# RECORDS

of the

# INDIAN MUSEUM

(A JOURNAL OF INDIAN ZOOLOGY)

Vol. XIV, 1918.

EDITED BY

THE DIRECTOR,

ZOOLOGICAL SURVEY OF INDIA

Calcutta:
PUBLISHED BY THE DIRECTOR, ZOOLOGICAL SURVEY OF INDIA

1918

# FAUNA OF THE INLE LAKE

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## LIST OF PLATES.



## ERRATA.

In the fifteenth line from top of page on page 22 for "*Prittopus breddini*" *read* "*Perittopus breddini*".

In line 12 from top of page on page 51 and under *Microrasbora erythromicron* for "P. 2" *read* "P. 12".

In the twelfth line of the fourth paragraph on page 57 between the words "contrivance" and "of" *insert* the word "consists".

In the second line from bottom of page on page 60 before the words "of variable" *insert* the words "and is".

In the fourth line of the second paragraph on page 62 for the word "former" *read* "latter".

In the first line on page 111 for "arge" *read* "larger".

In the ninth line from bottom of page on page 184 for "Glocidium" *read* "Glochidium".

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*N.B.*—An asterisk (*) preceding a line denotes a new variety or subspecies; a dagger (†) indicates a new species; a double dagger (‡) a new genus or subgenus; two asterisks (**) a new family: synonyms are printed in italics.

## A



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# PREFATORY NOTE

TO VOLUME XIV OF

THE

RECORDS OF THE INDIAN MUSEUM.

THE collections and observations on which this volume of the *Records of the Indian Museum* is based were made in February and March 1917, by Dr. F. H. Gravely and myself. I have to thank him for much assistance in the field and since we returned to Calcutta. I am also greatly indebted to Mr. C. E. Browne, I.S.O., Political Adviser, Yawnghwe, who did his utmost to further the objects of our tour. I have to thank Mr. G. C. B. Stirling, C.I.E., Superintendent of the Southern Shan States, for valuable advice.

There is one point in connection with the Inlé Lake to which I would direct the attention of naturalists and others. It is the extraordinarily favourable site for biological investigation of many kinds that the lake affords. Not only are almost unique opportunities for the study of variation in aquatic molluscs, recent and fossil, to be found in the neighbourhood and many peculiar species and even genera to be discovered, but the water of the lake is so clear that it is possible to watch the fish and other animals under natural conditions; the climate is good, the place, even now, not inaccessible, being within forty miles of the railway by motor. The people are both interested and willing to assist—a state of affairs not to be found in all parts of the Indian Empire. A small laboratory built out in the lake would not be expensive; it would afford facilities not easily to be bettered for both zoological and botanical work, and I believe that more good would be done to Indian research and Indian practical science by the foundation of a laboratory of the kind than by a great deal of so-called economic work.

The illustrations for this volume have been prepared mainly by the artists attached to the Zoological Survey of India, Babu A. C. Chowdhary, Babu S. C. Mondul and Babu D. N. Bagchi. The photographs of fishing boats, etc., in the Shan States were taken by Dr. Gravely.

N. ANNANDALE,

*Director,*

*Zoological Survey of India.*

# INTRODUCTORY ACCOUNT OF THE INLE LAKE.

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

( With Map. )

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## GEOGRAPHY OF THE LAKE.

**Situation of the Lake.**

The Inlé Lake[1] lies in the State of Yawnghwe on the Shan Plateau at a height of 3,000 feet above sea-level, in Lat. 20° 35′ N., Long. 96° 57′E. It is thus well within the Tropics but at an altitude that mitigates the violence of a tropical climate. The lake occupies the central part of a trough between two ranges of hills, which, like all the ranges of that part of Burma, run almost due north and south. At its two ends, and to a lesser extent on the western side, alluvial plains have been formed, and are gradually extending outwards into the water. Several streams run through the northern plain and combine in the swampy ground between land and water. None of these streams are of any great size. They come from the north and from the west ; one of the most important of them flows from a dried lake-basin situated only a few miles to the north-west of the Inlé Lake but 800 feet higher. This stream makes its way with a very sudden drop through a narrow gorge in the hills. The dried lake-basin, to which I shall have to refer frequently, is the He-Ho plain. On the western

[1] *Inlé* means the " Lake (*in*) of the Four " (*lé*). The name is said to be derived from a league of four villages which at some troublous period of history made themselves independent of the local Shan chief.

side a rather larger stream enters the lake by several mouths, coming also from the north-west, and rising in the high ground that separates the watershed of the Irrawaddy from that of the Salween. Before reaching the lake, and on the other side of a range of hills, it disappears, running for some miles at a great distance beneath the surface. This is a habit of rivers on the Shan Plateau, a habit that may have had considerable influence in the distribution of the fauna. On the eastern side a few hill-streamlets enter the lake ; many of them dry up in winter, and all are very short. From the south end of the lake a larger river makes its way southwards ; like the stream on the western side it disappears into the ground, but at some considerable distance south of the lake. Its subterranean wanderings are unknown, but there can be little doubt that much, if not all, of its water finally reaches a tributary of the Salween.

The lake is thus, in a sense, the centre of a closed system, without direct communication with any of the important river-systems of Burma, but, in a wider sense, it may be considered to belong to the system of the Salween.

**Dimensions of the Lake.**

For reasons that will be made clear shortly, it is impossible to state the dimensions of the Inlé Lake precisely. It is about 14 miles long, and about 4 miles broad. The depth varies with the seasons. In March it is nowhere greater than 12 feet, and the average depth is not more than 7 feet ; but at the end of the rainy season the greatest depth must be at least 20 feet.

**Water.**

The water is remarkable for its extreme clearness. It is thus possible, when there is no breeze, to watch the animals at the bottom almost as if they were in an aquarium. All the silt brought down by the streams is deposited before it reaches the middle of the lake. The clearness of the water is probably correlated with its chemical composition. Mr. R. V. Briggs has analysed a sample which came from the surface in the middle of the lake, with the following results :—

| | Per litre. |
|---|---|
| Total Solids | 0·1710 |
| Organic matter | 0·0160 |
| Calcium | 0·0222 |
| Magnesium | 0·0279 |
| Chlorine | 0·0017 |
| Sulphate ($SO_4$) | 0·0017 |
| Silica | 0·0010 |
| Carbonic Acid ($CO_3$) | 0·1030 |
| Iron | Less than 1 part in 5 million. |

No precise details are available as to the temperature of the water. We found it remarkably constant at the beginning of March, not varying more than 2 degrees Fahrenheit. The average surface temperature was about 71°F. (21·7° C.) at that season, and the average bottom temperature one degree Fahrenheit lower ; the average air temperature being about 73°F. (22·8° C.).

**Nature of the shore.**

I have already alluded to the impossibility of stating the exact dimensions of the lake. This is because of two facts, firstly because its size increases greatly in the wet season, secondly because it has not at any time of the year what may be called a solid margin, for it is completely surrounded by floating islands formed by the growth and decay of vegetation. These islands, which are massed together round the edge of the lake, are one of its most characteristic features. Many different kinds of plants take part in their formation, but those of primary importance are certain large grasses and sedges that send out long floating runners from which new upright stems arise. Floating plants such as duckweed become entangled amongst these runners, and at the same time submerged weeds, especially a species of *Ceratophyllum*, grow up to the surface, where their upper parts are killed by the heat of the sun or the growth of algae. The mass of vegetation thus entangled is further agglutinated by the luxuriant growth of an alga belonging to the family Rivulariaceae which forms large brownish masses. These elements of the island in the making both decay and grow. Their decay forms a kind of fen-peat, which is prevented from sinking by their floating and growing parts.

**Floating Islands.**

A floating island covered with rich soil is thus formed, and plants[1] of a great variety of species grow up upon it, forming dense entangled masses. Even conspicuously flowering orchids and small shrubs flourish in a little time. These islands not only afford shelter and food for a large part of the fauna, but are of great importance in practical agriculture. When a cultivator wishes to grow tomatoes, cucumbers, or indeed any kind of vegetable, he cuts off a piece of a floating island sufficiently large to form his field, and then ties a rope to it and tows it to a suitable situation. The next operation is to turn the island upside down, which is easily achieved as its equilibrium is by no means stable, to anchor it with a bamboo pole thrust through it into the bottom of the lake and then to pile up more peat from the bottom upon the exposed surface until it becomes solid enough for him to walk upon, and even to build a house or erect a pig-sty. The gardens thus formed are extremely fertile.

The presence of the floating islands, cultivated or in their natural state, causes a very distinct differentiation of the lake into two regions, an open central region and a swampy marginal zone. As we shall see, the fauna of these two regions is very distinct. I have also been able to recognize an intermediate zone, where the two regions meet.

At the ends of the lake, and especially at the southern end (to which floating matter is carried by a quite perceptible current), a considerable area is covered with floating islands, merging gradually into swampy land.

**Nature of the bottom.**

The bottom of the marginal zone, beneath the islands, is composed very largely of a black peaty substance somewhat inimical to animal life. That of the central region is of a very peculiar nature. Strictly speaking, indeed, the lake has not a solid bottom at all. Beneath the water there is a layer of semi-liquid consistency composed of extremely

[1] Large botanical collections were made and have been deposited in the herbarium of the Botanical Survey of India.

small particles of a greenish grey colour suspended at a constant level, but never in their natural position becoming consolidated even into real mud. These particles are largely of a calcareous nature, as is shown by the following analysis of a dried specimen from the bottom of the northern part of the central region. This analysis also was made by Mr. R. V. Briggs :—

| | Per cent. |
|---|---|
| Insoluble siliceous matter | 0·98 |
| Alumina | 1·30 |
| Oxide of Iron | 2·25 |
| Lime | 45·31 |
| Magnesia | 1·25 |
| Potash | 0·12 |
| Soda | 0·46 |
| Moisture | 3·10 |
| Carbonic acid | 33·15 |
| Phosphoric acid | 0·17 |
| Sulphuric acid | 0·41 |
| *Organic matter and combined water by difference | 11·50 |
| | 100·00 |

*Containing Nitrogen . . 0·619

On being dried the pea-soup-like mass forms a grey, very friable clay in which fragments of vegetable matter are abundantly present.

At some places the bottom is almost bare, the only growth upon it being a scanty one of such plants as *Potamogeton crispus*, *P. pectinatus*, *Hydrilla verticillata* and a species of Characeae, but over the greater part of this region dense masses of *Ceratophyllum* flourish, binding the bottom together with their roots to some extent, but not sufficiently to make it solid. The submerged thickets thus formed rise up to a height of at least 7 or 8 feet, and sometimes almost reach the surface. In some places they are in a flourishing condition even when their growing parts are almost in contact with the surface film, but at others they exhibit towards their upper extremities all the symptoms of ill-health, probably because of the growth of algae of various kinds among them.

## STRUCTURE OF THE SURROUNDING COUNTRY.

In order to understand the history and origin of the lake, and therefore of its fauna, it is necessary to consider the structure of the surrounding country. The lake lies in the great Limestone Zone of the Shan Plateau thus described by Middlemiss[1] :—

"In its essentials, and not considering the younger minor zones that are inlaid with it, it is a rugged, rocky country. The dark grey limestone frequently weathers almost black into sharp-edged honey-combed masses, into pinnacled crags and weather-beaten towers and walls : into deep basins and swallow-holes (often as regular and circular in outline as a gigantic amphitheatre, but sometimes funnel-shaped) : into strange valley systems without connection one with the other, and that often end mysteriously either as underground passages down which streams precipitate themselves and become lost, or as marshes and lakes where evaporation helped out no doubt by subterranean percolation causes a disappearance of the waters : into innumerable caves and passages beneath the ground, some now high and dry from the waters that caused them and which are locally mined for the nitrates that have accumulated upon the floors from the decomposition of cave animal deposits, others used as show places and temples ; others again unknown to fame and rich in their virgin beauty of stalactitic growths."

[1] *General Report of the Geological Survey of India for 1899-1900* : "Report on a Geological Reconnaissance in parts of the Southern States and Karenni," p. 130.

The age of the rocks is uncertain, but it is sufficient for our purpose to know that they are of marine origin, and very ancient, and that their formation must have long preceded the hollowing out of the Inlé basin.

**Superficial deposits.**

The superficial deposits of the district have great interest in relation to the living fauna in that they prove the former existence of lacustrine molluscs at places now devoid of water, particularly in the He-Ho plain and in smaller valleys among the hills of Yawnghwe. The shells from the deposits will be discussed later in a paper dealing primarily with the living forms.

The deposits are of four kinds :—(*i*) Red Soil, (*ii*) Peaty Deposits, (*iii*) Grey Clay and (*iv*) Recent Tufa.

**Red Soil.**

La Touche [1] has shown that the red soil which covers a great part of the Shan Plateau is the insoluble debris of limestone rocks dissolved by water. Soil of this kind covers most of the He-Ho plain and also of the flat ground at the head of the Inlé Lake. In a small valley, that of the Hsin-Dawng stream, about three miles east of the town of Yawnghwe and at several hundred feet above the level of the plain, there are two small limestone caves, the floor of which is formed of red soil and contains fossil shells and mammalian remains. The shells are closely related to but distinctly different from those both of the He-Ho and the Inlé basins.

**Peaty Deposits.**

An enormous amount of peaty matter is always being formed round the Inlé Lake and in other damp situations on the Shan Plateau. Together with the silt brought down by the streams that flow into the lake, it must in the end fill up the basin completely. On the He-Ho plain, especially round the margin of the old lake, there are considerable deposits of this origin. They contain numerous shells in a fossil or subfossil condition. These shells belong to the same genera and in many cases to the same species as those now living in the Inlé Lake.

**Grey Clay.**

At the western end of the He-Ho plain, between two small limestone spurs, a short distance above the point at which the He-Ho stream begins to descend through its gorge into the Yawnghwe valley, there is a deposit of grey clay exactly similar to that which is formed when the semi-liquid substance from the bottom of the existing lake is dried. The stream has cut through this deposit to a depth of at least 20 feet. It is full of shells differing in some cases from those found in the peaty deposits of the same neighbourhood but closely allied to them.

**Recent Tufa.**

One of the most extraordinary phenomena to be observed in the Shan States is the formation of calcareous tufa owing to the deposition of lime from solution in water. This phenomenon is thus described by La Touche [2] :

**Calcareous Dams.**

"The enormous extent to which the limestone of the plateau is being removed in solution by percolating waters has already been alluded to, and it is not surprising to find that, when the water comes again to the surface in springs and rivers, and is either evaporated or loses the carbonic acid which keeps the carbonate of lime in solution, the deposits thrown down should reach correspondingly huge dimensions. Indeed I doubt whether any other limestone tract

[1] *Mem. Geol. Survey Ind.*, Vol. XXXIX, p. 322.
[2] *Mem. Geol. Survey Ind.* Vol. XXXIX, p. 325.

can show deposits of this kind of such magnitude, at least in the open air. In the ordinary "Karst" region the evaporation usually takes place as the water trickles into the caverns and hollows worn out of the rock, with the formation of stalactites and stalagmite; but in the Shan States there are no open caverns in the great bulk of the limestone, owing to its universally shattered condition, which causes the mass to settle down as underground solution proceeds; though in the superjacent, more compact, Permo-Carboniferous limestones caverns are common enough. Thus the carbonate of lime which would ordinarily be deposited on the walls of the caverns and fissures is in this region brought to the surface and thrown down in the open. The brecciated structure of the rock also allows water to percolate freely through the mass in all directions, and this no doubt adds to the rapidity with which it is dissolved."

One can watch the formation of rocks where the lime-laden water is trickling over masses of leaves and roots. At the head of the He-Ho pass what appears at first sight to be a fossil coral-reef is actually in process of formation owing to water dripping upon the roots exposed when a bank of earth is washed away by heavy rain. The lime is deposited in concentric layers round each root, the organic matter of which gradually decays and disappears, leaving a hollow tube. On the He-Ho plain Dr. Gravely found curious ridges of tufa running for considerable distances some feet above the surface of the soil and clearly representing the beds of now perished streams. They were full of shells of the same species as those found in the peaty deposits.

Even from this brief description, which should be read in connection with the papers by La Touche and Middlemiss already cited, it will be clear that the surface of the Shan Plateau has been, and still is, subject to great changes with which the waxing and the waning of the Inlé Lake are intimately connected.

## Origin and History of the Lake.

The lake belongs to the type known as solution lakes—lakes with their basins hollowed out of limestone by the dissolving action of water. A common feature of such lakes is the presence somewhere in their bottom of a "sink" or deep pit down which the whole or a part of the water is liable to disappear. No "sink" exists in the Inlé Lake at present, but the point at which the river that flows out of it disappears underground may very possibly have, at one period, been beneath its waters. I have not seen this place and can, therefore, only point out again that a very large tract of country to the south of the lake must at one time have been covered by its waters, and have been gradually filled in by the two processes referred to above, *i.e.*, by the deposition of silt and the formation of peat, especially by the latter agency.

The lake must thus at one time have covered a much greater area than it does at present, and it must have been much deeper, though we have no evidence as to the height to which its waters reached. It may have been over a hundred miles long and several hundred feet deep. Moreover it is by no means the only lake that once existed in the neighbourhood. Indeed, superficial deposits in the emptied basins scattered amongst the hills of the Shan Plateau make it evident that the country was once a regular lake country. Some of the lakes must have disappeared at a remote period, but others have dried up recently, perhaps even in historical times. There are traditions which seem to point to this having occurred at He-Ho. The deposition of silt and the form-

ation of peat have not been the only factors that have led to the disappearance of water from the basins. Another cause has been the eating through of limestone rocks by water rendered acid by the decay of vegetation. The He-Ho stream makes its way down into the lower plain through an ancient limestone ridge, and it is not improbable that the water may have been finally drained from the upper plain by its cutting through this ridge in a comparatively short time under exceptionally favourable conditions.

It is not surprising, therefore, to find that the fauna of the Inlé Lake is a very highly specialised one, differing from any other aquatic fauna yet discovered. The lake is merely the last, shrunken relic of a once extensive system, the connections of which may have been greatly different at different periods in its history. It has, however, been isolated for a considerable time, and evolution has taken place rapidly and widely. To illustrate these facts the different groups of animals must be considered separately, and then the whole summarized. To do this is the object of the present volume.


Rec No 4715 E 17

MAP OF INLE LAKE AND DISTRICT.

0 1 2 3 4
Scale in Miles

Meliotypeographed at the Survey of India Offices Calcutta

# AQUATIC OLIGOCHAETA OF THE INLE LAKE.

*By* J. Stephenson, *D.Sc., Lt.-Col., I.M.S., Professor of Zoology, Government College, Lahore.*

Of the small but interesting collection of Oligochaeta made by Dr. Annandale at the Inlé Lake in the Southern Shan States, and kindly handed over by him to me for examination, the most remarkable specimens are a series of *Branchiura sowerbyi*. These have enabled me to demonstrate the existence of a penis (perhaps a pseudopenis, according to Michaelsen's definition, 5), and to show that in this form also, as well as in *Kawamuria japonica* (11), the muscular coelomic chamber is the apparatus for its extrusion. The amount of variation shown by these specimens in such features as length of body and length and number of gills is surprising.

I have taken this opportunity of also referring to two varieties of *Nais communis* from the Punjab which have recently come into my hands, though these are not part of the Inlé collection.

## Family NAIDIDAE.

### Genus **CHAETOGASTER.**

#### **Chaetogaster annandalei,** Stephenson.

Inlé Lake, S. Shan States. In Sponge (*Ephydatia fluviatilis*) ; 28th February, 1917. N. Annandale. Several specimens, none sexually mature. (No. W. 113-1.)

The identification rests on a comparison with individuals of the original batch of specimens from L. Biwa in Japan (11). The present specimens are about one-fourth larger ; in length a chain of two individuals is ·89 mm., the first being ·63 and the posterior ·26 mm. ; the diameter is ·175 mm. ; the setae of segment ii are 90$\mu$ and of more posterior segments 60$\mu$ in length.

#### **Chaetogaster limnaei ?** V. Baer.

In same tube as the above ; several specimens, none sexually mature. (No. W. 135-1.)

The length of these specimens is no greater, in the preserved condition, than that of *C. annandalei*, with which they occur ; but the other proportions are quite different ;—they are about twice as thick, and the setae also are markedly larger. So far as I can see, the only distinction between these specimens and *C. limnaei* is the rather smaller number of setae in these,—6 or 7 in segment ii and 3, 4, or 5 behind. *C. limnaei* has up to 8—12, according to Vejdovsky (12), who also remarks that the hinder segments have commonly more than the anterior ; this is not the case here, but it is pretty certain that the above numbers do not represent the actual state in the living animal, and that a number of setae

have fallen out ; in some segments I cannot discover any setae, and in one bundle I saw only one, though succeeding segments had four or five. The identification is however by no means above doubt.

*C. limnaei* is a European species which is parasitic on and in fresh-water Gastropods, or is occasionally free-living. It has not hitherto, I think, been recorded as living in sponges.

### **Chaetogaster bengalensis,** Annandale.

Small canal and flooded rice-fields near Than-taung on W. Side of Inlé Lake, Southern Shan States ; in *Ephydatia fluviatilis*. 28th February, 1917. N. Annandale. A number of specimens, none sexually mature. (No. W. 114-1.)

The identification rests on a comparison with the types of the species, kindly sent to me by Dr. Annandale. The species was originally obtained by him from water snails in Calcutta (1). I may supplement the original account by a few additional particulars, based on an examination of the present specimens.

The length of a chain of two individuals in the preserved condition is 1·8 mm. or more ; of the first individual of a chain measured separately, 1 or 1·2 mm. The diameter at the widest part is ·35—·38 mm. The comparatively short length just given does not conflict with Annandale's statement that the animal measures at least 10 mm. when fully expanded ; the type specimens are the same length as these.

*N* 10 or 11.

The setae of segment ii are in length 85$\mu$, 90$\mu$, and 104$\mu$ in three different specimens. The main portion of the shaft is straight, the prongs are almost equal in length and thickness as a rule, even to the oil immersion lens ; sometimes the proximal prong appears slightly thicker at the base. The position of the nodulus varies from the middle of the shaft to frankly distal (distal to nodulus : proximal to nodulus : : 2 : 3).

In more posterior segments the setae are shorter, 68$\mu$—74$\mu$ in length ; in thickness they are about 1·7$\mu$. Here again the greater part of the shaft is straight, the distal end being hooked, and the proximal gently curved ; no difference can be regularly made out between the terminal prongs, though sometimes the distal seems to be rather longer and thinner. The nodulus varies in position in the setae of the same bundle,—from the middle of the shaft to distinctly distal ; where the disposition could be minutely examined, the innermost seta of the bundle has the nodulus nearest the middle, and the most external seta has it most distally placed on the shaft (*cf.* Stephenson, 9*a*).

The number of setae in a bundle is, as Annandale has remarked, very large ; I counted 16 (as well as lesser numbers) both in the bundles of segment ii and in those further back (Annandale, 15—17). The much-curved line of insertion of the setae of a bundle is very striking.

The prostomium is practically absent,—it is merely the anterior lip of the mouth ; this is a large circular orifice, ventro-terminal, looking obliquely forwards and downwards. The section of the alimentary canal which succeeds the pharynx, usually called oesophagus, is short but quite distinct. The beginning of the next part of the canal, the swollen crop, is marked by a number of cells, arranged in a fairly broad ring

around the opening of the oesophagus into the crop ; these are part of the lining epithelium, as is seen in longitudinal sections, where they appear as prominent cells projecting into the lumen, almost constituting a circular valve.

There is a considerable granular more opaque mass in the cerebral ganglion, as in some other species of the genus (*cf.* Stephenson, 6).

*Remarks.*—The species is a well marked one, the large number of setae being very characteristic. In addition, the practical equality in length and thickness of the terminal prongs of the setae, even to the highest powers (correctly shown in Annandale's figure), with the short but distinct oesophagus, will also serve as good marks of distinction.

Not having noticed, in those species of *Chaetogaster* which occur in the Punjab, any specially curved line of insertion of the setae, I was much struck by this very marked feature in the present specimens ; the curvature seemed to me to be even more accentuated than in Annandale's figure. It is not, however, peculiar to this species ; Miss Davies, in describing *C. australis* (3), which has resemblances to the present species, mentions that the setae are arranged in the form of a semicircle, except in the case of those of segment ii ; Mdlle. Dehorne mentions it in her study of *C. diaphanus* (4), and adds that this arrangement is even more distinct in *C. limnaei.*

I do not add to the list of distinctive features of *C. bengalensis* the presence of a posterior sucker (the anterior sucker of Annandale is the margin of the mouth, as in the case of the leech). The posterior sucker is mentioned by Annandale in his original account ; in *C. australis*, Miss Davies says, " at the posterior end there is no definite sucker, but the animal seems capable of slightly flattening its body so as to somewhat resemble one " ; and for *C. victoriensis*, " movement takes place by means of a series of contractions and expansions with the aid of anterior and posterior suckers, somewhat like a leech." I have not been able to see the posterior sucker in the types of *C. bengalensis*, nor in the present batch of specimens ; in Annandale's figure it appears to be merely the margin of the anus,—but this aperture is not provided with any special musculature discoverable either in the examination of mounted specimens or in longitudinal sections. Notwithstanding the more or less definite statements I have quoted above, I do not think there will be found in any species of *Chaetogaster* a posterior sucker, that is, a definite muscular organ, whether including the anus or not. I believe that the attachment of the animal at the posterior end takes place by means of the hinder setal bundles, the hooked ends being turned forwards and taking hold of the substratum (as in the case of backward progression, *cf.* Stephenson, 6, p. 237) and that Mdlle. Dehorne (on *C. diaphanus*) correctly likens the mode of progression to that of a caterpillar,– " l'animal se déplace à la façon des chenilles arpenteuses, les soies bucco-pharyngiennes jouant le rôle de harpons, les soies moyennes et postérieures fixant la chaîne au substratum."

