(Plate VI, figs. 2, 2*a*, 2*b*).

1912. *Spongilla cinerea*, Annandale (*nec* Carter), *Rec. Ind. Mus.* VII, pp. 137, 387.

This sponge, though closely related to *S. cinerea*, can always be distinguished by the following characters:—

(1) Purple corpuscles are absent from both parenchyma and dermal membrane and are replaced in the former only by green corpuscles.

(2) The skeleton-spicules are more distinctly spiny, but also have smooth extremities.

(3) The skeleton is much less regular.

(4) The oscula are always small and surrounded by radiating exhalent channels.

Type-specimen.—P 59/1 *Zoological Survey of India (Ind. Mus.).*

Distribution.—I have examined specimens from the Kumaon lakes in the Western Himalayas as well as from the Koyna and Yenna rivers in the Satara district and from artificial reservoirs in the Satara fort and at Karla in the Poona district. At the last-named place I found the surface of the water densly covered with gemmules from dried sponges exposed on rocks.

Spongilla (Stratospongilla) sumatrana, Weber.

1890. *Spongilla sumatrana*, Weber, *Zool. Ergebn. Niederl. Ost.-Ind.*, I, p. 38, pl. iv, figs. 6-10.

S. sumatrana has not hitherto been recognized as occurring in British India, though reported from both Sumatra and the Nile. In describing *S. indica* and *S. gravelyi* I pointed out their close relationship to this species, but in the absence of linking forms was obliged to regard them as specifically distinct. Linking forms have, however, now been found and specimens of the *forma typica* discovered in Indian territory. The species seems to be an extremely plastic one and at least five varieties may be recognized. The species as a species must, therefore, be defined in somewhat general terms. I believe that the following description should be adequate.

Sponge thin and encrusting, of a bright green colour except when in deep shade or very muddy water, with small oscula and horizontal ramifying subdermal exhalent channels, with a hard but very friable skeleton formed of large numbers of macroscleres without well-defined spicule-fibres, with short slender macroscleres the majority of which are spiny, with slender amphioxous or amphistrongylous free microscleres that are always densely covered with short spines and are usually abundant in the dermal membrane, with short, compact amphistrongylous gemmule-spicules also covered with short spines; gemmules small, spherical, covered with a single layer of microscleres arranged mosaic wise in a single layer in an outer horny membrane, with a short, nearly straight foraminal tubule.

forma typica.

In this form the skeleton-spicules are sharply pointed and irregularly spiny; there are two kinds of free microscleres, one larger and more sharply pointed than the other; the gemmule-spicules are very short and stout, uniformly spiny and either straight or slightly curved. The gemmules are free. The skeleton is very compact.

The form was described from Lake Singkarah in Sumatra. I found small patches of dried sponge on the walls of a well at Medha that agree with a co-type sent me by Prof. Max Weber. The nilotic variety described by Weltner [1] seems to differ from the

[1] "Die Coelenteraten und Schwämme des Süssen Wassers Ost-Afrikas" in Mobius' *Ost.-Afrika*, IV (1908).

forma typica merely in slight differences in the measurements of the spicules.

var. **rivularis**, nov.

(Plate VII, fig. 2).

The skeleton-spicules are stouter and as a rule less sharply pointed than in the *forma typica*; the gemmule-spicules are relatively longer, more variable and often more irregular in outline; the skeleton is less compact; the gemmules are either free or fixed by means of their outer spiculiferous coat at the base of the sponge.

Type-specimen.—P 66/1 *Zool. Survey of India* (*Ind. Mus.*).

Locality.—Rocks in the river Yenna at Medha.

I could not distinguish living specimens from *S. perviridis*, side by side with which they were growing.

var. **centralis**, nov.

(Plate VI, fig. 3; plate VII, fig. 1).

The skeleton-spicules, though remaining long and relatively slender, are for the most part distinctly blunt at the tips. Otherwise the form resembles the var. *rivularis*.

Type-specimen.—P 71/1, *Zool. Survey of India* (*Ind. Mus.*).

Locality.—Rocky bed of a stream at Chakradharpur, Chota Nagpur.

var. **indica**, Annandale.

(Plate VII, fig. 3).

1908. *Spongilla indica*, Annandale, *Rec. Ind. Mus.*, II, p. 25, figs. 1, 2.
1911. *Spongilla indica*, *id.*, *Faun. Brit Ind.*, *tom. cit.*, p. 100, fig. 17.

Most of the skeleton-spicules are blunter and shorter than in the last variety; the gemmule-spicules are on an average much smaller and more slender; the skeleton is more compact and the gemmules are as a rule fixed at the base of the sponge.

Localities.—Nasik and Igatpuri in the Nasik district, Bombay.

var. **gravelyi**, Annandale.

1912. *Spongilla gravelyi*, Annandale, *Rec. Ind. Mus.*, VII, p. 385, fig. 1.

The skeleton-spicules are relatively long, slender, sharply pointed and sparsely spined; the gemmule-spicules have a peculiar curvature and are often knobbed at the end; the gemmules are free.

Locality.—Koyna river at Taloshi, Satara district, Bombay.

In distinguishing these varieties reference should be made to the figures here reproduced or cited. I have avoided giving detailed descriptions as it is possible that intermediate forms exist and it seems best in dealing with the varieties of a plastic species not to be too exact.