If I might venture an additional word of criticism, it is that sections do not show any special thickness of the pharyngeal wall ; nor is there any peculiarity, as Annandale supposes, in the manner of insertion of the setae of segment ii.

### Genus **NAIS.**

**Nais communis,** Piguet var. **punjabensis,** Stephenson.

Kasauli ; July, 1915. Baini Prashad. Several specimens, none sexually mature.

**Nais communis,** Piguet var. **caeca**, Stephenson.

Along with the above. Several specimens, none sexually mature.

It is interesting to find the blind variety of this worm along with the one possessing eyespots, as was the case in the material from Travancore from which the var. *caeca* was first described (Stephenson, 7).

## Family TUBIFICIDAE.

### Genus **BRANCHIURA.**

**Branchiura sowerbyi**, Bedd.

Inlé Lake, Southern Shan States. In very soft mud in the open lake in 7 feet of water ; green plants abundant. Several batches, 19th February to 5th March, 1917. N. Annandale. (No. W. 103-4—1.)

Kaung-daing, Yawnghwe State, Southern Shan States. In soft mud at edge of stream of warm water issuing from hot sulphur spring ; surface of mud barely covered with water ; no vegetation. Several specimens ; February, 1917. N. Annandale. (No. W. 111—1.)

Inlé Lake, Southern Shan States. In black mud at edge of lake in about 1 foot of water ; much decaying vegetation present. Several specimens ; 28th February, 1917. N. Annandale. (No. W. 112—1.)

Of the specimens collected at the various stations a number were sexually mature ; and a preliminary examination showed in some a feature not hitherto recorded,—a penis-like projection from the male orifice. This was however not present in all the sexual animals ; one showed a projecting penis on one side and not on the other ; a few showed two, the majority no penis at all. Three specimens were sectioned,—with none, one, and two penial projections respectively.

In those cases where there is no projecting penis the various structures have much the arrangement described by Michaelsen (5). Michaelsen divides the male deferent apparatus into the following parts :—

(*i*) the funnel ;

(*ii*) the vas deferens, which enters the wall of the next portion, the atrium, near the apex of the latter, and runs in that wall, in a direction away from the external aperture, to its very tip ;

(*iii*) the ental [1] portion of the atrium, a moderately wide tube surrounded by a thick layer of modified peritoneal cells ;

(*iv*) the middle portion of the atrium, a narrow continuation of the above, which soon enters the coelomic sac, in the upper part of which it winds about, accompanied by the paratrium ; the lumina of the atrium and paratrium finally unite ;

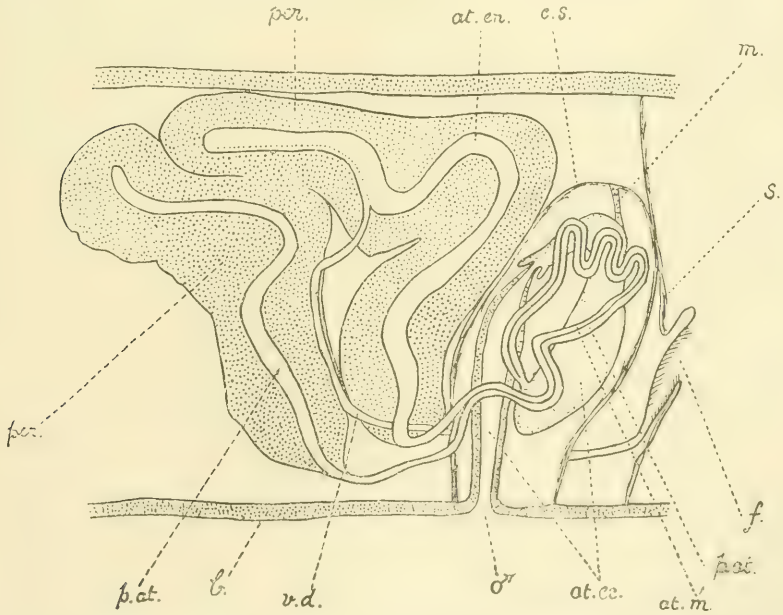
[1] Different authors use the terms "proximal" and "distal" in different senses in describing, for example, such a structure as the atrium, or a spermatheca. The more usual practice amongst English writers seems to be to take the fixed end,—that which is united with the bodywall,—as the proximal ; but Michaelsen calls the internal end proximal and the outer distal. To obviate confusion I use the terms "ental" and "ectal."

(*v*) the wider, ectal portion of the atrium has a generally vertical course to the exterior through the coelomic sac ;

(*vi*) the paratrium, a narrow tube ending blindly at its ental end and joining the atrium at the other ; it is also covered by a thick layer of modified peritoneal cells.

In all the cases hitherto observed the male orifice was quite simple (Beddard, 2 ; Michaelsen, 5 ; Stephenson, 9).

I may observe, first, that the ectal portion of the atrium is here divisible into two distinct sections,—a lower, the terminal part of the whole deferent apparatus, and an upper ; the distinction is, I believe, of some importance from the point of view of the protrusion of the penis. The upper section makes several bends in the upper part of the coelomic sac ; the epithelium lining the lumen is cubical, and the peculiarity of the cells is that the inner portion stains slightly or not at all,—less deeply than the basal part ; the hyaline appearance of the part of the cells which is towards the lumen gives them a distinctive character ; the nuclei are spherical, and stain rather lightly, showing scattered grains of chromatin in their interior. This section is divided from the lower usually by a distinct narrowing, and sometimes the walls of the tube appear folded here. The lower section has a generally vertical position in the sac ; its muscular coat is thick, and the epithelium is columnar, though of irregular height ; the nuclei are oval, and stain densely.




1.—*Branchiura sowerbyi ;* male genital apparatus, diagrammatic. *at. cc.*, *at. en.*, *at. m.*, the ectal, ental, and middle portions of the atrium ; *b.*, bodywall ; *c.s.*, coelomic sac ; *f.*, funnel ; *m.*, muscular band ; *p. at.*, paratrium ; *per.*, mass of peritoneal cells ; *s.*, septum 10/11 ; *v. d.*, vas deferens ; ♂, male aperture.

There are also a few other minor differences between these specimens and those investigated by Michaelsen. Thus the middle does not

suddenly become swollen where it passes into the ectal portion of the atrium,—the enlargement is gradual. The atrium extends as far as, and may extend further back in segment xii than the paratrium; both atrium and paratrium may be confined to segment xi. The portion of the vas deferens which is contained within the atrial wall is considerably greater than is shown in either of Michaelsen's figures (see the dotted line in fig. 1), and indeed the length of the ental portion of the atrium as a whole is here much greater, and its course more winding; it is here a much more conspicuous feature of the anatomy than the paratrium, though the reverse would seem, from the figures, to have been the case in Michaelsen's specimens. The lower (ectal) portion of the paratrium, of considerable length, has here a well-marked lumen and is lined by cubical cells; it has here escaped from the voluminous peritoneal investment. Michaelsen seems to be right in denying a muscular coat to the paratrium, at any rate to that part which is enclosed in the thick covering of peritoneal cells. Fig. 1 gives a diagrammatic representation of the male apparatus in the present specimens.

The penis, where it occurs, appears as a pear-shaped or cylindrical projection, sometimes twisted, from the male orifice. It is an evagination of the ectal portion of the atrium; and it is here that the distinction of the ectal portion into two sections, an upper and a lower, is of use; the lower part forms, when protruded, the outer wall of the penis, and the upper the axial canal which traverses the projection (text-figs. 2 and 3); the aperture of the protruded penis is thus the junction

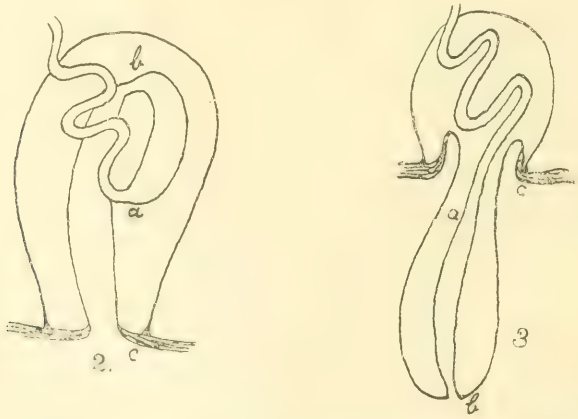



Fig. 2.—*Branchiura sowerbyi*; penis not protruded.
" 3.— " " penis protruded.
*a, b, c,* corresponding points.

between the upper and lower sections. This is borne out by the characters of the epithelium; the central tube is lined by cells of a cubical shape with a more lightly staining inner portion; but it is not so easy to recognize in the outer covering of the penial projection the characters of the cells lining the lower part of the atrium, since these are for the most part much flattened in their new situation.

When the penis is protruded the coelomic sac extends to only about half the height of the segment, and contains only the winding portions

of the conjoined atrium and paratrium ; the evagination of the terminal section of the atrium seems never to be complete, so that there is in full protrusion still a deep groove round the base of the penis, which thus projects from within the male aperture (text-fig. 3).

I was at one time inclined to doubt whether the "coelomic sac" was really coelomic,—whether its cavity was really a cut-off portion of the coelom. It seemed to me that the most terminal portion of the male duct,—that part which was originally included in the parietes,—might have hypertrophied to produce the penis, and in so doing might have raised up the inner part of the muscular layer of the bodywall so as to form the sac. On this supposition the cavity of the sac would not be coelomic, but only an enlarged split in the muscular wall of the body. In the same way the cavity of the gills is a space, not coelomic in origin, between the two muscular layers of the parietes ; there the outer muscular layer carrying the superficial epithelium projects outwards as a gill, here the inner layer carrying the peritoneal investment would project inwards as the sac-wall.

However, the atrium within the sac has an (apparently) peritoneal covering, well-marked in places, and consisting of cubical clear cells ; and a much flattened cell-layer can also be seen on the inner side of the sac-wall. The cavity and its contents appear therefore to be lined and covered respectively by peritoneal epithelium, and the space to be really coelomic.

The above condition is remarkably similar to that which I have recently described in *Kawamuria* (11). It is curious that the penial projection in *B. sowerbyi* has not previously been observed ; there is however nothing, in the more usual condition of the orifice, to indicate the possibility of such a protrusion,—the canal ends quite simply on the surface of the body. It is true that I recognized the function of the coelomic sac in *Kawamuria*,—to cause, by contraction of its walls, the extroversion of the contained tube ; but in *Branchiura*, which has the sac but, so far as I then knew, no protrusible penis, I considered the sac to have lost its function, and to be a rudimentary organ ; it is evidently at times fully functional.

The distance between *Branchiura* and *Kawamuria* is thus reduced ; the separation must now depend on the presence or absence of gills. I will not further discuss at present whether generic distinction is still justifiable, but may refer to what I wrote in my former paper.

The specimens showed much variation. In length one batch consisted of worms of 30, 28, 25 or fewer mm. ; in another the individuals were 45—70 mm. ; in others they were 90 or 100 mm., and one specimen reached the great length of 185 mm.

The number of pairs of gills was 40—47 in the shorter worms, and 90 in the longest ; but this was not the maximum. In one fragment 140 pairs were found, but the total length of the animal cannot be known. As many as 110 were found in an individual only 70 mm. long.

Sometimes nearly all the gills were well developed, only a few at the anterior end of the series being represented by mere tubercles ; in others a large number of the anterior gills were only tiny projections. But variation in this point seems to have no relation to the number of

gills or the size of the animal ; in a posterior fragment with 118 pairs, 43 were mere tubercles, and indeed all but the last 20 were little more ; in a specimen 100 mm. long, with 92 pairs, all but a few were well developed ; in the longest specimen, with 90 pairs, about half were tubercles only.

The length of the gills also varies. In an ordinary specimen they are perhaps somewhat shorter than the diameter of the body ; but in two examples of the present series they were very long,—about three times as long as usual,—filamentous, tangled together and hence difficult to count. In a third specimen of the same batch they were about twice as long as usual ; but in the fourth and last in the tube they were not noticeably longer than the ordinary.

As can be seen, these variations seem to be independent of each other ; nor can I connect them with the habitat except in a small degree. The specimens just mentioned, with the very long gills, were all taken from black mud at the edge of the lake, in about one foot of water, where much decaying vegetation was present ; the length might be correlated with deficiency of oxygen,—but one specimen had gills of only normal length. The length of the animals may however have a relation to the nature of the bottom in which they live ; thus those living in soft mud at the edge of a stream were the shortest (the stream was warm, and issued from a hot sulphur spring,—conditions which might perhaps have checked growth) ; lengths of 45—70 mm. were found in one foot of water in relatively stiff, peaty mud ; and specimens 90, 100, and 185 mm. were contained in the catches from the open lake, in seven feet of water. These very long specimens were taken on a bottom of extreme softness, indeed of semi-liquid consistency, in which it would be necessary for cylindrical bodies to be of great length in order to maintain a vertical position.

## Family MEGASCOLECIDAE.

### **Perionyx fulvus,** Stephenson.

Inlé, Yawnghwe State, Southern Shan States ; soft mud in muddy stream in $1\frac{1}{2}$—3 feet of water. 6th March, 1917. N. Annandale. Four specimens. (No. W. 108-1.)

The species was hitherto only known from a single specimen taken in Calcutta. I must here correct a mistake which has crept into my original account (10) ; the male pores are there said to be " not very close together on segment xviii." I do not know how the word " not " crept in ; my original notes have " male apertures very close together," and the figure of the male area in my notes (which I did not reproduce in the paper) is practically a facsimile of the one I give here (fig. 4), drawn from the present specimens, except that the apertures are there even rather nearer together.

FIG. 4.—*Perionyx fulvus ;* region of male apertures.

As the type specimen is incomplete posteriorly, I may give the following measurements ;—length 175 mm., thickness 4 mm. (max. 4·5) in

the case of the largest example; the others are smaller,—one which is only 98 mm. long and 2·5 to 3·25 mm. in thickness has well marked male apertures though no clitellum. The largest specimen had 178 segments.

The only notable difference of the specimens from the type is the colour; most species of *Perionyx* are distinguished by a rich purple colour dorsally, and the fact that the type specimen was yellowish brown and almost unpigmented suggested the specific name. The present examples however are a deep brownish purple above, pale below. The aquatic habitat is interesting.

An immature *Perionyx* was also obtained from the Inlé Lake, Southern Shan States, from black mud at the edge of the lake, in about one foot of water where much decaying vegetation was present. The locality, and the fact that it was also aquatic, suggest that the specimen belongs to the same species; and this is borne out to some extent by the commencing change in the male area, where the transverse grooves before and behind the male apertures, characteristic for *P. fulvus*, are beginning to appear. I mention it because of its colour, which seems to represent an intermediate condition between the fulvous and purple. To the naked eye it appeared a dusky purple dorsally in the anterior part, becoming increasingly lighter behind, and in the posterior half it is merely buff or tawny. Under the binocular dissecting microscope the colour is uniform at the anterior end; but behind this, longitudinal streaks of pigment are seen in each segment, purple on a yellow background, interrupted by the intersegmental furrows and not always corresponding in position from one segment to the next; the streaks are still present, but increasingly lighter, up to the hinder end, but there they only suffice to modify the yellow background to a buff tint (fig. 5). The deposition of pigment thus appears to take place in streaks, and not uniformly, a uniform tint being produced by expansion and coalescence of the streaks.

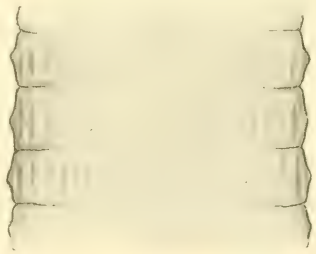


FIG. 5.—*Perionyx fulvus* (presumably); to show manner in which pigmentation develops.

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# AQUATIC RHYNCHOTA FROM THE SOUTHERN SHAN STATES.

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

The water-bugs collected by Drs. N. Annandale and F. H. Gravely in the Southern Shan States include many novelties and are of great interest on account of the unexplored state of the region in which the collection was made.

Although the families Hebridae, Pelogonidae and Naucoridae are unrepresented and only one species of Belostomatidae and two of Nepidae have been obtained, the remaining families are fairly represented. Of the thirty-three species listed below seven belong to the genus *Gerris* (Hydrometridae), three to the genus *Micronecta* (Corixidae), two each to the genera *Microvelia* (Hydrometridae), *Enithares*, *Anisops*, *Plea* (Notonectidae) and *Corixa* (Corixidae), and one each to *Mesovelia*, *Velia*, *Perittopus*, *Ptilomera*, *Onychotrechus*, *Ventidius*, *Metrocoris*, *Naboandelus*, *Nacebus* (Hydrometridae), *Ranatra*, *Cercotmetus* (Nepidae), *Sphaerodema* (Belostomatidae) and *Nychia* (Notonectidae).

This is probably by no means a complete list of the Aquatic Rhynchota of the Southern Shan States, as further research may discover many more known as well as new forms.

From the Inlé Lake itself one species of *Microvelia*, five of *Gerris*, one of *Naboandelus*, one of *Nacebus*, one of *Ranatra*, one of *Sphaerodema*, one of *Enithares*, one of *Nychia*, two of *Plea* and one of *Micronecta* were obtained.

Amongst the most striking forms may be mentioned the beautiful *Velia Y-alba* and a new species of *Nychia*, a genus which is very scarce in the Oriental Region. The species of *Plea* too are very interesting.

In order to render this enumeration as convenient as possible for reference, I have followed the arrangement adopted by Mr. Distant in his volumes of the *Fauna of British India, Rhynchota.*

Fam. Hydrometridae.
- *Mesovelia mulsanti*, Buch. White.
- *Velia Y-alba*, sp. nov.
- *Microvelia diluta*, Dist.
- *Microvelia burmanica*, sp. nov.
- *Perittopus breddini*, Kirk.
- *Gerris anadyomene*, Kirk.
- *Gerris nepalensis*, Dist.
- *Gerris fossarum* (Fabr.)
- *Gerris nitida* (Mayr.).
- *Gerris tristan*, Kirk.
- *Gerris paludum*, Fabr.
- *Gerris spinolae*, Leth. and Sev.
- *Ptilomera laticaudata* (Hardw.)
- *Onychotrechus lyra*, sp. nov.
- *Ventidius distanti*, sp. nov.
- *Metrocoris nigrofasciatus*, Dist.
- *Naboandelus signatus*, Dist.
- *Nacebus dux*, Dist.

Fam. Nepidae.
- *Ranatra varipes*, Stal.
- *Cercotmetus pilipes* (Dall.)

Fam. Belostomatidae.
- *Sphaerodema rusticum* (Fabr.)

Fam. Notonectidae.
- *Enithares templetoni* (Kirby).
- *Enithares intha*, sp. nov.
- *Anisops niveus*, Fabr.
- *Anisops sardea*, Herr.-Schaff.
- *Nychia infuscata*, sp. nov.
- *Plea quinquenotata*, sp. nov.
- *Plea areolata*, sp. nov.

Fam. Corixidae.
- *Corixa unicolor*, sp. nov.
- *Corixa septemlineata*, sp. nov.
- *Micronecta substriata*, sp. nov.
- *Micronecta soror*, sp. nov.
- *Micronecta fulva*, sp. nov.

## Family HYDROMETRIDAE.

### Subfamily *MESOVELIINAE.*

**Mesovelia mulsanti,** Buch.-White.

*Mesovelia mulsanti,* Distant, *Faun. Brit. Ind., Rhyn.* II, 1904, p. 169 ; *id. ibid.*, V (Appendix), 1910, p. 137.

A number of specimens in various stages of development from the marginal zone of the Inlé Lake, Yawnghwe State, 2—3-iii-1917.

A very widely distributed Oriental species, occurring also in North and Central America and in the Antilles.

### Subfamily *VELIINAE.*

**Velia Y-alba,** sp. nov.

(Plate VIII, fig. 1.)

Described from a single pinned specimen from the marginal zone of the Inlé Lake at Fort Stedman, Yawnghwe State, 28-ii-1917.

Head reddish-brown with a central, longitudinal, pale, impressed, smooth line on disk ; antennae hairy, ochraceous, the basal joint stout, curved, with sub-basal, submedial and apical fuscous annulations ; second joint a little shorter than first, broadly banded with fuscous a little beyond base and at apex ; third joint slender, subequal in length to second and fourth, almost entirely fuscous except at base, where it is pale ; 4th joint slender, with basal and apical fuscous annulations ; eyes black, deeply faceted, the facets appearing silvery in certain lights. Pronotum reddish-brown, the posterior area much darker, almost black and thickly covered with shallow punctures and short black hairs. On the anterior area there are two submarginal, bluish-grey, longitudinal fasciae widening posteriorly and extending from near the anterior lateral angles to a little beyond the junction of the anterior and posterior lobes ; sides of pronotum distinctly subangulate, the posterior angle rounded. Elytra dark brown with a large irregularly rectangular patch at basal angle, narrowed towards base, a small oblong one at about middle of inner margin and a reversed Y-shaped mark at apex, dull white. Dr. Annandale informs me that when the insect was alive these marks were of a bluish-grey tint. Underside light yellowish-brown, the prosternum and the mesopleura darker, a lateral series of silvery grey spots outwardly margined with black, extending from the prosternum to the sixth ventral segment, a suffusion of red on the underside of the connexivum and on the fifth, sixth and seventh ventral abdominal segments. Legs hairy, luteous, annulated with dark fuscous ; coxae and femora marked with red on the underside ; hind femora incrassated.

Rostrum ochraceous, with a broad, longitudinal, black band below.

Length 6 millim.

*Type* No. 7109/H. I. in the collection of the Zoological Survey of India.

### **Microvelia diluta,** Dist.

*Microvelia diluta,* Distant, *Faun. Brit. Ind., Rhyn.* V (Appendix), 1910, p. 139.

I have identified this species with some doubt. All the specimens that were collected were preserved in alcohol, and in this state the markings, especially those on the elytra, appear more distinct than those in pinned specimens, in which they have a tendency to fade or become discoloured. In the alcohol specimens there is a distinct interruption in the ochraceous band at the anterior margin of the pronotum, whereas in the pinned specimens in the collection of the Zoological Survey of India this band appears to be entire, and is also figured as such by Distant in his description of the species. Furthermore, the colour of the antennal joints and that of the underside seem to vary to a very marked degree in the specimens in alcohol.

A large number of specimens, in all stages of development, were taken on the surface of a small puddle at the foot of Elephant Hill, near Yawnghwe, 17-ii-1917, and two specimens from the surface of the marginal zone of the Inlé Lake, 2—3-iii-1917. This species has been recorded from Calcutta and Rajshahi in the Province of Bengal.

### **Microvelia burmanica,** sp. nov.

(Plate VIII, fig. 2.)

A single specimen (preserved in alcohol) of this species was obtained on a small stream at Hsamonghkam (Thamakan) 4,000—4,500 feet, Southern Shan States, 13—14-ii-1917, and a few from the Taung-gya Valley, Yawnghwe State, *ca.* 3,500 ft., 2-iii-1917.

I cannot identify this species with any described form. It resembles *M. albomaculata* most closely, but the position of the spots on the elytra is a little different, the relative length of the antennal joints and the colour of the legs, antennae and the underside are also different.

I have compared the Shan specimens with some specimens of *M. albomaculata* identified by Distant. The length he gives in his description of the latter is 2 mm., but the specimens he has identified are considerably smaller. The Shan specimens, though actually much larger than those of *M. albomaculata,* measure only 2 mm. in length.

In general colouration this species is very like *M. albomaculata.* A series of small deep black spots is situated within the marginal pubescent fascia near the inner margin of each eye, and there is a longitudinal, impressed, black line on the disk of the head not continued to the base or apex. The antennae are hairy, brownish ochraceous ; the greater part of the basal joint posteriorly is much paler ; the first joint is stout, curved outwards, longer than the second which is the shortest joint ; second joint stout at apex and tapering at base ; the third joint is slender, long, a little longer than the first ; the fourth joint is very long, slender, about as long as the second and third together ; eyes black.

The pronotum is as in *M. albomaculata,* except that there is a distinct, deep black, discal, longitudinal line extending from the anterior fascia to a little beyond the middle.

Hemelytra dull fuscous black with numerous greyish-white spots : a very large spot interrupted with fuscous occupies nearly the whole of the clavus ; corium with a small and a large basal marginal spot ; a large, centrally infuscate spot near inner margin, a smaller one near outer margin ; an elongate irregular subapical membranal spot, and a smaller elongate spot at inner angle. Body beneath black. Legs hairy, brownish ochraceous, darker towards the apices of the femora, tibiae and tarsi.

Length 1·9—2 millim.

In addition to the Shan specimens I have examined a number obtained by Dr. Gravely on the road from Thingannyinaung to Myawadi, Tenasserim, *ca.* 900 ft., 24—26-xi-1911.

*Type* No. 7106/H. I. in the collection of the Zoological Survey of India.

**Perittopus breddini,** Kirk.

*Prittopus breddini*, Bergroth, *Wien. Ent. Zeit.* XXV, p. 16.

There seems to be some doubt about the identity of this species. The genus was originally described from an apterous form by Fieber, in a very vague manner. Later on Kirkaldy defined it more fully and made *P. breddini*, a Javanese species, the type of the genus, the description being taken from an apterous form also. Bergroth described a macropterous form and placed it in this species. The only Burmese form as yet recorded, *P. rufus*, Distant, was described from an apterous insect. Dr. N. Annandale,[1] however, described a winged form from a small tributary of the Rangoon River, Burma, as that of *P. rufus*. The specimens from the Shan States, which are all winged, agree with the one described by Dr. Annandale as well as with Bergroth's description of *P. breddini* from Java, and apterous specimens from Sukli, east side of the Dawna hills, *ca.* 2,100 ft., Burma, agree with apterous specimens in the collection identified by Distant. Among those from Sukli there are also some winged forms which are exactly similar to the Shan ones. It seems probable that these all belong to one species, and as *P. breddini* was described before *P. rufus*, the Shan specimens must be placed under the former name.

A number of adult specimens were obtained from a small pool in the bed of a dry stream at He-Ho, *ca.* 3,800 ft., Yawnghwe State, 7—9-iii-1917 ; three specimens in the Taung-gya Valley, *ca.* 3,500 ft., 2-iii-1917, and six from Fort Stedman, *ca.* 3,500 ft., Yawnghwe State, 3-iii-1917. The species is common on small pools in streamlets in the State of Yawnghwe and also in the Dawna hills. The genus appears to be practically confined to a habitat of this kind.

Subfamily *GERRINAE*.

**Gerris anadyomene,** Kirk.

*Gerris anadyomene*, Distant, *Faun. Brit. Ind. Rhyn.*, II, p. 177.

A number of specimens in various stages of development from a pool at the western foot of Pagoda Hill, He-Ho, *ca.* 3,800 ft., Yawnghwe State (7—9-iii-1917).

[1] *Rec. Ind. Mus. VI*, p. 112 (1912).

This species was originally described from Pundaluoya, Ceylon, and it has also been recorded from the Philippine Islands. It has not, however, hitherto been found in Continental India.

### **Gerris nepalensis,** Dist.

*Gerris nepalensis*, Distant, *Faun. Brit. Ind., Rhyn.* V (Appendix), p. 143.

Several specimens, both pinned and in alcohol, from various localities as detailed below :—

Swamp at the head of the Inlé Lake, Yawnghwe State, 20-ii-1917.
Marginal zone of the Inlé Lake at Fort Stedman, Yawnghwe State, 28-ii-1917 and 2—3-iii-1917.
Canal, Than-taung, west side of the Inlé Lake, Yawnghwe State, 28-ii-1917.
Hsamonghkam (Thamakan), 4,000-4,500 ft., 13—14-ii-1917.

This appears to be a very common and widely distributed species. Specimens from various localities in Nepal, the United Provinces and from Kawkareik, Tenasserim, are in the collection of the Zoological Survey of India.

### **Gerris fossarum** (Fabr.)

*Gerris fossarum*, Distant, *Faun. Brit. Ind., Rhyn.* II, p. 178 ; *id. ibid.*, V (Appendix), p. 142.

This species was rather common on the lake itself and several specimens were obtained on the 2—3-iii-1917. Some also were got in the canal at Than-taung, Yawnghwe State, 28-ii-1917.

It has been previously recorded from Bombay and Bengal in India, and from Malacca, the Philippines, China and Australia.

### **Gerris nitida** (Mayr.)

*Gerris nitida*, Distant, *Faun. Brit. Ind., Rhyn.* II, p. 178 ; *id. ibid.*, V (Appendix), p. 142.

Two specimens from the marginal zone of the Inlé Lake, 2—3-iii-1917 and one from the edge of the Inlé Lake at Fort Stedman, Yawnghwe State, 28-ii-1917.

This species is found nearly all over India, Burma and Ceylon.

### **Gerris tristan,** Kirk.

*Gerris tristan*, Distant, *Faun. Brit. Ind., Rhyn.* II, p. 179 ; *id. ibid.*, V (Appendix), p. 144.

Seven specimens from the marginal zone of the Inlé Lake, Yawnghwe State, 2—3-iii-1917.

Originally described from Ceylon, but now known to occur in India and Burma also.

### **Gerris paludum,** Fab.

*Gerris paludum*, Distant, *Faun. Brit. Ind., Rhyn.* II, p. 180.

Two pinned macropterous specimens from the canal at Than-taung, Yawnghwe State, 28-ii-1917, and two in alcohol from a small stream, Hsamonghkam (Thamakan), 4,000-4,500 ft., 13—14-ii-1917.

I think I have identified this species correctly. The description given by Distant is very meagre. Douglas and Scott in their "British Hemiptera" have, however, given a more detailed description with which the specimens agree fairly well.

The only other example in the collection of the Zoological Survey has abbreviated elytra; it was taken in Palestine and was determined by Horvath.

**Gerris spinolae,** Leth. and Sev.

Of this very abundant species only a few specimens were obtained, *viz.*, two specimens from a swamp at the head of the Inlé Lake, Yawnghwe State, 20-ii-1917; two from the canal at Than-taung, Yawnghwe State, 28-ii-1917, and eight from the Inlé Lake, Yawnghwe State, 3,000 ft., 18—28-ii-1917.

**Ptilomera laticaudata** (Hardw.)

*Ptilomera laticaudata*, Distant, *Faun. Brit. Ind., Rhyn.* II, p. 185.

Six specimens from Taung-gya Valley, Yawnghwe State, *ca.* 3,500 ft., 2-iii-1917; two specimens from Than-taung, Yawnghwe State, *ca.* 3,000 ft., 28-ii-1917. "Not uncommon on jungle streams in Burma, the Malay Peninsula and Siam; markedly gregarious. N. A."

**Onychotrechus lyra,** sp. nov.

(Plate VIII., fig. 3.)

Described from one pinned and several alcohol specimens from the Taung-gya Valley, Yawnghwe State, *ca.* 3,500 ft., 2-iii-1917.

Ochraceous with numerous black markings which are sometimes more or less reduced or almost absent. Most of these markings are densely covered with fine greenish pubescence. Head with the apex black (seen from beneath), with a silvery white pubescent spot on each side; a large V-shaped mark on disk of vertex, a small marginal spot on each side before eyes and a slightly curved fascia on the posterior area near the inner margin of each eye, black.

Pronotum with four black spots or marks; two discal, which are largest and converge on the anterior margin, and two smaller, lateral, submarginal, touching the anterior margin.

Mesonotum very large, more than twice as long as the pronotum. A large harp-shaped mark on disk, anteriorly clothed with greenish and posteriorly with bluish-grey pubescence; on each side of this is a lateral curved line extending from the anterior margin to about the middle of disk, a short broad band connects this with another curved line, the inner part of which extends to the base of the mesonotum, with the outer portion reaching the region of the intermediate acetabula. Abdomen blackish above, the three apical segments medially ochraceous. Connexivum marked with ochraceous.

Antennae piceous, basal joint ochraceous. Legs ochraceous, tarsi black.

Propleura with a black spot almost touching the lateral spot on the pronotum. Mesopleura with a black impressed line, silvery pubescent, slightly sinuate anteriorly, not reaching the posterior margin. All the acetabula with a silvery pubescent black spot at base.

Sternum pale ochraceous with scanty silvery pubescence ; a central and two lateral black lines, the central line extending from the prosternum to the apical segment of the abdomen, the lateral lines from the front acetabula to near the intermediate acetabula.

Length 4·25 millim.

*Type* No. 7124/H. I. in the collection of the Zoological Survey of India.

**Ventidius distanti,** sp. nov.

(Plate VIII, fig. 4.)

Described from several specimens in alcohol, from the top of the gorge of the He-Ho River, Yawnghwe State, *ca.* 3,500 ft., 7-iii-1917.

*Apterous form.*—Head black with a large patch at base, and a transverse fascia at apex of face yellowish ochraceous ; eyes silvery grey, with a black patch on the disk ; antennae black, basal half of first joint yellowish.

Pronotum very short, black, a narrow ochraceous waved fascia at basal margin, anterior margin slightly concave, posterior margin almost straight. Mesonotum large, about as long as its greatest breadth, covered with decumbent hairs, disk obliquely striate on anterior area, ochraceous, with two broad lateral black fasciae curved inwards anteriorly and meeting narrowly on anterior margin, each extended posteriorly to meet a curved fascia on the intermediate acetabula ; a large subtriangular patch at centre of posterior margin ; the posterior lateral angles narrowly dull black.

Metanotum dull black with a small ochraceous spot near each basal angle.

Abdomen above dull white, the basal segment, a spot at lateral margin of each segment and the apical segment black.

Underside pale ochraceous ; legs black, base of anterior femora ochraceous.

Length 3 millim.

*Type* No. 7125/H. I. in the collection of the Zoological Survey of India.

**Metrocoris nigrofasciatus,** Dist.

*Metrocoris nigrofasciatus*, Distant, *Faun. Brit. Ind., Rhyn.* V (Appendix), p. 159.

Several specimens from foot of Elephant Hill near Yawnghwe, 17-ii-1917, and 6-iii-1917.

A few from a pool at the western foot of Pagoda Hill, He-Ho, 3,800 ft., Yawnghwe State, 9-iii-1917. Four specimens from a small stream near Fort Stedman, Yawnghwe State, *ca.* 3,500 ft., 3-iii-1917.

A somewhat variable species with a wide distribution having been recorded from the base of the Western Himalayas, Lower Burma, the Malay Peninsula and Siam. It probably also occurs in the Eastern Himalayas and Assam.

**Naboandelus signatus,** Dist.

*Naboandelus signatus*, Distant, *Faun. Brit. Ind., Rhyn.* V (Appendix), p. 164.

Several specimens from the marginal zone of the Inlé Lake, Yawnghwe State, 28-ii-1917, 2—3-iii-1917.

Two specimens from a swamp at the head of the Inlé Lake 20, 28-ii-1917, and six from the canal at Than-taung, west side of the Inlé Lake, Yawnghwe State, 28-ii-1917.

This species was first found in the Calcutta tanks. It is possible that it may be found throughout India and Burma.

**Nacebus dux,** Dist.

*Nacebus dux*, Distant, *Faun. Brit. Ind., Rhyn.* V (Appendix), p. 165.

Three specimens preserved in alcohol from the marginal zone of the Inlé Lake, Yawnghwe State, 2—3-iii-1917.

This species has been recorded from Calcutta and Mudon, Amherst District, Tenasserim.

Family NEPIDAE.

**Ranatra varipes,** Stal.

*Ranatra varipes*, Distant, *Faun. Brit. Ind., Rhyn.* V (Appendix), p. 316.

One specimen from swamp at edge of the Inlé Lake, Yawnghwe State (24-ii-1917), preserved in alcohol.

Most of these bugs do not retain their natural colouration when preserved dry and colour markings are not very reliable when descriptions are made from dried specimens. This specimen, however, agrees with the structural characters given by Distant in his description of the species.

It is very widely distributed and has been recorded from Nepal, Bengal, Ceylon and Burma.

**Cercotmetus pilipes** (Dall.).

*Cercotmetus pilipes*, Distant, *Faun. Brit. Ind., Rhyn.* III, p. 23.

One specimen, preserved in alcohol, from the He-Ho Marsh, Yawnghwe State, 8—9-iii-1917.

This species was originally described from Bhutan and does not appear to have been recorded from elsewhere.

Family BELOSTOMATIDAE.

**Sphaerodema rusticum** (Fabr.)

*Sphaerodema rusticum*, Distant, *Faun. Brit. Ind., Rhyn.* III, p. 36.

Two specimens from the Inlé Lake, Yawnghwe State, 2—3-iii-1917 ; one specimen from the river at Yawnghwe, 6-iii-1917 ; one from the edge of the Inlé Lake at Fort Stedman, Yawnghwe State, 28-ii-1917, and one specimen from the canal at Than-taung, west side of the Inlé Lake, Yawnghwe State, 28-ii-1917.

A very common and widely distributed species, having been recorded by Distant from India, Burma, Ceylon, Siam, Malay Peninsula, Sumatra, Java, Philippines, China and Australia.

## Family NOTONECTIDAE.

### **Enithares templetoni** (Kirby).

*Enithares templetoni*, Distant, *Faun. Brit. Ind., Rhyn.* III, p. 43.

One adult and two immature specimens from a small stream above Fort Stedman, Yawnghwe State, *ca.* 3,500 ft., 3-iii-1917.

This species appears to have a fairly wide range, occurring in Bombay, Ceylon and the Siamese Malay States.

### **Enithares intha,** sp. nov.

(Plate VIII, fig. 5.)

Two specimens from the marginal zone of the Inlé Lake at Fort Stedman, Yawnghwe State, 28-ii-1917, 2—3-iii-1917.

Head varying in colour from pale stramineous to pale ochraceous, sometimes tinged with light green ; eyes dark castaneous or black.

Pronotum and elytra stramineous ; the former foveately excavated, anterior angles distinctly blackish ; sternum blackish. Extreme base of corium fuscous.

Legs stramineous, with the underside of the fore and hind tibiae and hind tarsi black at apex.

Head short, its vertex longer than its greatest breadth at apex, about equal in length to the pronotum ; its lateral margins convex and slightly attenuate towards base ; breadth at apex more than the width of the hind margin of the eye.

Pronotum more than twice as broad as length in middle. Scutellum much broader at base than long. Corium about as long as head, pronotum and scutellum together. Posterior tibia about two-thirds longer than posterior tarsus. Smaller than *Enithares indica*, from which it differs by the total absence of any dark markings on the upperside, as well as in proportion of head and pronotum.

Length 8—8·25 mm.

*Type* No. 7137/H. I. in the collection of the Zoological Survey of India.

### **Anisops niveus,** Fab.

*Anisops niveus*, Distant, *Faun. Brit. Ind., Rhyn.* III, p. 46.

Several specimens from a large muddy pool without weeds, He-Ho, 3,800 ft., Yawnghwe State, 8-iii-1917.

If I have identified this species correctly, it is a very variable one, as among the specimens in alcohol there are some with various black

marks on the pronotum and elytra, and others entirely devoid of any dark markings.

*A. niveus* has a very wide distribution.

### **Anisops sardea,** Herr.-Schaff.

*Anisops sardea,* Distant, *Faun. Brit. Ind., Rhyn.* III, p. 45.

A single female specimen from He-Ho, *ca.* 3,800 ft., Yawnghwe State, 7—9-iii-1917.

I have identified this species from its size. In all other respects it is almost indistinguishable from *A. fieberi,* Kirk.

### **Nychia infuscata,** sp. nov.

(Plate VIII, figs. 6, 6*a*.)

A number of specimens preserved in alcohol, from the marginal zone of the Inlé Lake, Yawnghwe State, 2—3-iii-1917.

This genus has not hitherto been recorded from continental India. Kirkaldy, however, records it from Ceylon. My description is taken from specimens in alcohol.

Head pale greenish, eyes light purplish. Pronotum white, with a lateral fuscous spot at each hind angle. Scutellum white. Elytra whitish, transparent; corium white, next to the embolium a broad longitudinal band extending the whole length and a short discal one (sometimes almost absent) united with the other at base, extending to a little before the middle of the corium, fuscous; the latter apically dull white. Embolium yellowish-white, the outer margin dark fuscous. Antennae pale white; second joint clothed with black hairs, fourth joint with silvery hairs and with a fine black longitudinal line below.

Clypeus fuscous brown, apical third of rostrum black.

Sternum pale ochraceous, sides and the acetabula covered with long, fine, black hairs.

Underside of abdomen pale ochraceous, with a distinct, central, longitudinal carination which does not extend to the base of the abdomen, clothed on each side with long, black hairs, which are also present on the lateral margins of the ventral abdominal segments. Hairs on the sides and apex of the abdomen long and silvery.

Legs pale yellowish-white; front and intermediate coxae and femora marked with dark fuscous; posterior femora with fine longitudinal fuscous lines; posterior tibiae with a black longitudinal line below, fringed with long black hairs; posterior tarsi also fringed with long black hairs; anterior and intermediate tarsi outwardly fringed with fine long white silky hairs; posterior tibiae and tarsi nearly subequal in length, posterior femora extending beyond apex of abdomen.

In some specimens there is a small black spot near the middle of the inner margin of each elytron. Structural characters as those of the genus.

Length 4—5 mm.

*Type* No. 7098/H. I. in the collection of the Zoological Survey of India.

**Plea quinquenotata,** sp. nov.[1]

(Plate VIII, figs. 7, 7*a*.)

One specimen from the edge of the Inlé Lake at Fort Stedman, Yawnghwe State, 28-ii-1917.

Dull greyish-white; head with a central, longitudinal, yellowish fascia extending from base to about the middle of the facial region, wider posteriorly than anteriorly; eyes purplish-red; head densely punctured.

Pronotum greyish-white, densely punctured; posterior lateral area slightly fuscous; five small black spots above, situated two a little behind anterior margin on disk, one near each lateral angle and one at the middle of the basal margin.

Scutellum yellowish, sparingly punctured. Elytra densely punctured with brown; clavus with the punctures darker near the base and apex; corium greyish-white with a transverse fuscous band near middle and a large fuscous patch on its posterior third.

Legs pale ochraceous, extreme apices of femora and tibiae annulated with black.

Underside dark brown or black.

Length 1·5 millim.

*Type* No. 7145/H. I. in the collection of the Zoological Survey of India.

**Plea areolata,** sp. nov.

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

One specimen from the top of the gorge of the He-Ho River, *ca.* 3,500 ft., 7-iii-1917, and two from the marginal zone of the Inlé Lake, Yawnghwe State, 2—3-iii-1917.

Head pale ochraceous with three dark brown spots, one central, longitudinal, rectangular, the others rounded and placed obliquely, one on each side and above the central spot; vertex sparingly punctured, disk impunctate; eyes black.

Pronotum fuscous, with the anterior margin brown and the anterior area and three lines (one broad, central, longitudinal, not reaching posterior margin and two indistinct lateral, oblique), pale ochraceous; the central line is laevigate; anterior area of pronotum almost impunctate, with a single line of punctures on anterior margin, the greater part of the posterior area with very deep black punctures which under a high power of the microscope appear like areola or deep pits, each pit with a short stiff hair. Scutellum yellowish-grey, dark along the basal margin, sparingly punctured.

Clavus and corium greyish-white with numerous deep black punctures, apex of clavus slightly fuscous.

Underside black or fuscous; the legs ochraceous, posterior tibiae with a series of fairly long spines beneath, and with a long stiff hair

[1] In the figure of this species the artist has raised each part of the insect in profile in order to show the markings more distinctly. Figure 7*a* gives a side view of the insect.

arising from the base and extending beyond middle, visible only from below.

Length 2·25 mm.

*Type* No. 7146/H. I. in the collection of the Zoological Survey of India.

## Family CORIXIDAE.

### **Corixa unicolor,** sp. nov.

(Plate VIII, fig. 10; pl. IX, fig. 2.)

Two specimens from He-Ho, *ca.* 3,800 ft., Yawnghwe State, 7—9-iii-1917, in a large muddy pool without weeds.

Moderately elongate, greatest breadth about half the length, pronotum without fasciae; the hemelytra not mottled with piceous.

Head smooth, ochraceous, with a brownish patch at base which is emarginate anteriorly, basal margin darker, length equal to breadth between eyes, a distinct tubercle at centre of basal margin, inner margins of eyes discally subparallel, converging slightly on the facial area, eyes greyish-black, large, subtriangular, extending posteriorly over the lateral angles of the pronotum, a few punctures on disk of vertex.

Pronotum pitchy black, its length in middle about half its breadth, very minutely punctured, shining, subcordate; lateral angles rounded anteriorly, acutely pointed posteriorly; anterior margin sinuate in the centre, posterior margin rounded, a faint, short, medial carina on disk.

Elytra light brown, densely punctured and covered with short stiff hairs; subcostal area opaque, dusky grey, hairy.

Sternum pale ochraceous.

Abdomen beneath yellowish. Legs testaceous. Clypeus transversely striate and with a faint medial longitudinal carina.

Palae large, with a fringe of long hairs externally and with a row of fine, closely-set teeth on the underside.

Length 6·5—7 millim.

*Type* No. 7143/H. I. in the collection of the Zoological Survey of India.

### **Corixa septemlineata,** sp. nov.

(Plate VIII, fig. 9; pl. IX, fig. 1.)

One specimen from foot of Elephant Hill near Yawnghwe, 17-ii-1917, preserved in alcohol.

This species differs from all other allied species in the pronotum having seven distinct, regular, pale ochraceous fasciae on the disk. The lateral margins of the face are oblique. The pronotum is slightly broader than its medial length. The species is a slender one more than twice as long as its greatest breadth.

Length 4·5 millim.

*Type* No. 7099/H. I. in the collection of the Zoological Survey of India.

**Micronecta substriata,** sp. nov.

(Plate VIII, fig. 11; pl. IX, fig. 3.)

Five specimens from Fort Stedman, *ca.* 3,000 ft., Yawnghwe State, 24-ii-1917.

Head pale ochraceous, with a brownish tubercle at centre of basal margin; pronotum and scutellum pitchy black (in pinned specimen); elytra olivaceous grey with irregular fasciate, fuscous lines and spots, which are situated as follows:—Clavus with a long submarginal broken fascia and indistinct fasciae near its scutellar margins; corium with discal irregular fasciae converging basally and apically; a small linear spot on inner margin, three elongate spots on costal margin, one subbasal, one medial and one subapical, and a large subtriangular patch at the inner angle of the right elytron.

Elytra densely and minutely punctured, each puncture bearing a minute stiff hair.

Head broader than long; shorter than pronotum; longer in the middle than at the margins near the eyes; posterior margin slightly concave.

Pronotum large; in the middle about half as long as broad; lateral margins about one-third the width of the hind margin of the eye; anterior and posterior margins strongly convex. Underside very pale ochraceous.

Length 2·75 millim.

*Type* No. 7149/H. I. in the collection of the Zoological Survey of India.

**Micronecta soror,** sp. nov.

(Plate VIII, fig. 12; pl. IX, fig. 4.)

One specimen from Fort Stedman, *ca.* 3,000ft., Yawnghwe State, 24-ii-1917.

Head about as long as space between eyes at base, longer in the middle than at the margins near eyes; ochraceous with a very pale brownish patch on disk of vertex and a line of the same colour within the margin of each eye; a distinct tubercle at the centre of the hind margin of the head; eyes black.

Pronotum short, about a quarter as long as broad; anterior and posterior margins slightly convex; lateral margins almost nothing, about a quarter the width of the hind margin of the eye; olivaceous brown with a central black, transverse fascia not reaching the lateral margins.

The markings on the elytra are nearly the same as those of the preceding species, except that the apex of the corium is broadly margined with fuscous and the discal markings are more united.

Posterior tarsi with a distinct black line above.

Length 2·5 millim.

*Type* No. 7150/H. I. in the collection of the Zoological Survey of India.

**Micronecta fulva,** sp. nov.

(Plate VIII, fig. 13; pl. IX, fig. 5.)

Three specimens from under floating islands, Inlé Lake, Yawnghwe State, 19-ii-1917.

The description has been taken from two specimens in spirit as the third specimen, which had been pinned, has shrunk.

Head, scutellum, anterior margin of clavus, legs and underside dull yellowish-white. A small angulate mark at middle of hind margin of head, fuscous; eyes black.

Head longer than space at base between eyes.

Pronotum fulvous, with the anterior margin narrowly fuscous; subtriangular, the anterior margin broadly rounded, posterior margin almost straight; about half as long as broad; lateral angles about a third of the width of the hind margin of the eye.

Scutellum with a short transverse discal streak and the apex broadly fuscous. Clavus excluding anterior margin fuscous. Corium fulvous with some dashes of fuscous on disk.

Length 2·25 millim.

*Type* No. 7155/H. I. in the collection of the Zoological Survey of India.

## EXPLANATION OF PLATE VIII.

FIG. 1.—*Velia Y-alba*, sp. nov., enlarged.

,, 2.—*Microvelia burmanica*, sp. nov., enlarged.

,, 3.—*Onychotrechus lyra*, sp. nov., enlarged.

,, 4.—*Ventidius distanti*, sp. nov., enlarged.

,, 5.—*Enithares intha*, sp. nov. Head and pronotum, enlarged.

,, 6.—*Nychia infuscata*, sp. nov., enlarged.

,, 6*a*.— ,, ,, Dorsal view of head, enlarged.

,, 7.—*Plea quinquenotata*, sp. nov., enlarged

,, 7*a*.— ,, ,, (side view), enlarged.

,, 8.—*Plea areolata*, sp. nov., enlarged.

,, 8*a*.— ,, ,, Front view of head, enlarged.

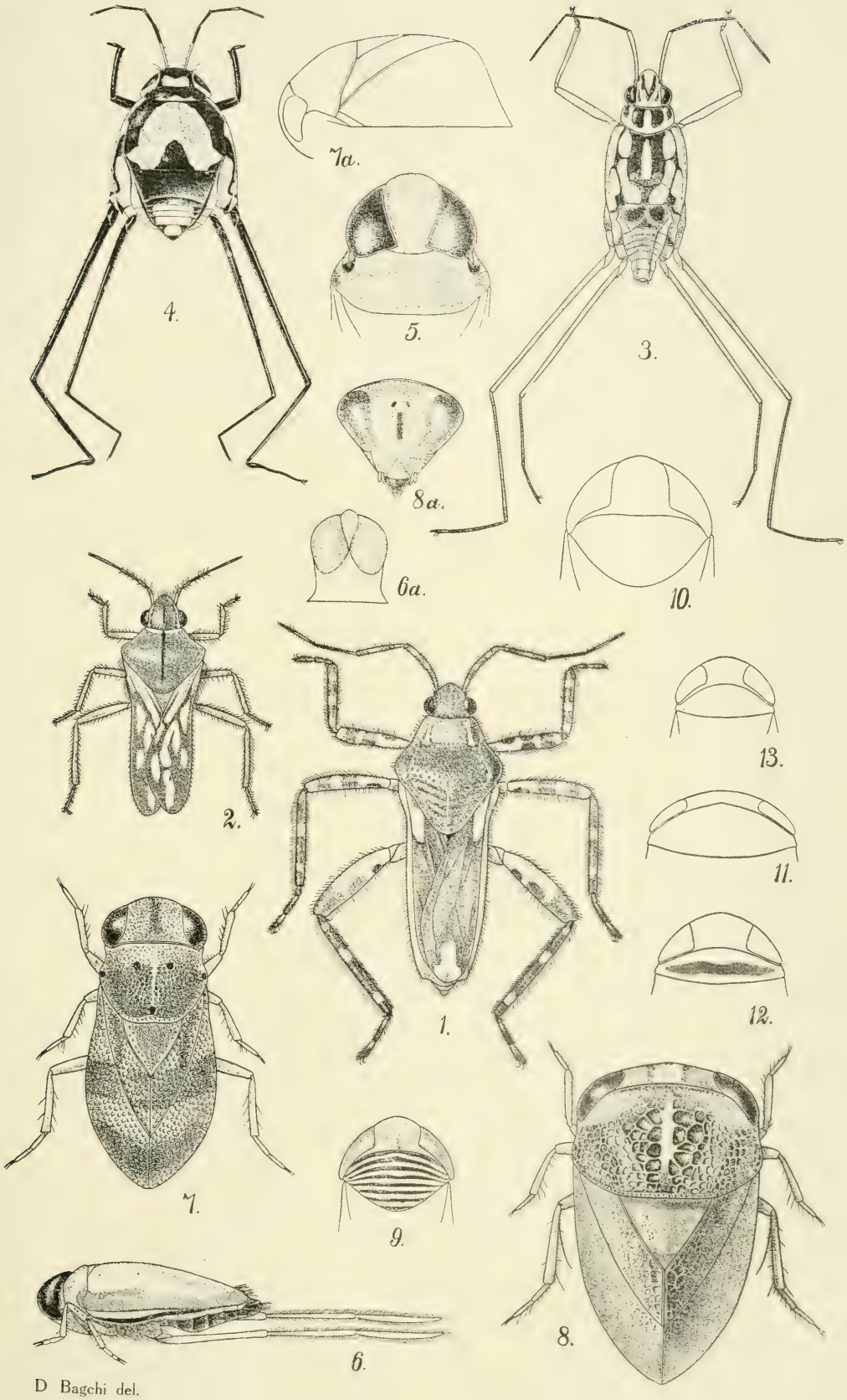
,, 9.—*Corixa septemlineata*, sp. nov. Head and pronotum, enlarged.

,, 10.—*Corixa unicolor*, sp. nov. Outline of head and pronotum, enlarged.

,, 11.—*Micronecta substriata*, sp. nov. Outline of head and pronotum, enlarged.

,, 12.—*Micronecta soror*, sp. nov. Outline of head and pronotum, enlarged.

,, 13.—*Micronecta fulva*, sp. nov. Outline of head and pronotum, enlarged.

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## EXPLANATION OF PLATE IX.

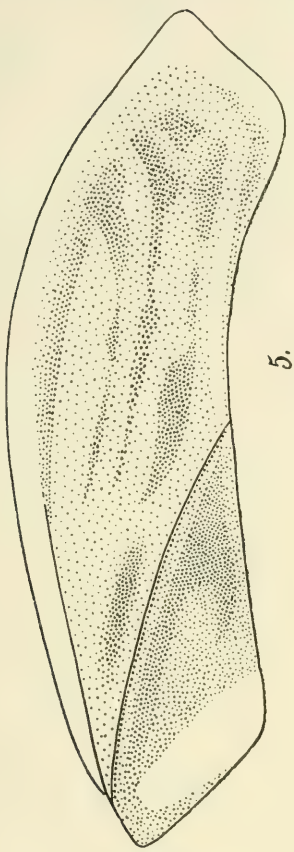
Fig. 1.—*Corixa septemlineata*, sp. nov. Right elytron, enlarged.

,, 2.—*Corixa unicolor*, sp. nov. Right elytron, enlarged.

,, 3.—*Micronecta substriata*, sp. nov. Right elytron, enlarged.

,, 4.—*Micronecta soror*, sp. nov. Right elytron, enlarged.

,, 5.—*Micronecta fulva*, sp. nov. Right elytron, enlarged.



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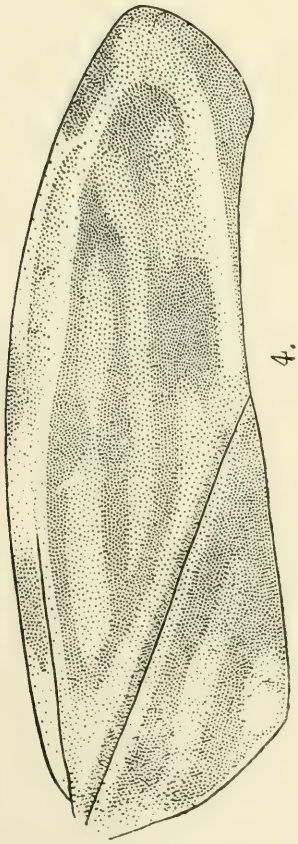

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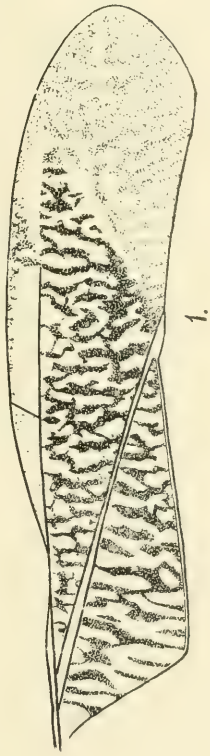

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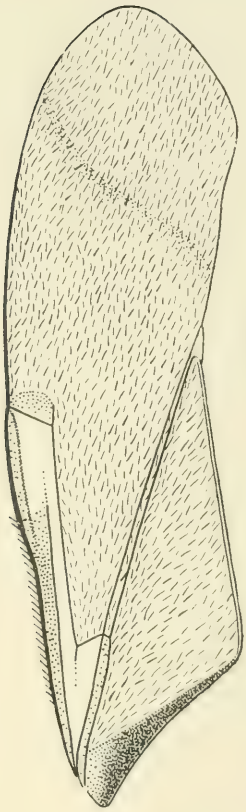

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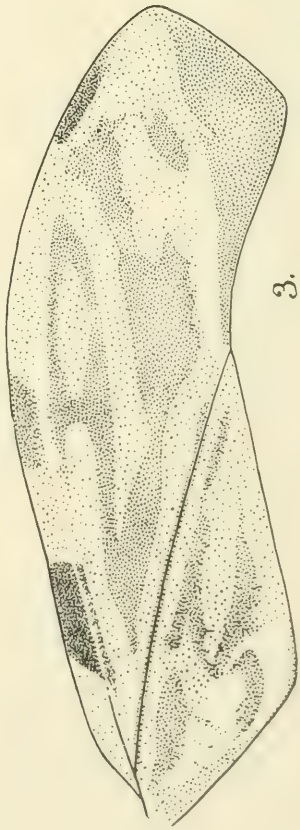

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# FISH AND FISHERIES OF THE INLE LAKE.

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

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## INTRODUCTION.

The fish of the Shan Plateau and its immediate vicinity have as yet received little attention from ichthyologists. In 1893 Boulenger (*Ann. Mag. Nat. Hist.* (6) xii, pp. 198-203) described a collection of twenty-seven species made by the late Mr. E. W. Oates in the Southern Shan States, while Vinciguerra reported upon the late Signor Fea's collection in 1889 in the *Ann. Mus. Stor. Nat. Genova* (2) ix (xxix), pp. 129-260. The latter collection, though none of it came actually from the plateau, included numerous specimens from Karen-ni, which lies immediately to the south, and from the Upper Salween.

A large part of Mr. Oates's collection was obtained at Fort Stedman on the Inlé Lake, but the fish were probably purchased in the market, several of the species are not lacustrine and the most interesting of the true Inlé forms, most of which are of very small size, were not represented.

The fauna of the Inlé Lake is of a highly peculiar character and it is not surprising that among the smaller fish we obtained there is a large proportion of undescribed forms. It was, however, perhaps hardly

to be expected that we should discover no less than three new genera and even a new family. These belong either to the Cyprinidae or to the eels ; it is among the latter that the new family finds a place. Its type is, indeed, perhaps the most primitive form of eel yet known. New species were discovered also in the genera *Nemachilus* and *Barilius* (Cyprinidae) and *Ophiocephalus* (Ophiocephalidae).

The complete list of the species now known to inhabit the lake, all of which are represented in our collection, is as follows. For convenience of reference I have arranged them here according to the order adopted in Day's volumes in the *Fauna of British India*, but I have departed somewhat from this system in the taxonomic part of the paper.

PHYSOSTOMI.

Family Chaudhuriidae, nov.
*Chaudhuria caudata*, gen. et sp. nov.

Family Symbranchidae.
*Amphipnous cuchia* (Ham. Buch.).
*Monopterus albus* (Zuiew).

Family Clariidae.
*Clarias batrachus* (Linn.).

Family Cyprinidae.
*Lepidocephalus berdmorei* (Blyth).
*Nemachilus brevis*, Boulenger.
*Nemachilus brunneanus*, sp. nov.
*Discognathus lamta* (Ham. Buch.).
*Cirrhina latia* (Ham. Buch.).
*Barbus sarana caudimarginatus*, Blyth.
*Barbus schanicus*, Boulenger.
*Barbus stedmanensis*, Boulenger.
*Cyprinus carpio intha*, subsp. nov.
*Sawbwa resplendens*, gen. et sp. nov.,
*Microrasbora rubescens*, gen. et sp. nov.
*Microrasbora erythromicron*, sp. nov.
*Barilius auropurpureus*, sp. nov.

Family Notopteridae.
*Notopterus notopterus* (Pallas).

ACANTHOPTERIGII.

Family Mastacembelidae.
*Mastacembelus oatesii*, Boulenger.
*Mastacembelus caudiocellatus*, Boulenger.

Family Ophiocephalidae.
*Ophiocephalus striatus*, Bloch.
*Ophiocephalus harcourt-butleri*, sp. nov.

In addition to these twenty-two species and races the following fish are known to inhabit the Inlé basin, having been recorded from Fort

Stedman by Boulenger (*op. cit.*: 1893) or being represented in our collection:—

*Nemachilus botia* (Ham. Buch.).
*Barbus dukai*, Day.
*Barbus tor* (Ham. Buch.).
*Barbus nigrovittatus*, Boulenger.
*Barbus stoliczkanus*, Day.
*Barilius ornatus*, Sauvage.
*Danio aequipinnatus* (McCl.).
*Ophiocephalus gachua*, Ham. Buch.
*Ophiocephalus siamensis*, Günther.

Most of these species probably live in canals and in streams that run into or out of the lake. We found *Nemachilus botia*, *Barbus dukai* and *Danio aequipinnatus* common in small streams in the surrounding hills, and the Mahseer (*Barbus tor*) is caught both in the river that flows out of the southern end of the lake and on the He-Ho plain.

There are several noteworthy points about the lake species. Most, perhaps all of them also occur in sluggish streams and pools on the He-Ho plain, and it is clear that the fish-fauna of the lake that once occupied that plain and the fish-fauna of the Inlé Lake were practically identical. With this exception, however, no less than 12 species (more than half of the true lacustrine species) and 2 genera are apparently endemic. The geographical relations of the fish of the whole basin will, however, be discussed later in more detail.

The absence of certain families and the scanty representation of others is noteworthy, but is probably correlated with the fact that the lake is situated in an isolated position at a fairly high altitude. The place of the Cyprinodontidae is taken to a large extent by unusually small and highly specialized members of the Cyprinidae.

## PHYSICAL AND OTHER CONDITIONS IN THE LAKE AS THEY EFFECT THE FISH.

In the general introduction to this volume I have given an account of the Inlé Lake. Here I need do no more than repeat, with slight omissions and alterations, what I said about the biological aspect of the fisheries in a pamphlet recently published by the Government of Burma.[1]

The Inlé Lake is situated in the State of Yawnghwe (Southern Shan States) at an altitude of 3,000 feet above sea-level and is about 14 miles long by 4 miles broad. It is surrounded by marsh-land of a peculiar type, comparable on a small scale to the *sudd* of the Nile and composed of dead and living vegetation matted together and floating on the surface of the water. In the dry season the lake is nowhere more than 12 feet deep. So far as fish are concerned, a very important feature of the water is its clearness, which permits sunlight to penetrate to the bottom and thus encourages the growth of dense submerged thickets of weed.

[1] *A note on the Fisheries of the Inlé Lake, Southern Shan States* (Government Press, Rangoon: 1917).

The bottom is composed of very soft, semi-liquid mud and there are no rocks either at the edge or beneath the surface of the water.

The temperature of the water never sinks as low as freezing point and that of the bottom differs very little from that of the surface, which remains fairly uniform throughout the twenty-four hours. We found at the beginning of March that the surface temperature in the middle of the lake was about 70° Fahrenheit.

The water is heavily charged with lime. The following analysis of a sample taken from the surface near the middle of the lake has been made by Mr. R. V. Briggs, F.C.S., M.S.P.A. :—

| | Per litre. |
|---|---|
| Total solids ... ... ... ... ... | 0·1710 |
| Organic matter ... ... ... ... ... | 0·0160 |
| Calcium ... ... ... ... ... | 0·0222 |
| Magnesium ... ... ... ... ... | 0·0279 |
| Chlorine ... ... ... ... ... | 0·0017 |
| Sulphate ($SO_4$) ... ... ... ... ... | 0·0017 |
| Silica ... ... ... ... ... | 0·0010 |
| Carbonic acid ($CO_3$) ... ... ... ... | 0·1030 |
| Iron ... ... ... ... | Less than 1 part in 5 million. |

The edible fish of the lake are either rapacious in habits or else live mainly on weed. There is an almost complete absence of species that feed on the surface. This is probably due in large measure to the clearness of the water, which is unfavourable to the growth of minute floating organisms. At first sight the dense weed of the lake would seem to provide an ideal food-supply for vegetarian fishes, but as a matter of fact a great part of the weed belongs to the genus *Ceratophyllum*, the horny nature of which is indicated in its name. It is very doubtful whether this weed is really edible from the fishes' point of view.

An important question in all fisheries is that of cover. Particularly at the breeding season, it is necessary for the fish to hide themselves, and as a rule they avoid bright sunlight. There is no lack of cover in the Inlé Lake and the horny nature of the most abundant weed is doubtless beneficial from this point of view. The eagerness with which the fish seek for cover is illustrated by several of the methods used in capturing them. Another function that the weeds perform is that of providing an abundant supply of oxygen.

As in many well-populated districts, the chief enemy of the Inlé fish is man, but I do not think, as I will explain later, that his enmity should at present be restrained. After man the most active agents of destruction are rapacious fishes such as the snake-heads, which are themselves among the most important species economically. Gulls, cormorants and other piscivorous birds are fairly abundant, but probably never excessively so ; the various ducks for which the lake is famous amongst sportsmen cannot do much harm, as they feed chiefly on weed and for the most part desert the lake before the main breeding-season of the fish, in which they might do great damage by devouring the spawn. Internal parasites rarely do appreciable harm to freshwater fish living in natural conditions ; we found no trace of any parasitic disease among those of the lake.

According to the Intha fishermen, most if not all of the fish of the lake breed in February, March and April. This view is confirmed by an examination of the roes, which were ripe or nearly ripe in all species examined at the end of February and in March ; probably some species breed a little earlier than others, but this is a point on which further investigation is necessary before a definite opinion can be expressed.

## GEOGRAPHICAL RELATIONS OF THE FISH OF THE INLE BASIN.

Thirty-one species of fish, belonging to 7 families and 17 genera are known to live in the Inlé basin. Six of these families are widely distributed in the fresh waters of the Oriental and Ethiopian Regions, but one (Chaudhuriidae), which is described for the first time in this paper, is only known from the Inlé Lake, in which it is represented by a small and remarkably primitive species.

Of the 17 genera, 13 are distributed all over the Indian and the Indo-Chinese sections of the Oriental Region, while one (*Monopterus*) first makes its appearance, as we go from west to east, in Burma, but ranges as a monotypic genus over the whole of the eastern part of the Oriental and the south-eastern districts of the Palaearctic Regions. It may therefore be classed as Far Eastern. Another genus (*Microrasbora*), though here described as new, is possibly also Far Eastern, for the small size of its representatives may well have caused them to be overlooked in many places and species probably occur in the Malay Peninsula. The remaining two genera of the 17 are only known at present from the Inlé basin ; one (*Chaudhuria*) is the genotype of the new family to which I have already alluded, while the other (*Sawbwa*) is represented by a peculiar little scaleless fish somewhat remote from any species known elsewhere. It belongs to the family Cyprinidae.

Of the 30 species of fish, no less than 12 (*i.e.*, 2/5ths or 40 per cent.) are known only from the Inlé and He-Ho basins, while a sub-species (*Cyprinus carpio intha*) apparently occurs only in the Southern Shan States. Boulenger[1] has noticed (by implication) the Siamese element in the fish-fauna, but this element is much less strongly marked than the endemic one, being represented by but two species. They are *Ophiocephalus siamensis* and *Barilius ornatus*.[2] Neither of these is a true lacustrine fish ; both were discovered in the Menam and *Barilius ornatus* has also been found in the Upper Salween. Small as the Siamese element is, however, it is but little larger than what we may call the endemic Burmese element, which is also represented by two species (*Barbus stoliczkanus* and *Lepidocephalus berdmorei*), but in addition by a sub-species of the Indian *Barbus sarana*. The one Far Eastern species is *Monopterus albus*.

A more important element than any of these except the endemic Shan element is that of species which occur in the Indian section of the Oriental Region, that is to say west of the Bay of Bengal. This

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[1] *Ann. Mag. Nat. Hist.* (6) xii, p. 199 (1893).
[2] Sauvage, *Bull Soc. Philom.* (Paris) vii, p. 153 (1883).

element is represented by 10 species, most of which are Oriental in an exact sense in that they are distributed over a large part of the Oriental Region.

Thus we see that the two most important elements in the fish-fauna of the Inlé basin are the endemic Shan element and the Oriental element, while small but distinct groups of Siamese and Burmese species occur. In other words, the fauna is an isolated one. A considerable number of adaptable Oriental species, whose wide range proves their powers of migration, established themselves as members of it at a remote period, but the number of species that have entered the district from neighbouring countries in comparatively recent times is small. How far this isolation is confined to the two connected basins and how far it is of a more comprehensive kind, embracing the whole of the Shan Plateau or even the Salween system generally, we do not yet know precisely, but Boulenger has recorded from the Southern Shan States six species that apparently do not occur in the Inlé basin, and he did not describe any of these as new, the majority being well-known Indo-Burmese fish and one or two characteristically Burmese. Vinciguerra, moreover, has recorded from the Salween and its tributaries a large number of species, only a small proportion of which were new and none of which were closely allied to the peculiar Inlé forms. So far, therefore, as our knowledge extends it would seem that a large proportion of the endemic Shan forms are to be found most commonly if not exclusively in the Inlé and He-Ho basins, which were the longest survivors, though one is now empty, of the old lakes of the country.

## INTHA NAMES OF THE INLE FISH.

The fishermen of the Inlé Lake belong to a tribe alien to the Shans and speaking a dialect of Burmese thought to be akin to that spoken in Tavoy. They call themselves *Intha* or Sons of the Lake. In a pamphlet[1] on the Inlé fisheries published recently by the Government of Burma I have given a list of the local names of fish, but at the time of its publication was unable to identify many of the species specifically owing to the fact that the collection had not been completely worked out. The indigenous names were repeatedly checked both among the fishermen and in the bazaar at Fort Stedman. Mr. C. E. Browne, I.S.O., Political Adviser at Yawnghwe, has been kind enough to revise their orthography. *Nga* is the ordinary Burmese for "fish," but it is never omitted in referring to any particular species.

| | | |
|---|---|---|
| Nga hkon-ma | ... | ... *Barbus sarana.* |
| Nga hku ... | ... | ... *Clarias batrachus.* |
| Nga hpe ... | ... | ... *Notopterus notopterus.* |
| Nga hpein... | ... | ... *Cyprinus carpio.* |
| Nga lu ... | ... | ... *Cirrhina latia.* |
| Nga myesok-ma | ... | ... *Nemachilus brevis.* |
| Nga mywe... | ... | { *Mastacembelus oatesii.* / *Mastacembelus caudiocellatus.* |

[1] *A note on the Fisheries of the Inlé Lake, Southern Shan States* (Government Press, Rangoon : 1917).

| | |
|---|---|
| Nga ohn-ma ... | ... *Ophiocephalus harcourt-butleri.* |
| Nga pya-tha-ma ... | ... *Nemachilus brunneanus.* |
| Nga pya-tha-ywet ... | ... *Barilius auropurpureus.* |
| Nga shin ... ... | *Monopterus albus.*<br>*Amphipnous cuchia.* |
| Nga taung-nwe ... | ... *Barbus stedmanensis.* |
| Nga taung-taing-tet ... | ... *Discognathus lamta.* |
| Nga thalido ... | ... *Lepidocephalus berdmorei.* |
| Nga thange-kyebya ... | *Microrasbora rubescens.*<br>*Microrasbora erythromicron.*<br>*Sawbwa resplendens.* |
| Nga yan ... ... | ... *Ophiocephalus striatus.* |
| Nga yit ... ... | ... *Barbus schanicus.* |

Most of these names are probably dialectic or local, but Day in the *Fauna of India* gives "Nga yan" as one of the Burmese names of *Ophiocephalus striatus*, "Nga khoo" as that of *Clarias batrachus*, "Nga tha-laydoh" as that of *Lepidocephalus berdmorei*, and "Nga khon-mah-gyee" as that of *Barbus sarana*. Nga mywe ("Nga mwey" in Day) is probably a generic name applied to any kind of *Mastacembelus*; it means, literally, "snake fish." Nga shin ("Nga-sheen" in Day, who applies it to *Amphipnous cuchia*) is probably in the same way a generic name for any kind of eel, while Nga thange-kyebye ("small white fish") is applied to any small silvery fish used in making dried whitebait. Mr. Browne tells me that Nga taing-tet as applied to *Discognathus lamta* is a coined name, meaning "the post-climbing fish" and referring to the peculiar habits of the species (see p. 45); but the name is well understood among the Intha. At He-Ho, where there are no posts for it to climb, it is known as "stone-climbing fish," *Nga kyauk-tet.*

The only name for the true Carp on the Inlé Lake and at He-Ho is Nga hpein or Nga pein, but Mr. G. C. B. Sterling informs me that at Kentung it is called Pa nai, "which is the usual Shan equivalent for Nga Pein."

## SYSTEMATIC DESCRIPTION OF THE COLLECTION FROM THE INLE LAKE.

### Order **APODES.**

### Family CHAUDHURIIDAE, nov.

The family may be defined as consisting of—

Small Apodes with a fan-shaped, practically free caudal fin provided with well-developed rays and supported by a pair of hypural bones; with pectoral fins; with minute scales; with the vent situated a long distance from the head; with teeth arranged in bands on the jaws only; with lateral nostrils; with the gill-openings separate and the integument covering them supported by few branchiostegal rays; with all the pharyngeal slits wide; with four fully developed gill-bearing branchial arches; with the heart close to the branchial arches; with an air bladder with the frontals paired, the ethmoid and vomer distinct and the former separating the maxillaries in front; with well-developed zygapophyses on the vertebrae.

The Chaudhuriidae differ from all other living eels as yet known in the strong development of the true tail. In this respect they resemble the Cretaceous genus *Urenchelys*,[1] Woodward, which has been made the type of a distinct family by Regan,[2] but the structure of the skull is very different. So far as skull-structure is concerned they seem to be related rather to *Heterenchelys*, Regan (*op. cit.*, *p.* 383), which he also regards as the type of a family, but the structure of the vertebral column is different.

Only a single genus and species is at present known.

**Chaudhuria,** gen. nov.

The body is covered with very small scales embedded in the skin ; it is somewhat compressed, especially in the caudal region, which is approximately equal to the head and body in length. The caudal fin is united to the dorsal and anal by a low membrane ; its rays are completely segregated. The dorsal and anal are well-developed but confined to the caudal region. The pectorals are small and lie immediately behind the gill-openings. The snout is not produced ; the anterior tubular nostrils are situated near its tip ; the posterior nostrils are rather large and lie immediately in front of the eyes. The mouth is small and horizontal. The lips are tumid, but the lower lip only so at the sides. The eyes are well-developed. The gill-openings are wide and in the main of lateral position. The teeth are small, sharply pointed and slightly recurved ; they are absent from the vomer and ethmoid ; on the jaws they are arranged in a narrow band. The frontals form a somewhat asymmetrical suture on the roof of the skull. The vomer forms a sharp ridge on the roof of the mouth. The jaws closely resemble those of *Heterenchelys*, Regan. The suspensorium is vertical. The pharyngeal bones seem to be poorly developed ; I have not been able to make out their structure. The otoliths are enclosed at the base of the skull on each side in a thin-walled capsule composed of two bones ; there are two otoliths in each capsule, both flattened and cake-like but one much larger than the other. There are comparatively few vertebrae. The neural arch is produced into an upright flattened plate or spine in front of the true neural spine.[3] The ribs are well-developed, and there are strong interspinous bones. The size of the only known species is very small.

Development is probably direct, for the ova are large and well supplied with yolk.

*Type-species.—Chaudhuria caudata*, sp. nov.

I have much pleasure is associating with this remarkable new genus the name of my friend and colleague Dr. B. L. Chaudhuri, to whom I have been indebted for considerable assistance in the preparation of this paper.

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[1] *Cat. Foss. Fishes B. M.* iv, p. 337, pl. xviii, figs. 1—3 (1901).

[2] *Ann. Mag. Nat. Hist.* (8) x, pp. 379, 380 (1912).

[3] Mr. R. H. Whitehouse has kindly given me a detailed account of the structure of the tail, which will be published immediately after this paper.

**Chaudhuria caudata,** sp. nov.

(Plate I, fig. 1; pl. IV, fig. 1—10.)

B. V. D. 39-40. P. 6. A. 42-43. C. 7.

The length of the head to the gill-opening is contained about $7\frac{2}{5}$ times in the total length without the caudal fin, the greatest depth of the body 14-16 times, the caudal fin about 22 times. The caudal region is strongly compressed and tapers considerably; the vent is situated half way between the tip of the tail and that of the snout. The lateral line is complete and extends along the middle of the caudal peduncle. The snout is considerably longer than the eye, which is of moderate size and fairly prominent; the lower jaw projects slightly beyond the upper. The mouth barely reaches as far back as the level of the anterior border of the eye. The pectorals are situated about half way up the body;

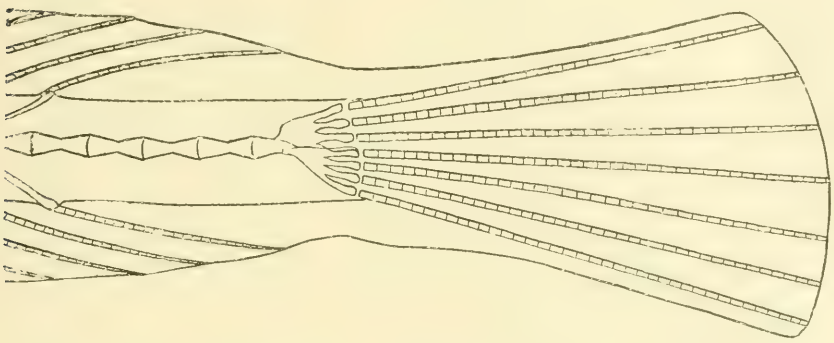


FIG. 1.—Tail of *Chaudhuria caudata.* From a specimen mounted whole in Canada balsam.

The hypural bones are represented diagrammatically and the dorsal and ventral elements of the vertebrae are omitted.

their basies are concealed under the opercula. The branchiostegal rays are long and curved. The internal branchial isthmus is broad. The dorsal and anal are of almost equal length and depth. In the middle of the caudal region they have each less than half the depth of the body, but towards the caudal peduncle they become deeper than the body. The caudal fin is markedly asymmetrical when fully expanded, slightly rounded or subtruncate, and more strongly developed on the ventral than on the dorsal side.

The bones of the skull are extremely delicate and the jaws are feeble. The teeth are arranged biserially in the posterior part of both jaws and triserially near the tip; in the latter region they are slightly enlarged.

There are about 70 vertebrae.

The back and upper part of the sides of the head, body and caudal region are dark purplish brown, somewhat mottled; the whole ventral surface and the lower part of the sides are yellowish white. The fins are white with very fine and often interrupted dark lines running along each side of each ray; minute dark spots are often present at the base of the rays.

The largest specimen examined is 52 mm. long, but individuals of little more than half that length were found to be sexually mature.

*Type-specimen.*—No. F 9402/1 *Zoological Survey of India* (*Ind. Mus.*).

*Locality.*—Inlé Lake, Southern Shan States (alt. 3000 ft.); February, 1917.

The structure of the vertebrae is peculiar. The centra are elongate, amphicoelous, broader in front than behind and much constricted in the middle. Their ephiphyses sometimes remain distinct and the elements that form the neural and haemal arches, though welded together, are never incorporated with them but remain as a kind of cloak only attached to them at the sides. They have a thin and membranous character. The neural arch (except at the extremity of the tail) bears two spines or a spine and a flattened triangular plate which projects vertically upwards. On the first two vertebrae these structures are incompletely fused together, but on the vertebrae of the trunk and on the caudal vertebrae they are quite distinct. On the trunk and on the anterior part of the caudal region the anterior process has a lamellar form, but on the greater part of the caudal region it is a spine closely resembling the posterior one but directed less backwards. The zygopophyses, both neural and haemal, are well-developed both on the precaudal and the anterior caudal vertebrae.

Two of the four specimens obtained were taken in fishing-baskets filled with peat and weeds and sunk in the open lake, the other two amidst dense vegetation at the edge of floating islands. The stomach of a specimen was full of young crustaceans apparently still in their egg-shells.

In one female, captured at the end of February, the ovaries were ripe. They contained ova in all stages of development. The largest eggs, which were about to be laid, were broadly ovoid or subspherical. They were about 0·68 mm. long by 0·59 mm. broad. At one end there was a depression probably surrounding a minute micropyle. The ovum was contained in a delicate horny shell marked with asymmetrical sinuous concentric striae and raised at either side of the terminal depression into a low ridge.

## Order **SYMBRANCHOIDEA.**

## Family SYMBRANCHIDAE.

### **Monopterus albus** (Zuiew).

1889. *Monopterus javanensis*, Day, *Faun. Brit. Ind., Fishes* I, p. 70, fig. 28.
1889. *Monopterus javanensis*, Vinciguerra, *Ann. Mus. Stor. Nat. Genova* (2) IX (xxix), p. 357.
1916. *Monopterus albus*, Weber, *Fishes Indo-Austr. Arch.* III, p. 413, figs. 210, 211.

This fish is not uncommon at the edge of the Inlé Lake but is perhaps more abundant in pools and rice-fields. It is eaten by the Intha but not by the Shans, who think that its flesh causes leprosy. It is usually captured with a two-pronged spear.

The species is found all over Southern Asia east of the Bay of Bengal; its range extends to Northern China and Japan.

**Amphipnous cuchia** (Ham. Buch.)

1889. *Amphipnous cuchia*, Day, *op. cit.*, p. 69, fig. 27.
1899. *Amphipnous cuchia*, Vinciguerra, *op. cit.*, p. 356.

Not uncommon with the last. The Shans and Intha do not distinguish the two species, which they catch in the same way.

*A. cuchia* is widely distributed in India and Burma.

## Order **OSTARIOPHYSI.**

### Family CLARIIDAE.

**Clarias batrachus (Linn.).**

1889. *Clarias magur*, Day, *op. cit.*, p. 115, figs. 48, 49.
1889. *Clarias magur*, Vinciguerra, *op. cit.*, p. 191.
1913. *Clarias batrachus*, Weber, *Fishes Ind.-Austr. Arch.* II, p. 190, fig. 74 (p. 187).

This species is common in the marginal zone of the Inlé Lake and in slow-running streams and muddy pools of the district. It lives buried in mud.

Specimens from the Shan Plateau are of comparatively small size, apparently never much more than a foot long, and of a dense black colour. Their flesh is considered excellent both by the indigenous peoples and by Europeans, many of whom regard them as the best edible fish of the country. They are caught chiefly in basket-traps near the mouth of streams. The roe was ripe in some females examined at the beginning of March, but not in all.

*Clarias batrachus* has a very wide range in India, Burma, Ceylon and Malaysia, extending as far east as the Philippines.

### Family CYPRINIDAE.

**Lepidocephalus berdmorei** (Blyth).

1889. *Lepidocephalichthys berdmorei*, Day, *op. cit.*, p. 221.
1889. *Lepidocephalichthys berdmorei*, Vinciguerra, *op. cit.*, p. 341.

A very common species in small streams that run into the Inlé Lake or traverse the He-Ho plain. It also occurs in ponds and marshes and occasionally in the marginal zone of the lake. It seems to be equally at home in clear brooks and in muddy still or running water. It is an important element in the dried whitebait manufactured on a large scale by the Intha, and is, therefore, of some economic importance.

The species appears to be common both in Upper Burma and in Tenasserim. It is very closely related to *L. guntea*, the common Indian form, of which Vinciguerra records specimens from various places in the same countries.

**Nemachilus brevis,** Boulenger.

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

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

This is one of the commonest of the smaller bottom fishes in the Inlé Lake, in both the central region and the marginal zone of which it is

found. It does not grow more than 60 mm. in length. The male differs from the female in colouration and also in the shape of the body (see pl. II, figs. 1, 1a); as a rule, instead of being merely spotted or mottled, it has on the sides a number of short black vertical bars, which sometimes fuse together to form an irregular longitudinal bar. The bars are variable both in number and in size. The male has, further, a small cartilaginous pad immediately in front of the lowest quarter of the eye.

This fish also forms an ingredient of dried whitebait. It has only been found in the Inlé basin and on the He-Ho plain but lives both in still and in running water, in ponds and slow streams as well as in the lake, in which it seems to be most abundant in the central region. We did not see it in fast-running water.

### **Nemachilus brunneanus,** sp. nov.

(Plate II, fig. 2.)

B. 111. D. 12-13 (3-4/9-10). P. 10. V. 8. A. 8-9 (2-3/5-6).

A small, slender species related to *N. rupicola* and *N. multifasciatus*[1] but differing from both in proportions, in the number of the fin rays and in its very large eyes.

Depth of body a little greater than the length of the head, a little less than $\frac{1}{6}$ the total length. Eye very large and prominent, a little narrower than the interorbital space, nearly as long as the snout, occupying nearly $\frac{1}{3}$ the length of the head. Head naked, with 6 barbels, 2 rostral and one maxillary on each side; the outer rostal barbel not quite reaching the anterior margin of the eye, about twice as long as the inner; the maxillary barbel the longest, but not much longer than the outer rostral, extending backwards almost to the posterior margin of the eye. Body entirely covered with small scales. Dorsal fin rather high; pectoral fins long, slender and falcate, longer than the head; tail fin deeply notched.

Colouration somewhat variable but not differing with sex; the ground colour of the head and body pale olivaceous; the head mottled and spotted with dark green or black; a variable number of dark horizontal bars on the sides of the body, sometimes narrow, sometimes fairly broad, sometimes alternately complete and reaching half way down the side from the back. Caudal and anal fins reddish in life; all the fins white in preserved specimens; two or three dotted longitudinal lines on the dorsal and the same number of V-shaped dotted lines on the caudal; a small black spot or blotch at the base of the dorsal in front and two rather smaller black spots on each side of the caudal peduncle.

The largest specimen in a large series is only 4·5 cm. long.

*Type specimen.*—No. F 9406/1, *Zoological Survey of India* (*Ind. Mus.*).

*Distribution.*—This little loach is abundant in the waters of the Yawnghwe valley and seems to be equally at home in clear hill-streams,

[1] See Vinciguerra, *Ann. Mus. Civ. Stor. Nat. Genova* 2, IX (XXIX), pp. 336, 337 (1890).

in muddy rivers and among the weed-thickets of the Inlé Lake, in which it occurs both in the central region and in the marginal zone. It is an important ingredient in the dried whitebait sold in the local markets.

The species is named after Mr. C. E. Browne, I.S.O., Political Adviser, Yawnghwe, to whom we are indebted for much assistance on our tour.

### **Discognathus lamta** (Ham. Buch.).

1889. *Discognathus lamta*, Vinciguerra, *op. cit.*, pp. 275, 279 (fig.).
1913. *Discognathus lamta*, Annandale, *Journ. As. Soc. Bengal* (n. s.) IX, p. 36, fig. 1.

Specimens from the Inlé Lake belong to the true *D. lamta*, as do also some from He-Ho. One individual, however, from the latter locality represents a distinct and apparently undescribed species. As great confusion exists in reference to the species and races of the genus, and as most of the specimens belonging to the collection of the Indian Museum are interned at present in Hungary, I refrain from describing the new form.

I have already alluded to the post-climbing propensities of *D. lamta*. To understand them it is necessary to realize that houses are often built by the Intha on posts standing in water as much as ten or twelve feet deep. We lived for some time in a house of the kind more than a mile from shore in the Inlé Lake, and it was possible to watch the ascent of the house-posts by the fish, which was usually seen in the first instance swimming out from a thicket of weeds. It then settled, with its head pointing upwards, low down on one of the house-posts and began to move up it slowly, browsing as it did so on the small algae and polyzoa (*Hislopia lacustris*) with which the posts were covered. The sucker-like structure of the lips enabled it to retain a fairly tight hold on the post while it remained still; its ascent was effected by gentle and almost imperceptible movements of the tail. When it approached the surface of the water it usually moved away either to another post or into the thicket, but sometimes it turned round and went downwards on the original post, and in the course of its ascent it frequently circumvented the post in a spiral course. The Intha are well aware of this habit and have coined a name for the fish accordingly, but the Danu who live on the He-Ho plain, and do not build their houses in water, have apparently noticed the same habit in respect to rocks. They do not distinguish between *D. lamta* and the other species that occurs with it.

*D. lamta* is extremely difficult to catch. It is very rapid in its movements when disturbed and wary even when engaged in climbing. It, therefore, has no economic importance in the presence of other species of equal and larger size that are less active and cunning.

The species was described originally from northern Bengal and it certainly occurs, alone or with closely allied species, over the greater part of north-eastern and Peninsular India. Vinciguerra records it from several localities in Upper Burma. It is, however, impossible at present to state the precise geographical range of any form of the genus.

**Cirrhina latia** (Ham. Buch.).

1889. *Cirrhina latia*, Day, *op. cit.*, p. 279.

This fish has probably a number of local races, but the matter cannot be settled without examining good series from many different parts of India and Burma. In the Inlé Lake it does not grow much longer than 6 or 7 inches and is of a very slender form. It is abundant amongst dense thickets of vegetation, but appears to live entirely on the bottom.

Vast numbers are sometimes taken in the great fishing enclosures erected in the lake by the Intha fishermen. As the supply of fresh fish then exceeds the demand, a considerable proportion of a large catch is often dried in the sun, as a rule without being cleaned or salted. The dried fish are sold in the bazaar sorted out into at least two sizes.

**Barbus sarana caudimarginatus,** Blyth.

(Plate III, fig. 3.)

1860. *Barbus caudimarginatus*, Blyth, *Journ. As. Soc. Bengal* XXIX, p. 157.
1889. *Barbus sarana*, Vinciguerra, *op. cit.*, p. 287.
1893. *Barbus Oatesii*, Boulenger, *op. cit.*, p. 201.

I have examined a co-type of Boulenger's *Barbus oatesii* from Fort Stedman and also a large series of specimens from the Inlé Lake and the He-Ho basin. They do not differ in any respect from specimens from Tenasserim and Upper Burma in the Indian Museum identified by Day and others as *Barbus sarana*. Moreover, the colouration of the living fish agrees very closely with that given by Blyth as typical of his *Barbus caudimarginatus*. In my own field-notes I find the following description :—

" Bluish green on back ; sides greenish silvery ; belly white. Pectoral fins olivaceous, other fins and lips reddish. Anterior border of dorsal and upper and lower borders of caudal dark bluish green. A vertical dark bar extending down posterior margin of preopercular and another, somewhat curved, immediately behind the opercular border."

I do not quite understand Boulenger's statement that each scale is edged with black ; but this was probably an artificial condition. It has disappeared in the co-type I have examined.

I take it, for the reasons given, that this form is no more than a Burmese race of the common Indian *B. sarana* (Ham. Buch.), differing only in colouration and in possessing a more variable number of lateral scales. Vinciguerra discusses its relationship to *B. rubripinnis*, Cuv. and Val., *B. pinnauratus* (Day) and *B. chrysopoma*, Cuv. and Val. and seems to be of the opinion that the first at any rate may be identical with Blyth's race, but I have not the material to discuss the question further myself.

The Burmese race of *B. sarana* is common in the Inlé Lake, in which it is not, according to the Intha fishermen, ever longer than a hand. It is found chiefly near villages and among floating islands and is caught in basket-traps and drift-nets. Its small size renders it less valuable than its larger congeners, but its flesh is said to have a good flavour.

**Barbus schanicus,** Boulenger.

(Plate III, fig. 4.)

1893. *Barbus schanicus*, Boulenger, *op. cit.*, p. 201.

This is perhaps the largest and heaviest Cyprinid fish caught in the lake. It is stated to attain a weight of 7 lbs. Large individuals are commonly 18 inches long and very deep in proportion. The back in living specimens is of a deep blackish green and the fins and tail are tinted with a paler shade of the same colour.

At any rate in February and March, the *Nga yit* is not so abundant in the markets round the lake as its two congeners. It is, however, said by the Intha fishermen to be caught chiefly in canals and at the mouths of the rivers that open into the lake near its southern extremity, and to be much more abundant in these localities at some seasons than others. It is, therefore, in all probability a fluviatile fish that migrates into the lake occasionally in search of food or in order to breed. The species is only known from the Inlé Lake.

The fish is caught with cast-nets in canals and streams and speared in the lake.

**Barbus stedmanensis,** Boulenger.

(Plate III, fig. 2.)

1893. *Barbus compressus*, Boulenger, *op. cit.*, p. 202 (*nom. preoc.* [1].)
1917. *Barbus stedmanensis*, *id.*, *in litt.*

The name *Barbus stedmanensis* is suggested by Dr. Boulenger in place of *Barbus compressus*, the name he originally gave the species. The fish has no resemblance to the *Barbus compressus* of Day, which probably came from Kashmir. The type of the latter is in the collection of the Indian Museum and I have been able to compare it with a co-type of *Barbus stedmanensis* sent from the British Museum some years ago.

This fish has a very herring-like appearance owing to the shape of its body and head and the direction of the mouth. It is said to attain a weight of 3½ lbs. The back in life is almost black and the dorsal and caudal fins are margined with the same colour, while the tip of the anal and the upper border of the pectoral are also infuscated.

*B. stedmanensis*, as its shape suggests, is an active and probably to some extent a predacious species, though I found the stomach full of weeds in some specimens. It is usually caught in a dip-net, speared or captured in special traps.

**Cyprinus carpio intha,** subsp. nov.

(Plate III, fig. 1.)

1893. *Cyprinus carpio*, Boulenger, *op. cit.*, p. 200.
1904. *Cyprinus carpio*, Regan, *ibid.* XIII, p. 190 (*in part*).

Tate Regan has pointed out that the Carp of the Southern Shan States is a distinct race, distinguished by the largeness of its scales. This race

[1] *Barbus compressus*, Day, *Proc. Zool. Soc.* 1869, p. 555.

is not peculiar to the lake but is widely distributed in the Southern Shan States. It is common in the streams of the He-Ho basin (3,800 ft.) and I have recently received a specimen from Mr. G. C. B. Sterling, who obtained it from the market at Kentung more than 300 miles east of the lake. Mr. A. G. Gahen has also sent me specimens from Loilem in the Mong Sit State.

I have examined a large series of specimens, in which the number of the lateral scales varies from 25 to 30 $\frac{4\text{-}5}{6\text{-}7}$. In the Inlé bazaars I saw few individuals more than about a foot in length, and the fishermen told me that the largest they ever caught—and those rarely—weighed about 7 lbs. In life the back and sides of the head are of a greenish bronze colour becoming gradually paler below. The dorsal and caudal fins are greenish, the other fins and the lips reddish.

The Carp is perhaps the most abundant and certainly one of the most esteemed fish in the bazaars at Fort Stedman, Nan-Pan, and Yawnghwe. No attempt seems to have been made to cultivate it artificially and, if the Intha fishermen can be believed, the local race has not the remarkable vitality of the Chinese and European forms. The fish is caught by spearing, in drift nets and in peculiar weed-trawls consisting of a bag-shaped net attached to a large triangular frame of bamboo.

### **Sawbwa,** gen. nov.

The genus consists of small Cyprininac resembling the *Puntius* section of *Barbus* but totally devoid of scales and with a reduced pharyngeal dentition.

The form is compressed but not elevated ; the abdomen is not trenchant ; the dorsal profile is convex. The head is of moderate size, the eye large, the mouth small, terminal and oblique, the upper jaw protrusible ; there are no barbels. The dorsal and anal fins are short, having not more than 7 branched rays each ; the dorsal has a toothed bony spine ; the anterior part of the dorsal is in front of the anal. The pharyngeal teeth are few in number (4 in the type-species) and arranged uniserially.

*Type-species.—Sawbwa resplendens,* sp. nov.

### **Sawbwa resplendens,** sp. nov.

(Plate II, fig. 3 ; pl. IV, fig. 15.)

B. III. D. 9-10 (2-3/7). P. 7. V. 7. A. 7(2/5). C. 18.

The greatest depth of the body is $\frac{1}{5}$ of the total length, that of the caudal peduncle about $\frac{1}{10}$ ; the length of the head $\frac{1}{4}$, that of the caudal fin slightly less. The eye is at least as long as the snout, its diameter is equal to that of the interorbital space. The lateral line is obscure. The anterior border of the dorsal fin is considerably nearer the base of the caudal fin than the tip of the snout ; it is slightly in front of the point midway between the base of the ventral and the anterior border of the anal. The pectoral is rather small and does not extend back to the base of the ventral ; the tip of the ventral extends back as far as the vent. The posterior border of the

anal is nearer the vent than the base of the caudal. The caudal is strongly forked, its two points being subangular. The second (or third) spine of the dorsal is stout and bears in its middle region from six to twelve strong spinelets some of which are usually double; its upper part, which is smooth, is curved backwards; the whole spine is shorter than the head. The last branched dorsal ring is divided almost to its base.

The pharyngeal teeth (4 in number) are elongate and narrow, strongly concave on the upper surface; their tips are subtruncate but concave and with a minute terminal projection at either end.

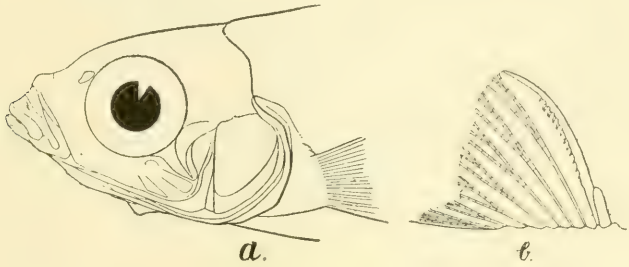



FIG. 1.—*Sawbwa resplendens*, sp. nov. *a*. Head. *b*. Dorsal fin.

Preserved specimens are whitish, more or less definitely suffused with green pigment on the back and blackish on the dorsal surface of the head. The sides of male examples are sometimes covered with black chromatophores. The fins are as a rule colourless, except for rows of minute dots running parallel to the rays; in adult males the tips of the dorsal and anal are sometimes blackened. The belly and the sides of the head are silvery. In life the female has much the same colouration as that of preserved specimens, but the silvery appearance of the body is more intense and more universal. The breeding male is much more brilliant, the sides and lower surface of the head, the chest, caudal and anal fins being bright scarlet and the sides of the body bright metallic steely blue.

The length of the adult fish does not exceed 25 mm.

Ova were observed issuing from the vent of a female. They are spherical and enclosed in a delicate, smooth membrane; each is provided with an extremely fine filament of considerable length. The diameter of the egg does not exceed 0·75 mm.

*Type-specimen.*—No. F 9413/1, *Zoological Survey of India* (*Ind. Mus.*).

This little fish is extremely common all over the Inlé Lake and in the swamps that surround it. It lives in large shoals among dense vegetation both in the clear waters of the central region of the lake and in the peaty and often foul water near the edge. Fully coloured males were observed only in the latter situation. Ripe females were taken in February and March.

In spite of its small size, the species is of economic importance to the Intha as it forms an ingredient in the dried whitebait that is one of the chief products of the lake.

**Microrasbora,** gen. nov.

To this genus I assign two small fish found in the Inlé and He-Ho basins, and possibly also at least two others described from the Malay Peninsula.

The genus *Microrasbora* is closely allied to *Rasbora*, Bleeker and *Brachydanio*, Weber, but is distinguished from the former by the total absence of the lateral line and by the longer anal fin and from the latter by the fact that there is no prominence on the jaw. The mouth is small and almost semicircular and opens obliquely upwards. The species assigned to the genus are very small, strongly compressed, rather deeper in the body than most species of *Rasbora* and as a rule of brilliant or at any rate conspicuous colouration. The general facies is like that of *Danio*, but there are no barbels.

The species I assign to *Microrasbora* are *Microrasbora rubescens*, sp. nov. (type-species), *Microrasbora erythromicron*, sp. nov., and possibly *Rasbora heteromorpha* and *R. maculata*, Duncker.[1] The two former are from the Inlé Lake and the latter from the Malay Peninsula. I have not seen the Malay species, which may be generically distinct.

**Microrasbora rubescens,** sp. nov.

(Plate II, fig. 3 ; pl. IV, fig. 13.)

B. III. D.8-9 (2/6-7). P. 11. V. 7. A. 13-15 (3/10-12). C. 26 Ll.29-32-L.t. 7.

The greatest depth of the body is from $\frac{1}{5}$ to $\frac{1}{4}$ the total length, being considerably greater in adult than in sub-adult individuals ; the length of the head is also $\frac{1}{4}$ the total length and the depth of the caudal peduncle a little more than $\frac{1}{9}$ in adults. The eye is longer than the snout and its diameter is greater than that of the interorbital space. The scales are large, thin, transparent and difficult to see ; they are easily removed from the living fish ; each scale bears several radiating striae and the concentric growth lines are well marked. The caudal and anal fins have a distinct sheath of scales at their base. The anterior border of the dorsal fin is slightly in advance of that of the anal and immediately above the vent ; it is much nearer the base of the caudal fin than the tip of the snout. The pectoral extends back further than the base of the ventral, which does not quite reach the vent and does not overlap the anal when pressed back. The anal is rather long, but its posterior border is nearer the vent than the base of the caudal. The caudal is strongly forked. All the fin rays are segmented and none are bony.

The pharyngeal bones have a well marked external prominence. The teeth number about 15 and are arranged triserially. Their form and arrangement is shown in pl. IV, fig. 13.

The colouration of preserved specimens is much like that of similar specimens of *Sawbwa resplendens*. In life the sides and ventral surface of the head, the caudal, anal and sometimes the dorsal fin are orange-scarlet in adults of both sexes. The whole body of the breeding male is suffused with the same colour. A dark mid-lateral streak extending forwards from the base of the tail to the level of the anterior border

[1] *Mitt Naturh. Mus. Hamburg* XXI, p. 182, pl. i, figs. 4, 5 (1203).

of the dorsal fin or further is often conspicuous. Sometimes it expands into a well-defined spot at the base of the caudal.

Our largest specimens are 30 mm. long.

*Type-specimen.*—No. F 9386/1 *Zoological Survey of India* (*Ind. Mus.*)

This little fish is very abundant all over the Inlé Lake (3,000 ft.), in ponds and marshes in the same valley and also in streams and pools in the old He-Ho lake-basin 800 feet higher. In habits it resembles *Sawbwa resplendens*, with which it is frequently taken. It is an even more important ingredient in the dried whitebait of the local bazzars.

### **Microrasbora erythromicron**, sp. nov.

(Plate II, fig. 5 ; pl. IV, fig. 14.)

B. 111. D. 9-10 (1-2/8). P. 2. V. 6. A. 9-11 (1-2/8-9). Ll. 21-25. L. t. 7.

The greatest depth of the body is about $\frac{1}{4}$ of the total length, the length of the head the same or slightly more, the depth of the caudal peduncle $\frac{1}{10}$. The eye, which is prominent, is twice as long as the snout and much broader than the interorbital space. The scales are very large but thin and have their sculpture obscure. The anterior border of the dorsal fin is distinctly in advance of the vent and a little nearer the base of the caudal than the tip of the snout. The pectoral when expanded hardly reaches the base of the ventral ; the anal is short, its posterior border lying nearer the vent than the base of the caudal ; the caudal is forked. The scaly sheaths of the dorsal and caudal are very well-developed.

The pharyngeal bones resemble those of *M. rubescens* in form and in the large number of teeth they bear, but are relatively shorter and stouter.

Preserved specimens are of a greyish colour, darker on the back than on the sides and belly, with about 12 obscure blackish vertical stripes on the body and a black spot surrounded by a pale ring on the caudal peduncle. The fins are colourless. In the living fish, however, the whole surface is deeply suffused with scarlet, the vertical stripes are blue and the ocellus on the tail is much more conspicuous.

Our largest specimen is only 20 mm. long and even smaller examples are fully mature.

*Type-specimen.*—No. F 9385/1 *Zoological Survey of India* (*Ind. Mus.*).

This gorgeous little fish was taken only at the edge of the Inlé Lake, among the stems of decaying grass from floating islands. It is markedly gregareous. Numerous specimens have been identified from samples of dried whitebait from the market at Fort Stedman.

### **Barilius auropurpureus**, sp. nov.

(Plate II, fig. 4 ; pl. IV, figs. 11, 12.)

B. 111. D. 9 (2/7). P. 12. V. 7. A. 18 (3/15). Ll. 39-41. L. t. 9 ($7\frac{1}{2}/1\frac{1}{2}$).

The habit is slender and sprat-like. The dorsal profile is higher than the head but not strongly arched, the ventral profile sinuous. The head is long and narrow, the snout sharply pointed. The greatest

depth of the body is about $\frac{1}{5}$ the total length, that of the caudal peduncle $\frac{1}{13}$ to $\frac{1}{14}$; the length of the head slightly less than the greatest depth of the body. The eye is large, a little shorter than the snout and narrower than the interorbital space. There are no barbels. The anterior border of the dorsal fin is immediately above the vent and very slightly in advance of that of the anal; it is much nearer the base of the caudal than the posterior margin of the operculum. The pectoral is long and narrow; adpressed it reaches beyond the base of the ventral, which does not reach the vent. The anal is distinctly longer than the dorsal. The caudal is long and strongly forked. The anal has a well-developed scaly sheath. The scales of the body are large, thin, deciduous and obscurely sculptured.

The pharyngeal bones are short and strongly curved. Each bears about 13 sharp curved teeth arranged triserially.

Preserved specimens are of a dark olivaceous green on the sides and back and the upper surface of the head, white on the belly and silvery on the sides of the head. There about 14 short bluish vertical bars on the middle part of the sides, the series beginning behind the operculum and extending backwards to the level of the posterior margin of the dorsal; on the caudal peduncle it is continued as an irregular horizontal stripe formed by the coalition of further bars. The fins are white and bear rows of minute black dots parallel to the rays. In life this is one of the gorgeous freshwater fishes with which I am acquainted. The back is suffused with deep purple, the vertical bars and caudal stripe are bright ultramarine blue surrounded with a halo of gold, the cheeks are brilliantly iridescent and the whole fish is silvery. The fins of the adult male are pale greenish yellow. Specimens from muddy streams are paler and less brilliant than those from the open lake.

Large specimens from the Inlé Lake are nearly 100 mm. long but in streams in the neighbourhood they do not exceed 70 mm.

*Type-specimen.*—No. F 9432/1 *Zoological Survey of India* (*Ind. Mus.*).

The species is common all over the Inlé Lake and in streams and rivers in the same valley. It is gregarious in habits and is the only fish commonly seen at the surface of the water. The house we lived in near Fort Stedman was built on poles out in the lake a mile from shore. Large shoals of *B. auropurpureus* were attracted by the refuse from our kitchen, beneath and around which they swarmed for the greater part of the day and apparently for the whole night, swimming immediately below the surface. Their natural food in this position consists largely of the small caddis-flies and mayflies that issue from the water every evening and flutter over its surface in enormous numbers. In the heat of the day the fish descend to the bottom, where, through the clear water, we observed them tugging worms or insect-larvae from the mud. As their mouths are not adapted for this mode of feeding they are obliged to turn over on their sides or on their backs when they have got hold of a worm the greater part of which is embedded. In clear water at any rate, in which alone the fish attains its maximum brilliance of colouration, it is extremely quick and wary in its movements, so much so that the Intha fishermen, who do not despise much smaller fish, make

no serious attempt to catch it. They were able to obtain specimens for us with a dip-net, but only at the expense of great labour. In muddy water such as that of the Yawnghwe river it is much easier caught, but I did not see it in any of the markets and have been unable to detect specimens in samples of dried whitebait.

*B. auropurpureus* breeds rather earlier than most of the fishes of the lake, but the breeding period is evidently prolonged. We found shoals of young post-larval stages and of small fish that had not yet attained the characteristic bright colouration, on the surface near the middle of the lake. In all of these there is a dark mid-lateral band and a row of close-set black dots above the anal fin. I figure two of the younger stages.

## Family NOTOPTERIDAE.

### **Notopterus notopterus** (Pall.)

1889. *Notopterus kapirat*, Day, *op. cit.*, p. 406, fig. 129.
1889. *Notopterus kapirat*, Vinciguerra, *op. cit.*, p. 355.
1913. *Notopterus notopterus*, Weber, *op. cit.*, p. 9.

This fish is common in the Inlé Lake, but is always small, never exceeding 10 inches in length. Most of the specimens obtained were very dark in colour, the back being black and the sides dark grey. As, however, I have pointed out elsewhere,[1] individuals exposed to a bright light in an aquarium assume this colouration, which in those from the lake is doubtless due to the clearness of the water. *N. notopterus* is also common at He-Ho. It has a wide distribution in India, Burma, Siam, Malaya and the Malay Archipelago. The small size of the fish and its exceeding boniness interferes with its economic value, but large numbers are sold in the Intha bazaars. They are mostly caught with hook and line or taken in weed-trawls. They live as a rule among weeds near the shore of the lake.

## Order **ACANTHOPTERIGII.**

## Family MASTACEMBELIDAE.

This family is represented in the Inlé fauna by two species of *Mastacembelus*, both of which are, as far as we know, endemic in the Inlé and He-Ho basins.[2]

### **Mastacembelus caudiocellatus,** Boulenger.

(Plate I, fig. 3.)

1893. *Mastacembelus caudiocellatus*, Boulenger, *op. cit.*, p. 199.
1912. *Mastacembelus caudiocellatus*, *id.*, *Journ. Acad. Nat. Sci. Philadelphia* (2) XV, pp. 198, 200.

A photograph of a specimen is reproduced on plate I, fig. 3 to show the characteristic colouration. The ocelli on the sides of the tail are not

[1] Annandale, *Journ. Bom. Nat. Hist. Soc.* XXI, p. 693 (1911-12).

[2] Dr. Boulenger's statement that they occur in the Irawaddi is due, as he informs me, to a misapprehension. See *Journ. Acad. Nat. Sci. Philadelphia* (2) XV, p. 200 (1912).

always to be clearly distinguished as such, for they are perhaps more often mere pale spaces in a dark reticulation. Young and adults agree in colouration. The species is a small one ; no specimens longer than 235 mm. were obtained. It is common in the Inlé Lake, where it occurs both at the edge and in the open parts, always among dense vegetation.

The fish is said to be " sweet " and is eaten by the different tribes that live in the Southern Shan States.

### **Mastacembelus oatesii,** Boulenger.

(Plate I, fig. 2.)

1893. *Mastacembelus oatesii*, Boulenger, *op. cit.*, p. 199.
1912. *Mastacembelus oatesii*, *id.*, *op. cit.*, pp. 198, 200.

This is a larger species, commonly attaining a length of 370 mm. The dorsal spines can be retracted into fleshy sheaths and the praeopercular spines are often completely concealed. Fully adult individuals are of an almost uniform dark greenish colour, but in the young the belly is pale and the sides bear a series of irregular dark, pale-spotted bars (sometimes broken up into spots or blotches), while the sides of the head are ornamented with alternate dark and pale horizontal lines and bars. The caudal fin at this stage is black with a broad white vertical bar ; the ventral fins are pale with a dark edge and the pectorals are almost wholly pale. The difference in colouration between the young of this species and *M. caudiocellatus* is illustrated in figs. 2 and 3, plate I.

The Intha do not distinguish between the two species of the genus.

## Family OPHIOCEPHALIDAE.

### **Ophiocephalus striatus,** Bloch.

1889. *Ophiocephalus striatus*, Day, *op. cit.*, II, p. 363.
1889. *Ophiocephalus striatus*, Vinciguerra, *op. cit.*, p. 184, fig.

This fish is by far the largest in the lake, attaining a weight of 10 lbs. or over. Together with *Clarias batrachus* it has a pre-eminence in favour among the Europeans of the district, but I am not sure that the Intha themselves do not prefer the true Carp. *O. striatus* is caught with hook and line (the bait often being a small live *Notopterus*) and in special traps made of reeds. It is often abundant in the local markets.

The species has a wide distribution in Continental Asia extending as far east as Eastern China and the Philippines.

### **Ophiocephalus harcourt-butleri,** sp. nov.

(Plate II, fig. 7 ; pl. IV, figs. 16, 17.)

D. 28-38. A. 16-25. L. l. 40-45. L. t. 14-15.

A small species resembling *O. gachua*, but distinguished by the smaller scales on the head, the longer, narrower, less flattened head, etc.

The total length is from 5 to $5\frac{1}{2}$ times the greatest depth, from $3\frac{1}{2}$ to $3\frac{3}{4}$ the length of the head and from $5\frac{1}{2}$ to 6 times the length of the caudal fin. The length of the orbit is from $\frac{1}{27}$ to $\frac{1}{30}$ the total length

and from $\frac{2}{5}$ to $\frac{2}{3}$ the breadth of the interorbital space. The number of spines in the dorsal fin is usually between 30 and 34 and that in the anal fin between 20 and 25. The number of scales between the orbit and the preopercular angle is 5 or 6; the number between the dorsal and the tip of the snout is 13 to 15. The ventral is less than half the length of the pectoral.

The teeth are for the most part villiform and are arranged in numerous lines on both jaws, but there is an inner row of larger conical teeth both in the upper and in the lower jaw. The arrangement is best shown in a figure (pl. IV, fig. 17).

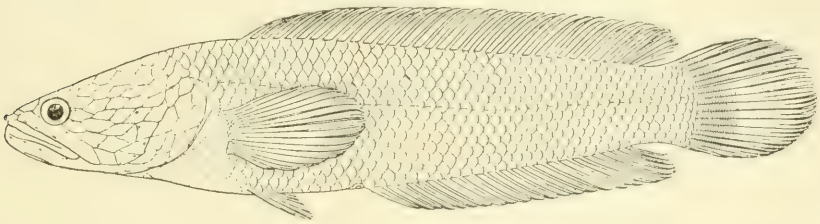


FIG. 2.—*Ophiocephalus harcourt-butleri*, sp. nov.

Two colour-forms can be distinguished :—

A. The whole body and head and the greater part of the fins are almost uniformly black, the ventral surface being only slightly paler and a little mottled and the pectoral fins showing slight traces of transverse banding; a narrow margin of red or reddish orange runs round the vertical and the caudal fins.

B. The head and body are gray or olivaceous, pale on the ventral surface and with incomplete dark < shaped markings on the side (as a rule more or less interrupted), an indistinct dark blotch at the base of the pectoral fin, pale longitudinal lines on the dorsal and vertical lines on the caudal fin.

Form B preserves to a large extent the juvenile colouration (pl. II, fig. 7), in which the markings are more distinct and the blotch at the base of the pectoral is the centre of a well-defined ocellus. There is never an ocellus on the dorsal or the tail.

Our largest specimen (from the Inlé Lake) is 22·6 cm. long, and from all accounts the species does not grow more than 25 cm. long.

*Type-specimen.*—(Form A) No. F 9439/1 *Zoological Survey of India* (*Ind. Mus.*) from Fort Stedman.

*Distribution.*—This species is abundant all over Yawnghwe and the neighbouring states. We obtained specimens not only from the Inlé Lake but also from He-Ho (3,800 ft.) and Thamakam (4,200 ft.); it lives on a muddy bottom in sluggish streams and also in all parts of the Inlé Lake, hiding itself as a rule among weeds. Large numbers are sold in the local markets.

The species is named after His Honor Sir Harcourt Butler, K.C.S.I., C.I.E., I.C.S., Lieutenant-Governor of Burma at the time of our visit to Yawnghwe, now Lieutenant-Governor of the United Provinces.

## FISHERIES OF THE LAKE.

### LICENCES.

The fisheries of the Inlé Lake are of the greatest possible importance to the population of its shores, though the revenue that they provide for the state is not large, never rising much above 13000 rupees a year. This revenue is gathered in the form of licences for the use of different kinds of fishing apparatus. The licences are issued monthly to individuals and give the licencee the right to use as many traps, etc., as he can set himself or otherwise utilize without assistance. I have to thank Mr. C. E. Browne, I.S.O., Political Adviser, Yawnghwe, for the following statistics :—

*Receipts from Yawnghwe fisheries for the last 8 years.*

| | Rs. |
|---|---|
| 1908-09 ... ... ... ... | 11,824 |
| 1909-10 ... ... ... ... | 12,074 |
| 1910-11 ... ... ... ... | 12,759 |
| 1911-12 ... ... ... ... | 11,029 |
| 1912-13 ... ... ... ... | 10,233 |
| 1913-14 ... ... ... ... | 11,005 |
| 1914-15 ... ... ... ... | 13,025 |
| 1915-16 ... ... ... ... | 12,769 |

*Fishing implements used in Yawnghwe State and rate charged for each.*

| | Monthly charge. *Rs.* | *a.* | *p.* |
|---|---|---|---|
| 1. Hmyon-gyi (" Large trap ") ... ... | 2 | 0 | 0 |
| 2. Hmyon-seik ... ... ... ... | 0 | 0 | 3 |
| 3. Hmyon-Paung-Nyat ... ... ... | 0 | 0 | 3 |
| 4. Hmyon-Taung-In ... ... ... | 0 | 0 | 3 |
| 5. Hmyon-Te ... ... ... ... | 0 | 0 | 3 |
| 6. Hmyon-Nga-Hmwe ... ... ... | 0 | 0 | 3 |
| 7. Hmyon-Kwet-Kya ... ... ... | 0 | 0 | 3 |
| 8. Hmyon-Kyi-Dauk ... ... ... | 0 | 0 | 3 |
| 9. Hmyon-Waing ... ... ... | 0 | 0 | 3 |
| 10. Hmyon-Chok ... ... ... ... | 0 | 0 | 3 |
| 11. Hmyon-Hpyu ... ... ... ... | 0 | 0 | 3 |
| 12. Hmya-Tayaw-To (Hmya=Hook) ... ... | 0 | 4 | 0 |
| 13. Hmya-Tauk ... ... ... ... | 0 | 0 | 1 |
| 14. Hmya-Tan-Kyo ... ... ... | 0 | 0 | 1 |
| 15. Hmya-Tan-Let-Kaing ... ... ... | 0 | 4 | 0 |
| 16. Ne-Khayin (day-spear) ... ... ... | 0 | 4 | 0 |
| 17. Nyat-Khayin (night-spear) ... ... | 1 | 0 | 0 |
| 18. Po-San (silk net) ... ... ... | 1 | 0 | 0 |
| 19. Kyi-San (cotton net) ... ... ... | 1 | 0 | 0 |
| 20. Hpyin-San ... ... ... ... | 0 | 8 | 0 |
| 21. Chaung-Ya-Thè ... ... ... | 2 | 0 | 0 |
| 22. In-ya-Thè ... ... ... ... | 4 | 0 | 0 |
| 23. Pazunseik-Ngè-Ya-Thè ... ... ... | 0 | 8 | 0 |
| 24. Nga-Yan-Paik (Paik=net) ... ... | 0 | 8 | 0 |
| 25. Nga-Pein-Paik ... ... ... | 0 | 8 | 0 |
| 26. Nga-Kon-Ma-Paik ... ... ... | 0 | 8 | 0 |
| 27. Hmaw-chit-Paik ... ... ... | 1 | 8 | 0 |
| 28. Paik-Yat-Kyi ... ... ... ... | 4 | 8 | 0 |
| 29. Hsaung ... ... ... ... | 0 | 4 | 0 |
| 30. Hu-Yin ... ... ... ... | 0 | 4 | 0 |
| 31. Kun (casting net) ... ... ... | 2 | 0 | 0 |
| 32. Ka-Tat-Htaung-Hnyut ... ... ... | 0 | 0 | 1 |
| 33. Pet-Ka ... ... ... ... | 0 | 4 | 0 |

Both these tables refer to the whole of the Yawnghwe State and no separate statistics are available for the Inlé Lake; but the lake fisheries are of very much greater importance than those of streams, swamps and rice-fields.

The names of fishing apparatus given in the second table are not in all cases intelligible even to a Burmese scholar, for many of them are strictly local. I have to thank Mr. G. deP. Cotter of the Geological Survey of India for elucidating some of them. They are not in most cases the same as those I obtained myself from the Intha fishermen in reference to specimens collected. It may be remembered, however, that the word *Hmyon* means a basket or basket-work trap of any kind, *Hmya* a hook, *Khayin* a fish-spear and *Paik* a net. *Nga* means fish. The specific Intha names of different species of fish will be found on pp. 24, 25. *Nga-Yan* is *Ophiocephalus striatus*, *Nga-Pein* or *Hpein* the true Carp, *Nga-Kon-Ma* the Burmese Red-finned Barbel (*Barbus sarana caudimarginatus*).

## FISHING BOATS.

The Intha ("Sons of the Lake") are great boat-builders and boatmen, very fond of boatracing. All their boats are, however, of one type. They are long and narrow, almost flat-bottomed and with very little freeboard. The two ends of the boat are identical, each is raised and bifurcated at the tip and a little widened so that a rope passed over it does not slip. The bottom of the boat is built of the outer sections of several tree-trunks laid end to end, and its size is measured by the number of logs thus used. Planks are built up above the logs and the whole is covered with a thick layer of *thitsi* varnish composed of wood-oil from the tree *Melanorrhoea usitata* mixed with damar resin. Broken shells of Gastropod molluscs from the lake are sometimes mixed with the varnish and applied on the raised ends of the boat to give the boatmen foot-hold.

The boats are rowed by means of paddles with fairly long blades. The Intha as a rule row standing and use their legs as well as their arms in rowing. The leg is hooked round the outside of the paddle in such a way that the two first toes touch and sometimes grasp the shaft from behind above the top of the blade. The position is shown very well in the photograph on pl. V, fig. 1. It is not uncommon to see a man rowing with his right arm and right leg, standing on his left leg and wielding a fish-spear with his left arm (pl. VI, fig. 2). Women also row in the same fashion. The right and left arms and legs are used indiscriminately. When a man is fishing in a boat by himself he often uses a simple contrivance to keep it steady while he is spearing fish or otherwise employed. The contrivance of two flat, more or less paddle-shaped pieces of wood tied together by a piece of string, which is laid across the boat near one end and is sufficiently long to allow the two boards to hang into the water one on each side (pl. VI, fig. 2).

Sails are not very often employed and the Intha are not skilled in their use. A single mast is, however, sometimes fixed in a block fastened to a cross-bar near one end of the boat and a narrow oblong sail of cloth hoisted on it. A much commoner practice is the use of a large

silk umbrella as an accessory sail. When there is a slight breeze behind the boat it is a common sight to see a man or woman kneeling in front and holding up a large umbrella of oiled silk for this purpose. The umbrella is the same as that used for protection against sun or rain.

## Fish-Traps and Baskets.

The fish-traps used in the Inlé Lake are not different in general principle or structure from those used in most parts of the East. They depend for their efficacy largely on the fact that many fish have a habit of thrusting themselves into any hole that seems likely to lead to a sheltered retreat. It is always easier, owing to the direction of the fins, for a fish to go forwards through a small aperture than for it to retreat backwards, and apparently fish have not the sense to turn round and go by the way they came. Consequently the traps used in the Inlé Lake, with the exception of certain baskets with which I will deal later, have one or more entrances fitted with a funnel-shaped passage-way that has the narrower end innermost.

Perhaps the most characteristic trap of the kind known to the Intha is that used in catching the Inlé Herring Barbel (*Barbus stedmanensis*) and called by them *pwanhnwet*: see pl. VII, fig. 3. It is of stout barrel-shaped form and is neatly constructed of very fine strips of cane crossing diagonally in two directions, and of some twenty rather stouter strips of the same material bent in circles. The diagonal strips pass alternately above and under the circular ones. The trap is made in two longitudinal halves, each of which has several circular strips twisted round its open end. The two halves are roughly tied together with coarse twine and can be separated in order to remove the fish. There is an entrance at either end of the complete trap. Its funnel-shaped passage-way is formed of inwardly projecting strips of bamboo which converge considerably. They are strengthened by other strips wound round them in a spiral. The trap is never baited, but is either laid amongst weeds with a stone inside to keep it from floating or else suspended in the lake under a small floating island, which is anchored by means of a rope and stone. The floating island may be a mass of peat with vegetation growing on it or simply a mass of floating weed. A plant frequently used for the purpose is *Ammania rotundifolia*.

A coarser type of trap (pl. VII, fig. 4), used chiefly for catching *Ophiocephalus striatus*, is often set in the lake. It is made of slender but very strong reed-stems peeled and coated with *thitsi* varnish. They are fastened parallel to one another by means of bands of some tough bark twisted round and between them in a double spiral. At the two ends and in the middle there is a twig or strip of bamboo bent in a circle and fixed inside the reeds to strengthen the whole. The strips of bark and the internal supports are manipulated in such a way that the trap is somewhat compressed at one end; otherwise it has an almost cylindrical shape. It is about 82 cm. long and 44 cm. deep. There are two compartments and both the round end of the trap and the partition between the compartments are provided with a passage-way of converging reeds. The compressed end is provided with a moveable

door of reed-stems. This trap, which is called *pwanhnwet-nga-yan* is very like one from Bengal figured by Day in his hand-book of "Indian Fish and Fishing" compiled for the Fisheries Exhibition in London of 1883. The reference is to pl. 1, fig. 4 of the book. The chief difference is that the Intha trap is truncated at the compressed end instead of being produced.

The other traps recognized for revenue purposes by the Yawnghwe State are probably used for the most part in rice-fields, canals, etc., rather than in the lake itself; the only other type which I know to be set in the lake is the one used in connection with the large fishing enclosures which I will discuss later. In general structure it resembles the conical frames (pl. V, fig. 1) used in connection with fish-spears, but is not more than 4 feet long and relatively narrow. A funnel-shaped passageway is fitted in the broad end and a hole at the narrow end is filled with weeds when the trap is set. The fish are extracted from this hole.

The traps used in rice-fields differ only in small details from those used all over India and Burma. Two types are common. One is conical and has a funnel-shaped entrance. It resembles the large traps used in the enclosures but is only about a foot long and is made of very narrow strips of reed-stem. The other, which stands upright, has a flat bottom of bamboo-matting. The upright sides are made of very narrow strips of bamboo arranged closely parallel to one another in a vertical direction. In cross-section the trap is shaped like a figure of 8 with the double curve of one side smoothed out into a single convexity. In the depression on the other side there is a series of narrow slits, through which the little fish and prawns enter. As the top is open and the whole trap not more than eighteen inches high, it can only be used in very shallow water.

Two kinds of baskets are used in catching small fish and prawns. One (pl. VII, fig. 2) of these (*hmyonkwet*) is broadly cylindrical, and is formed of a very coarse network of rough bamboo strips, with a number of similar strips twisted round the top. A specimen is 42 cm. high and 1·3 m. in circumference. Baskets of this kind are filled with peat, fresh weeds and stones, and sunk in the open parts of the lake. They are left at the bottom for 24 hours or more, and then fished up with a fishing spear. Several hundreds are often laid down by a single boat or a pair of boats, on which they are piled to a great height. Fish of various kinds, especially the small Cyprinidae and the species of *Mastacembelus* and *Notopterus*, go into them, apparently to look for food among the peat as well as to take shelter, for the peat is considered necessary. They remain in hiding amongst the weeds when the basket is drawn up. The monthly licence for using baskets of this kind is only three annas.

The other kind of fishing basket (pl. VII, fig. 1) is also made of bamboo strips, but the strips are much narrower and more carefully prepared, and the workmanship is neat and close. The structure is that of a more normal basket with upright strips radiating from the bottom, and with finer strips passing horizontally alternately in and out, below and above them. A large specimen is 26 cm. deep, and

1·47 m. in diameter. Small Cyprinidae, and especially small prawns, are caught by dipping baskets of the kind into the water under duckweed or other floating plants among the floating islands in the marginal zone of the lake and in canals and water-channels in the surrounding country. The water runs out through the interstices of the basket when it is lifted, leaving the little fish and prawns in a mass of weeds.

## Nets.

At least six different types of nets are recognised by the revenue officers of the Yawnghwe State. Some of these nets are distinguished by the name of the fish which they are used in catching. There is the *nga-yan-paik* (*i.e.*, the net for catching *Ophiocephalus striatus*), the *nga-pein-paik* (*i.e.*, the Carp net), and the *nga-kon-ma-paik* (*i.e.*, the net for catching *Barbus sarana*). There are also the *hmaw-chit-paik*, the *paik-yat-kyi*—names I cannot explain—and the *kun* or cast-net.

The prices of monthly licenses for these different nets are as follows :—

| Kind of Net. | Monthly Licence. | | |
|---|---|---|---|
| | *R* | *a.* | *p.* |
| Nga-yan-paik ... ... ... ... | 0 | 8 | 0 |
| Nga-kon-ma-paik ... ... ... ... | 0 | 8 | 0 |
| Hmaw-chit-paik ... ... ... ... | 1 | 8 | 0 |
| Paik-yat-kyi ... ... ... ... | 4 | 8 | 0 |
| Kun ... ... ... ... ... | 2 | 0 | 0 |

The relative efficacy of the different nets can be gauged to some extent by the licence paid for their use. I am not sure that all of them are used actually in the lake, for the revenue statistics from which my information is drawn apply to the whole of the State of Yawnghwe and the names given me by the fishermen do not agree with those in the official list.

The Carp net and the barbel net are drift-nets of very ordinary structure. That used for the Carp is made of fine silk (imported overland from China) of considerable length but only about 1½ feet deep ; the mesh is 24 mm. across. There are small floats of some very light wood fastened to a double string that runs along the top. They are flattened cylinders about 8 mm. long, and are fastened at intervals of about 15 cm. Along the bottom of the net there are small leaden weights consisting of thin plates about 7 cm. long bent round another double string and hammered tight. When not in use the net is festooned on a bamboo. The net for barbel is precisely similar in construction, but is made of cotton and has a slightly smaller mesh, about 20 mm. across. I am told that the *Ophiocephalus* net has a considerably larger mesh. All these are used most commonly in connection with floating islands, which are towed out into the middle of the lake and there anchored. The fish take shelter under them, and the nets are drawn round them, or along one side.

The weed-trawl (pl. V, fig. 2) is a much more characteristic net. It has a triangular or almost triangular frame of variable size, but at least 5 feet long. The frame is made of two bamboos bent into an

arch above and tied together with twine. A third bamboo passes transversely through holes in their free ends. The net itself is bag-shaped, and has a small mesh of about 12 mm. It is made of cotton. A long rope is fastened to each of the lower angles of the framework. Two boats have to be used in fishing with this net. A man stands upright in one of these boats holding the top of the framework in his hands, he plunges it downwards and throws the two ropes across to two men in the other boat. They haul in the ropes until the net is horizontal and the two boats are close together. The bag is then emptied out into the second boat. The contents consist of a mass of weeds, with Carp, *Notopterus*, *Barbus sarana*, *Ophiocephalus striatus* and any other fish that may have taken shelter among the weeds.

The *Sin* or dip-net is of various sizes, and may be either square or oblong. It is used mainly for catching the herring-like *Barbus stedmanensis*, and the sprat-like *Barilius*, both open-water fish. The mesh is naturally smaller for the latter than for the former. The net is fastened at its four corners to two stout bent pieces of bamboo which are crossed above and temporarily tied together with string. A longer straight bamboo is tied above them as a handle. The net is allowed to sink into the water where a shoal of fish is seen, and rice-chaff is sprinkled on the surface above it. The fish come to this, thinking it to be some kind of food, and the net is drawn up from below them. The large dip-nets worked with a windlass that are often seen in Travancore, on the Talé Sap in Peninsular Siam and in many parts of China are not used on the Inlé Lake.

The cast-net is used rather in canals and flooded rice-fields than in the lake itself. It does not differ in construction or method of use from nets employed in other parts of the East.

## FISHING ENCLOSURES.

I did not see real stake-nets of any kind in use on the lake, but driftnets are sometimes used in connection with large enclosures (pl. V, fig. 3). These are made in the following manner :—Masses of living weed (*Ceratophyllum*) are collected in boats and allowed to dry. They form a felted substance of some strength. With this walls are built in the lake round areas often of large size. They reach from the bottom to well above the surface of the water and are fixed in position by long bamboo poles driven through them into the mud of the bottom. Small holes are made in the walls at intervals a short distance below the surface and the mouths of conical fish traps made of bamboo (see above) are fixed in the holes. The bottom of the enclosed area is then systematically stirred up by means of bamboos and the fish are driven out into the traps. The nets are suspended in the air on bamboos above the walls of the enclosures to catch those fish that may attempt to leap out.

## HOOKS AND LINES.

The revenue department of Yawnghwe recognize several different kinds of methods of using fish-hooks, but I have little information as to the methods except that both fishing-rods made of long reeds and

long lines with many hooks are used. A common bait for large fish such as *Ophiocephalus striatus* is a small living *Notopterus*. The cost of the monthly licence for the use of different kinds of fishing lines varies from one to four annas.

### Fish-Spearing.

The most profitable and one of the most heavily taxed methods of fishing is that of spearing (pl. VI, figs. 1, 2, 3). The spears are of two kinds, one (pl. VI, fig. 4) with two prongs and one with five (pl. VI, fig. 5). The former is used for spearing Carp and all other fish except eels, it is called *kyin* or *khyin*. The monthly license for its use costs four annas if it is used by day, but one rupee if it is used by night with a small fire in the front portion of the boat. An accessory frequently employed with this type of spear is a large conical frame made of strips of bamboo bound together with ratan and sufficiently long to reach the bottom of the lake. It has a small hole at the top and is without a bottom. This contrivance is let down over fish in the water and they are then speared through the hole at the top.

The spear with two prongs is only used in catching the eels *Amphipnous cuchia* and *Monopterus albus*. It is of much less importance than the one with five prongs. It is named *shin-su*.

The construction of the two kinds of spears is essentially the same but that of the *shin-su* is somewhat simpler than that of the kind with five prongs. Its shaft is made of a slender bamboo about 5 feet long. The two prongs, each of which has a single barb on the inner surface, are apparently cast in one piece with a spike at the base, which is inserted into the tip of the shaft. They are fixed in position by means of some kind of resin and the tip of the shaft is strengthened by a copper band hammered tight round it. The prongs are of course of iron.

The shaft of the five-pronged spear is longer and more slender and is formed of the stem of a stout reed covered with *thitsi* varnish. The five prongs are all in one piece and each has a single barb ; they are bound to the shaft by thin twine or cotton thread covered with resin or *thitsi* varnish. The shaft is sometimes as much as 12 feet long.

### Chief Edible Fish of the Lake.

In the systematic part of this paper I have stated briefly, in discussing each species, its economic status. It may be convenient here to summarize what has been said on the subject : at the same time I wish to say a little more about the dried whitebait that is so characteristic a product of the Yawnghwe State.

All the species commonly sold in the market are abundant, a fact probably correlated with the comparatively small number of species represented in the lake. There are no really large fish in the Inlé Lake and several of the species certainly do not attain the size they attain in the lowland waters of Burma. This may be due to the lack of a sufficiently abundant supply of nitrogenous food or to other causes of like nature. Some of the fish of the lake are always very small, not growing more than an inch long. The great majority of the

fish are eaten commonly by the people, but several species are of little economic importance because they are of relatively small size and are at the same time difficult to catch. To this category belong the species of *Barilius*, a sprat-like fish which as a rule swims near the surface, and *Discognathus*, which is provided with an adhesive apparatus connected with the mouth and feeds by crawling up house-posts and the like and grazing on the minute vegetation attached thereto.

The chief food fishes among the larger species that are eaten fresh are the following :—

*Clarias batrachus*, *Cirrhina latia*, *Barbus sarana caudimarginatus*, *Barbus stedmanensis*, *Cyprinus carpio intha*, *Notopterus notopterus*, *Ophiocephalus striatus* and *O. harcourt-butleri*. Of these, Europeans prefer *Clarias batrachus* and *Ophiocephalus striatus*, but the favourite fish of the Intha seems to be the local race of the true Carp.

The larger fish are seldom preserved by salting or drying, but half-grown Murrel are occasionally split, cleaned and salted, while a surplus catch of *Cirrhina latia* is frequently dried without even being cleaned. Small dried fish of the latter species are sold separately from larger ones.

The dried whitebait consists of small fish of diverse species, which are captured mostly in rice-fields at the time when they are being drained in autumn. A comparatively small number are, however, taken among the floating islands near the edge of the lake. The fish are caught in the baskets described above and also in small traps of types widely distributed in India and the surrounding countries. The fish identified from samples of whitebait purchased in the Intha bazaars are :—

*Lepidocephalus berdmorei*, *Nemachilus botia*, *N. brevis*, *N. brunneanus*, *Cirrhina latia*, *Danio aequipinnatus*, *Cyprinus carpio intha*, *Sawbwa resplendens*, *Microrasbora rubescens*, *M. erythromicron*, *Mastacembelus oatesii* and *M. caudiocellatus*. Of the larger species only a small number of young individuals were found to be present. The great bulk of all the samples examined consisted of the species of *Lepidocephalus*, *Nemachilus*, *Sawbwa*, *Danio* and *Microrasbora*.

Several different qualities of whitebait are recognized in the local markets, the difference depending chiefly on the species present or predominant. The selection is, however, perhaps to some extent different in different villages. In Fort Stedman bazaar I found two qualities commonly on sale in February : A sample of the first quality (called *Poktha*) consisted of 74 per cent. of small loaches and 26 per cent. of Cyprininae of species that never grow more than 2 inches long. The second quality was called *Nga tha-hpwe-gyauk* and only differed from the first in having a very much smaller proportion of loaches. In the Nan-Pan bazaar at the same season three qualities were distinguished. The first quality was called (*Nga Me*="black fish"). It consisted of loaches and of small Cyprininae in about equal proportion. The second quality (*Nga Mi*="red fish") consisted mainly of *Danio*, with some loaches and a few (not more than 5 per cent.) of young *Cyprini* and *Cirrhinae*. The third quality (*Nga Hpyn*="white fish") consisted mainly of *Sawbwa* and *Microrasbora* with a small admixture of young loaches and a few young *Cirrhinae*.

No salt is used in preserving these small fish, which are dried in the sun on bamboo mats. The product is exported to other parts of the Southern Shan States and possibly even further afield.

Small prawns of the genus *Caridina* are captured and utilized precisely in the same manner as the small fish, and they form an even more important article of local export. They will, however, be discussed more appropriately when the Crustacea of the lake are described.

Except for the licencing of different kinds of apparatus there is no restriction[1] placed on the fisheries of the Inlé Lake, and I could discover no facts that would justify any such restriction at present. The lake, however, is bound to become gradually smaller and shallower, and the fish to become scarcer as the area available for them is restricted. When this occurs the only course will be to experiment in the intensive culture of the Carp and of the small fish used in making dried whitebait. There is every reason to hope that experiments of the kind would be successful.

[1] Some of the Intha think it wrong to fish in the "Buddhist Lent," in summer and autumn, but this is not the breeding-season of the fish and no legal restriction or strong religious influence is exerted in the matter.

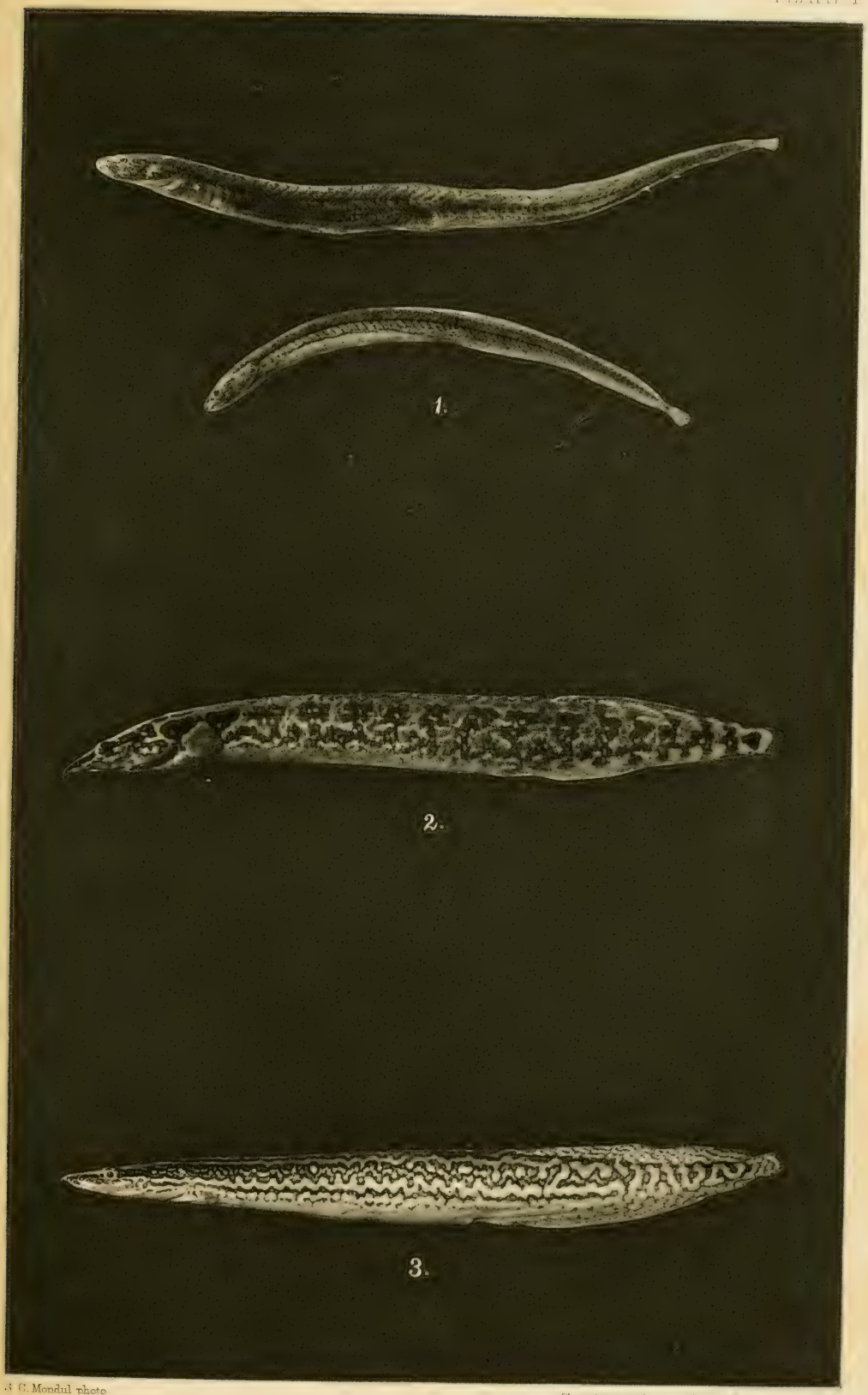
## EXPLANATION OF PLATE I.

PHOTOGRAPHS OF PRESERVED SPECIMENS OF INLE FISH.

FIG. 1.—Type-specimens of *Chaudhuria caudata*, gen. et sp. nov., × 2.

,, 2.—Young specimen of *Mastacembelus oatesi*, Boulg., nat. size.

,, 3.—Adult specimen of *M. caudiocellatus*, Boulg., $\times\frac{1}{2}$.




B. C. Mondul photo

Photogravure, Survey of India Offices, Calcutta, 1918

FISH OF THE INLÉ LAKE

## EXPLANATION OF PLATE II.

PHOTOGRAPHS OF PRESERVED SPECIMENS OF INLE FISH.

FIG. 1.—Male specimen of *Nemachilus brevis*, Boulg., × 2.

,, 1*a*.—Female specimen of the same species, × 2.

,, 2.—Type-specimen of *Nemachilus brunneanus*, sp. nov., × 2.

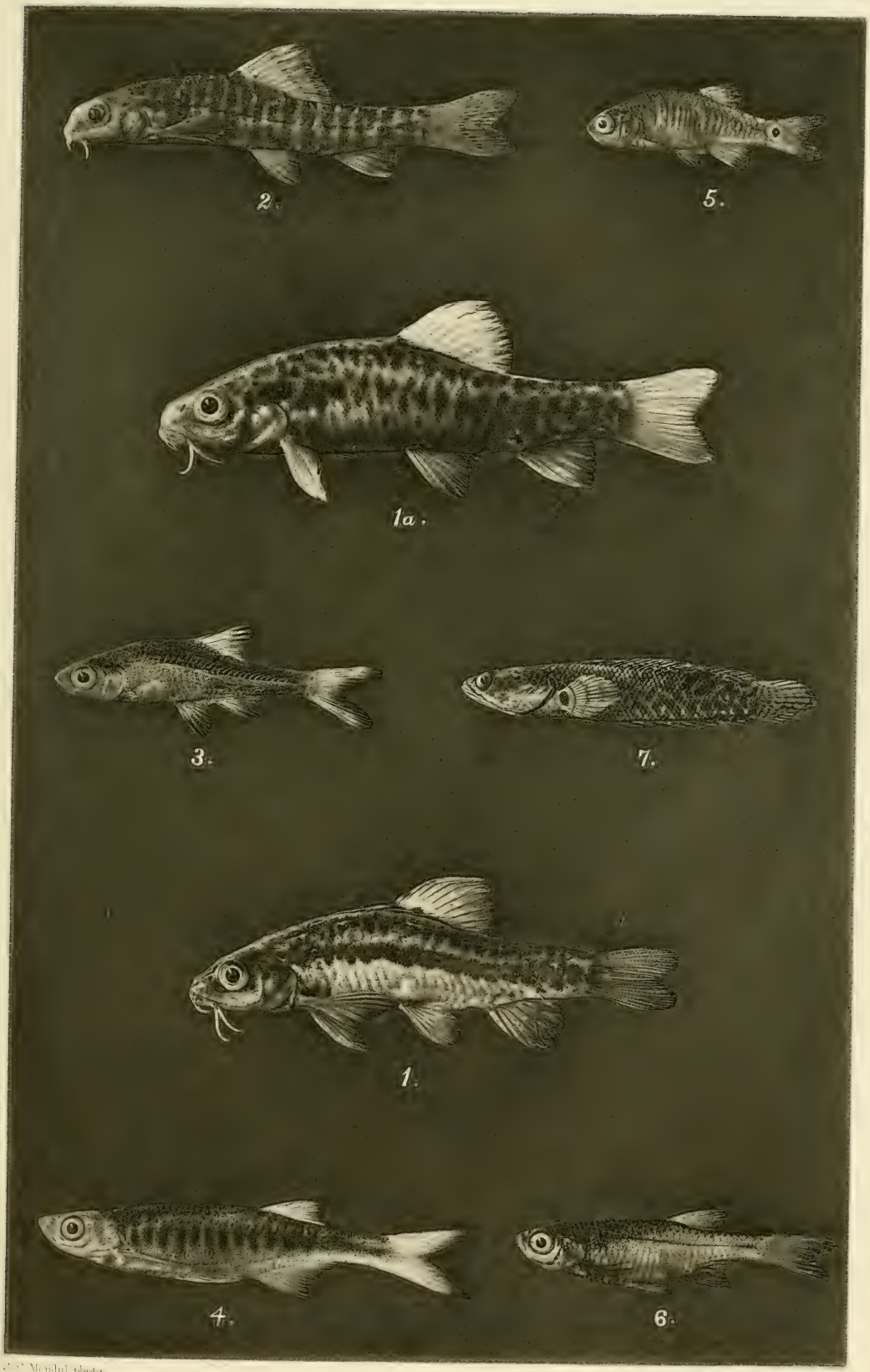
,, 3.—Type-specimen (male) of *Sawbwa resplendens*, gen. et sp. nov., × 2.

,, 4.—Co-type of *Barilius auropurpureus*, sp. nov., somewhat reduced.

,, 5.—Type-specimen of *Microrasbora erythromicron*, gen. et sp. nov., × 2.

,, 6.—Type-specimen of *Microrasbora rubescens*, sp. nov., × 2.

,, 7.—A young specimen of *Ophiocephalus harcourt-butleri*, sp. nov., nat. size.




A. C. Mondal photo. Photogravure Survey of India Offices Calcutta 1918

FISH OF THE INLE LAKE

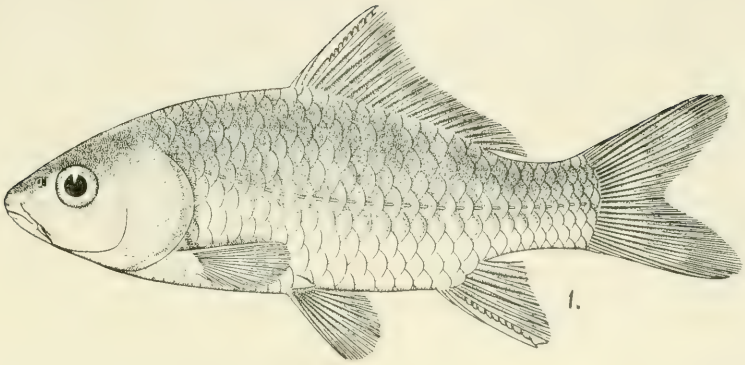
## EXPLANATION OF PLATE III.

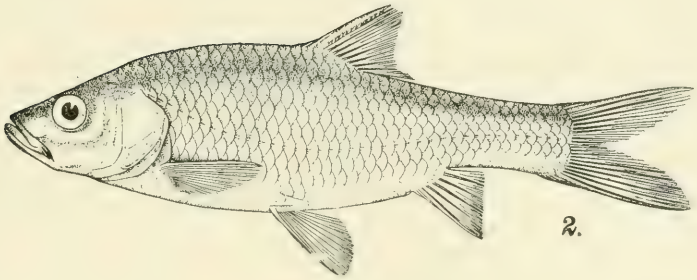
Fig. 1.—*Cyprinus carpio intha*, subsp. nov.

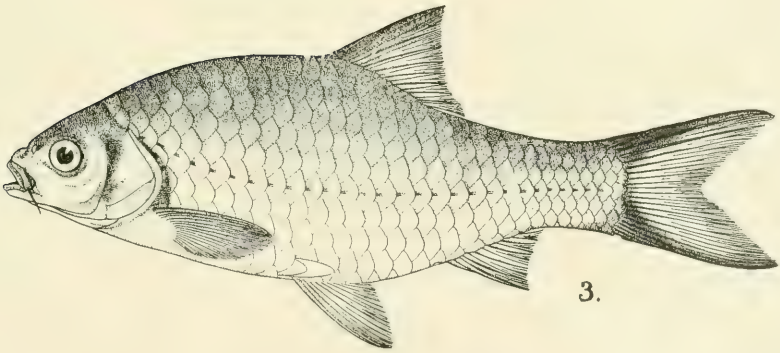
,, 2.—*Barbus stedmanensis*, Boulenger.

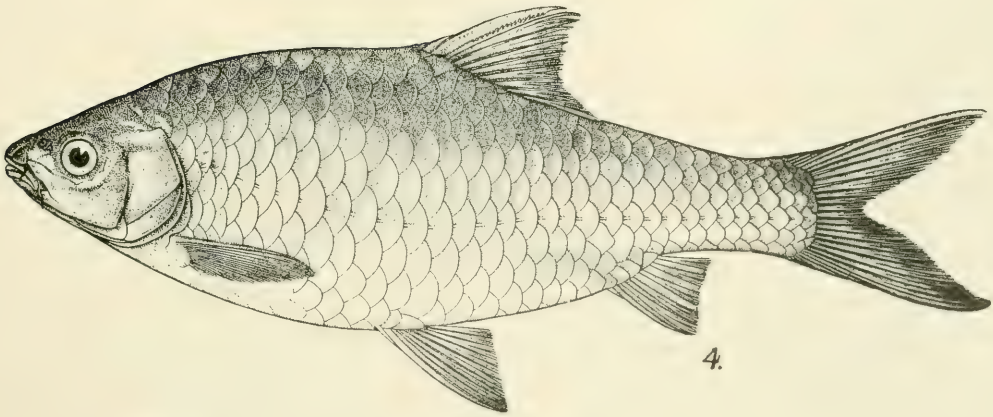
,, 3.—*Barbus sarana caudimarginatus*, Blyth.

,, 4.—*Barbus schanicus*, Boulenger.




A. C. Chowdhary del.

FISH OF THE INLE LAKE.

## EXPLANATION OF PLATE IV.

*Chaudhuria caudata*, gen. et sp. nov.

FIG. 1.—Head and forequarters of type-specimen as seen from the left side, × 9.

,, 2.—The same from below. The right operculum has been raised slightly to show the base of the pectoral fin.

,, 3.—Upper jaw from below, × 15. *e*=ethmoid : *m*=maxillary : *v*=vomer.

,, 4.—Lower jaw from above, × 15.

,, 5.—Slightly oblique anterior view of the atlas vertebra, × 25.

,, 6.—Oblique lateral view (from the right side) of the second vertebra, × 25.

,, 7.—Lateral view of a trunk vertebra, × 22·5.

,, 8.—Lateral view of a caudal vertebra, × 44.

,, 9.—Ripe egg viewed as a solid object, × 10.

,, 10.—The same viewed by transmitted light after staining with borax carmine, clearing with oil of cloves and mounting in Canada balsam.

*Barilius auropurpureus*, sp. nov.

FIG. 11.—Early post-larval stage in which the tail is not yet forked and the dorsal fin undifferentiated, × 6.

,, 12.—A later stage, × 5.

*Microrasbora rubescens*, gen. et sp. nov.

FIG. 13.—Right pharyngeal bone, × 15.

*Microrasbora erythromicron*, sp. nov.

FIG. 14.—Left pharyngeal bone, × 25.

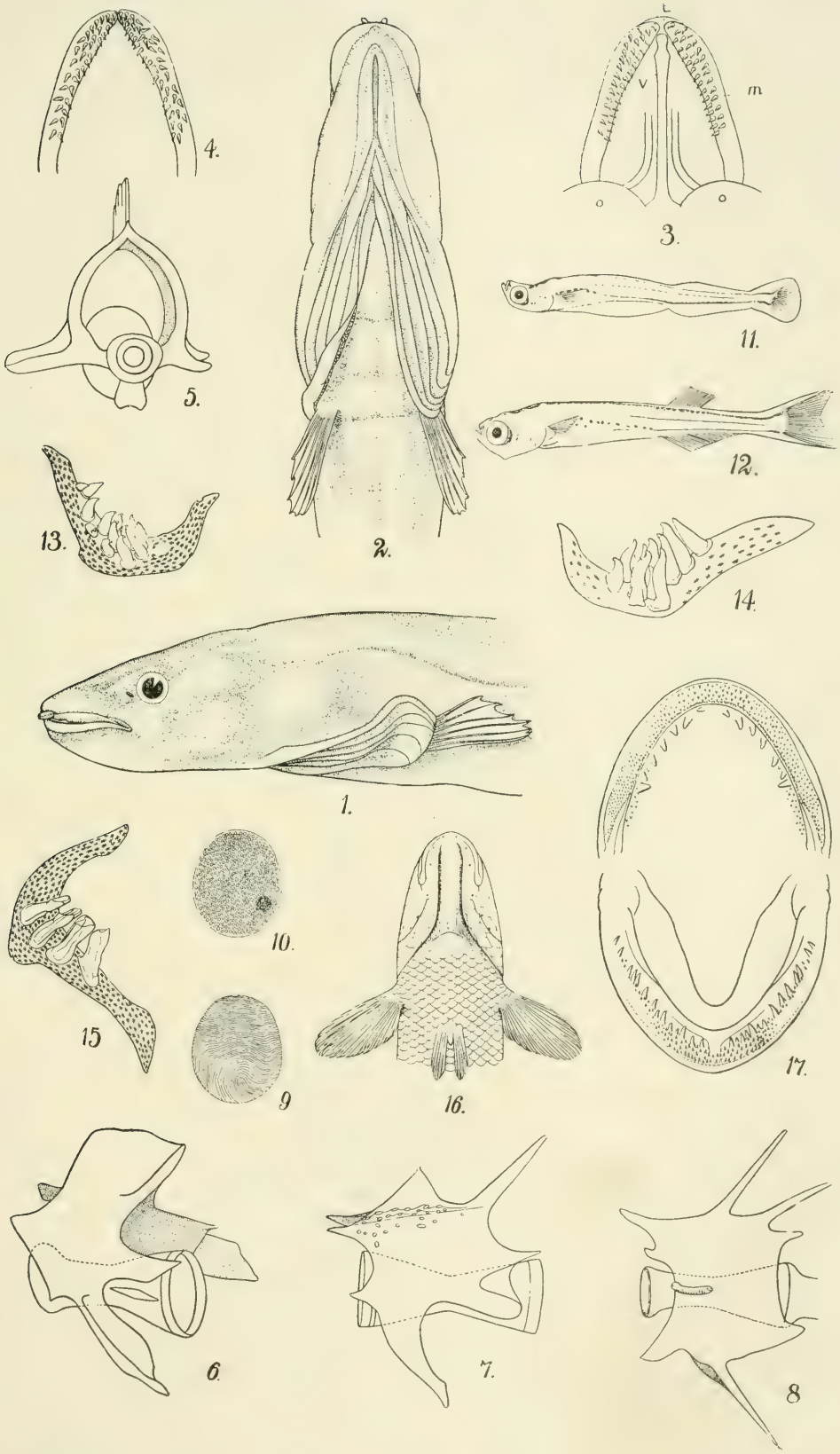
*Sawbwa resplendens*, gen. et sp. nov.

FIG. 15.—Right pharyngeal bone, × 15.

*Ophiocephalus harcourt-butleri*, sp. nov.

FIG. 16.—Head and forequarters from below, × ½.

,, 17.—Jaws and teeth, × 2.




D. Bagchi del.

FISH OF THE INLE LAKE.

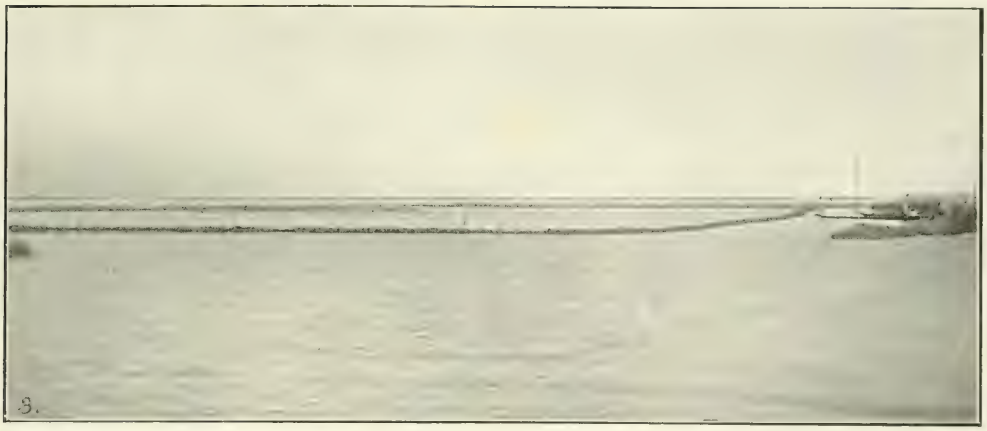
## EXPLANATION OF PLATE V.

FISHING AND ROWING ON THE INLE LAKE.

FIG. 1.—Boatman rowing in the Intha style with arm and leg. The white marks on the sides of the boat represent lines of broken Gastropod shells incorporated with the varnish to give foot-hold.

,, 2.—Use of the weed-trawl among the floating islands near Nan-Pan at the south end of the lake.

,, 3.—Large fishing enclosure made of dried *Ceratophyllum* off Fort Stedman.






F. H. Gravely photo.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1918.

## EXPLANATION OF PLATE VI.

### Fish-spearing on the Inle Lake.

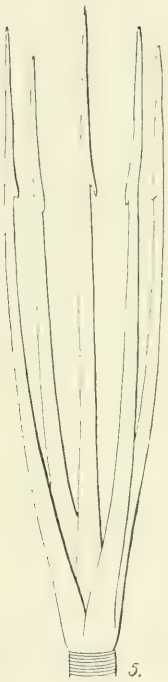
Fig. 1.—Boats with spears and bamboo frames to be let down over fish in the water.

,, 2.—A single boatman spearing fish and rowing at the same time. Note the plank hanging into the water from the hind part of the boat to keep it steady while the boatman is otherwise engaged.

,, 3.—Stirring up the mud at the bottom of the lake with bamboo poles as a preliminary to fish-spearing.

,, 4.—Prongs of eel-spear, actual size.

,, 5.—Prongs of ordinary fish-spear, $\times \frac{4}{7}$.



5.

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F. H. Gravely photo.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1918.

## EXPLANATION OF PLATE VII.

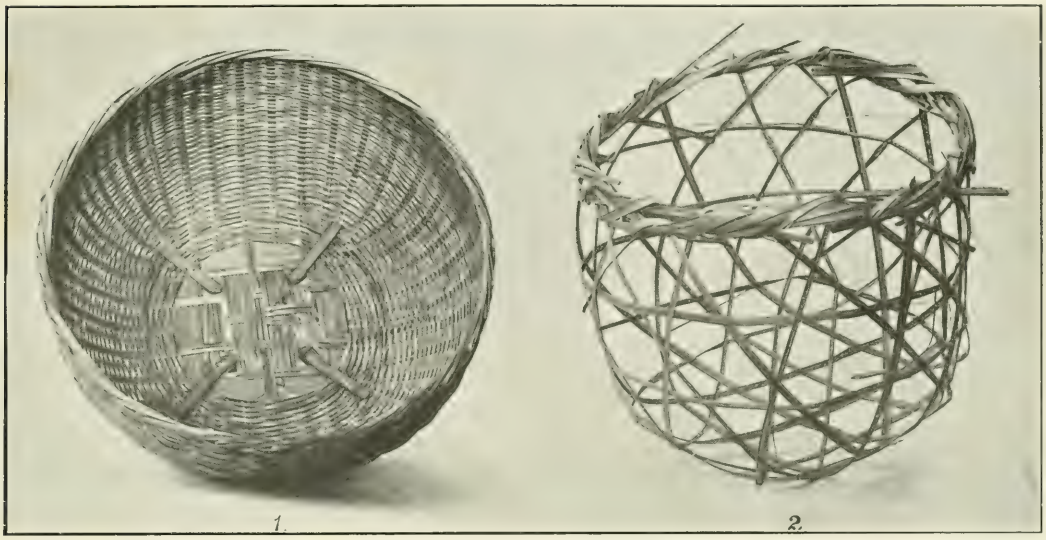
### Intha fish-traps and baskets.

Fig. 1.—Shallow bamboo basket used in catching small fish and prawns among floating plants at the edge of the Inlé Lake and elsewhere in the district, $\times \frac{1}{8}$.

,, 2.—Rough bamboo basket filled with peat, weeds and stones and sunk in the central part of the lake to catch various kinds of fish, $\times \frac{1}{8}$.

,, 3.—Trap for *Barbus stedmanensis*. The two halves can be separated to take out the fish, $\times \frac{1}{6}$.

,, 4.—Trap with two compartments to catch *Ophiocephalus striatus*, $\times \frac{1}{8}$.



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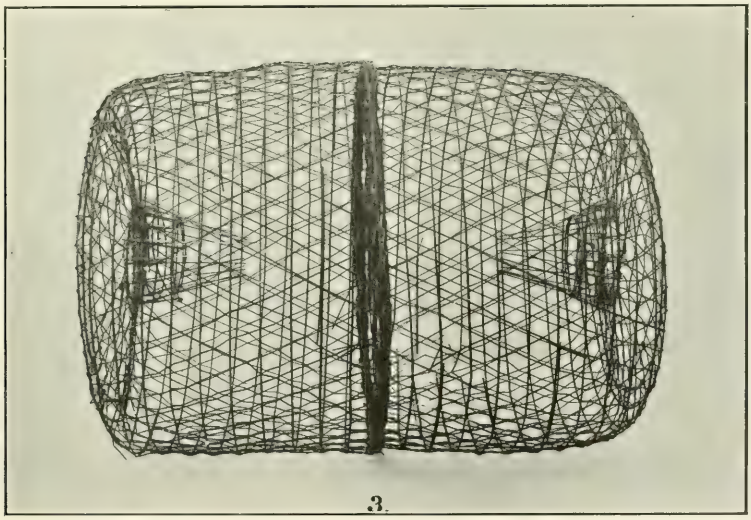

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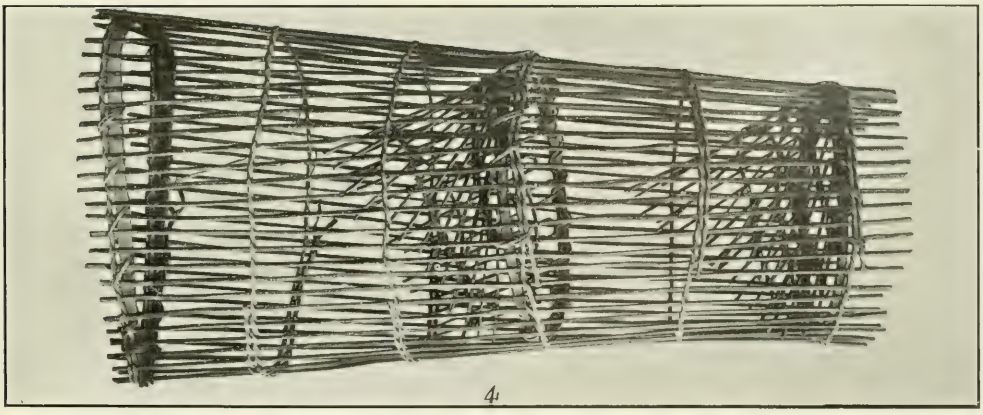

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S. C. Mondul, photo.

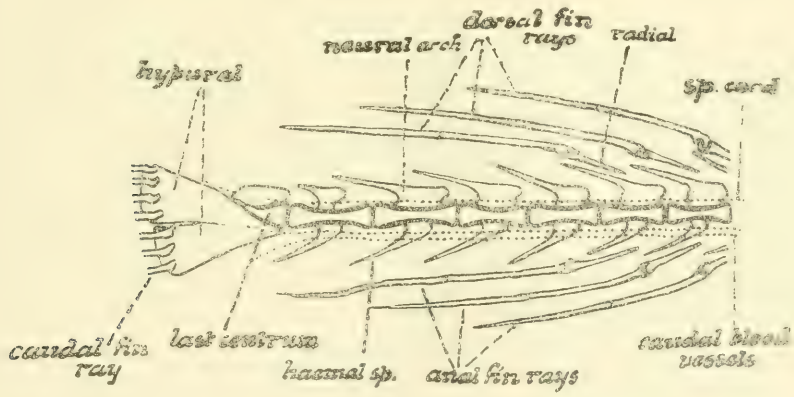
Photo-engraved & printed at the Offices of the Survey of India, Calcutta, 1918

# THE CAUDAL FIN OF THE EEL *CHAUDHURIA*.

(With text-figure.)

*By* R. H. Whitehouse, *M.Sc., Professor of Zoology, Government College, Lahore.*

A special interest attaches to the caudal fin of this peculiar eel [1] since it is discontinuous ; in all other known eels the caudal fin is continuous with the dorsal and anal fins, in which the fin-rays are supported by radials or interspinous bones alternating with the neural and hæmal spines. In *Chaudhuria*, the last fin-rays of the dorsal and anal fins are attached to radials situated between the sixth and seventh vertebral arches counted from the posterior end ; there is thus a considerable space devoid of fin-rays separating the dorsal and anal from the caudal fin. However the fin fold is practically continuous and the last dermotrichia of the dorsal and anal fins reach backward as far as the last centrum.




The neural and hæmal arches of the terminal centra are typical of the Apodes, the neural arch having an extended base with a long backwardly directed spine. The penultimate centrum has a somewhat reduced neural arch ; this is a feature common not only to the eels but to the majority of the Teleostean fishes, and is probably due to suppression consequent on the upturning of the extremity during the heterocercal stage. As regards the spine of this neural arch, I cannot say with certainty whether it is present or not ; the anterior dorsal edge is certainly truncated, which suggests the absence of the spine ; at the same time, there *appears* to be a very small spine attached to this angle of the arch, but determination by dissection of such a small structure is almost impossible ; the point however is of minor importance. The neural arch of the last centrum is typically elongated, extending some

[1] The genus and its only known species (*C. caudata*) are described by Annandale on pp. 27-28 of this volume.

short distance along the upper edge of the hypural bone, and is devoid of a spine.

Two large hypural bones are present, fused at their bases and firmly attached to, or even fused with, the last centrum ; the last (*i.e.*, the upper) hypural is the larger and bears four jointed fin-rays, while the ventral hypural bears three. None of the fin-rays bifurcate, but extend as simple rays to the edge of the fin fold.

The courses of the spinal cord and the caudal blood vessels are indicated in the figure by dotted lines.

It will be seen that this caudal fin is a wholly ventral structure, since all the supports are ventral to the spinal cord. In the majority of Teleosts, a few dorsal elements enter into the caudal fin, but in *Chaudhuria* all such elements have been eliminated ; this is a definitely specialized character. The separate caudal fin itself also suggests a specialization above the average eel, and it is probable that the tail is a more definitely propulsive organ than in other Apodes where progression is by a wriggling motion after the fashion of the primitive fishes.

# CHELONIA AND BATRACHIA OF THE INLE LAKE.

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

With Plate XX.

## CHELONIA.

The fishermen of the Inlé Lake recognize two species of Chelonia; to one they give the name *Leik Pu*, to the other *Leik Kambar*. The latter is evidently a species of *Trionyx*; it is said to be round and flat, to have no scales on its back, to grow to a large size and to have round black spots on its back when young. It may be *Trionyx phayrei*, which seems to be found at higher altitudes than any other species in Burma, but we did not see a specimen. The *Leik Pu* is a local race of the widely distributed terrapin *Cyclemys dhor* (Gray). I describe it here as :—

### **Cyclemys dhor shanensis,** subsp. nov.

The shell of both sexes is somewhat elongate, but that of the female is relatively broader than that of the male. The shields are also broader, specially those of the dorsal row. The dorsal surface of the male shell is flattened, while that of the female is convex. The whole of the margin of the carapace is a little retroverted; in front of and behind the bridge of the plastron it is distinctly concave above. The growth-lines are strongly developed on the shields. In a young adult female the suture running across the outer part of the abdominal shield and representing the plastral hinge is almost obliterated, being represented merely by a faint superficial groove[1]; but the suture between this shield and the pectoral is strongly marked. In a slightly older male the suture between the shields is very nearly straight and practically all external trace of the hinge has disappeared. The whole of the shell is very dark brown or black with fine radiating yellowish lines on each shield. These lines tend to disappear with age. The head and neck are greenish black and are uniformally marbled with dull olivaceous. The limbs and tail are blackish. The skull resembles that of the typical form but the snout is perhaps a little broader and blunter.

*Measurements of shells with callipers (in millimetres).*

| | Male. | Female. |
|---|---|---|
| Total length ... ... ... ... | 225 | 184 |
| Breadth ... ... ... ... | 138 | 137 |
| Depth ... ... ... ... ... | 78 | 72 |
| Length of plastron ... ... ... | 198 | 174 |
| Length of bridge ... ... ... ... | 70 | 65 |

[1] This groove shows more clearly in the photograph (plate xx, fig. 2*a*) than it does on the actual specimen.

*Type-specimens.*—Male No. 18594 ; female No. 18593, *Zoological Survey of India (Ind. Mus.).*

The male type is from Fort Stedman on the Inlé Lake, altitude 3,000 feet ; the female from a small stream from the He-Ho plain 800 feet higher.

This tortoise is largely aquatic in habits, sitting at the edge of canals and other bodies of water and diving to the bottom when disturbed.

I have examined a large series of adults of the typical form of *Cyclemys dhor* from different parts of Burma and from the Khasi and Garo Hills in Assam. In none of them is the hinge of the plastron obliterated in the way in which it is in the Shan specimens, although some of the shells are evidently those of aged individuals in which the growth-lines on the shields have been entirely worn away. In an old living specimen from the Garo Hills recently examined, the hinge, though still represented on the shields by an open suture, was quite immovable. The typical form shows the same sexual difference in shape of shell, but its colour seems to be invariably paler than in the Shan form.

## BATRACHIA.

The season of our visit was a very bad one so far as the collection of Batrachia was concerned. The frogs and toads of the Shan Plateau undergo a longer period of hibernation than the mildness of the climate would seem to justify were it not that most of them are tropical species. They were only beginning to arouse themselves from their winter sleep in March and as a matter of fact we did not see a single adult batrachian in the Inlé basin. Several tadpoles were, however, found in small hill-streams running into the lake and we obtained specimens of one frog, a common and widely distributed form, both at He-Ho and some four hundred feet higher at Thamakan.

### **Rana kuhlii,** D. and B.

1917. *Rana kuhlii*, Smith, *Journ. Nat. Hist. Soc. Siam* II, p. 262, pl.—, figs. 1, 1*a*, 1*b* (larva).

Tadpoles of this species were abundant in streams at Hsing-Dawng and near Fort Stedman. I have identified them by comparison with specimens sent me from Siam by Dr. Malcolm Smith, who has just described the larva in the *Journal of the Natural History Society of Siam.* It is clear from his investigations that the tadpole[1] I assigned provisionally to this frog recently was incorrectly identified.

The species is widely distributed in southern Asia east of the Bay of Bengal.

### **Rana limnocharis,** Wiegm.

Frogs from the Shan States belong to the typical form of the species but are rather small ; I saw none more than 45 mm. in length from snout to vent. The specimens we found at Thamakan were in a well and seemed to be in a half torpid condition. I believe that I heard frogs

[1] Annandale, *Mem. As. Soc. Bengal* VI, p. 147 (1917).

of the species croaking in the swamp at the north end of the Inlé Lake at the beginning of March.

### **Bufo melanostictus,** Schneid.

Dr. Gravely collected a number of tadpoles in the old valley of the Kawlaw river east of Ngot at an altitude of about 3,500 feet. They are all young and had probably spent the winter in a larval state.

### **Megalophrys montana,** Kuhl.

We obtained in a small stream above Fort Stedman a tadpole of the genus *Megalophrys* that agrees precisely with those from Penang[1] and differs in the same characters from those of the Himalayan species.

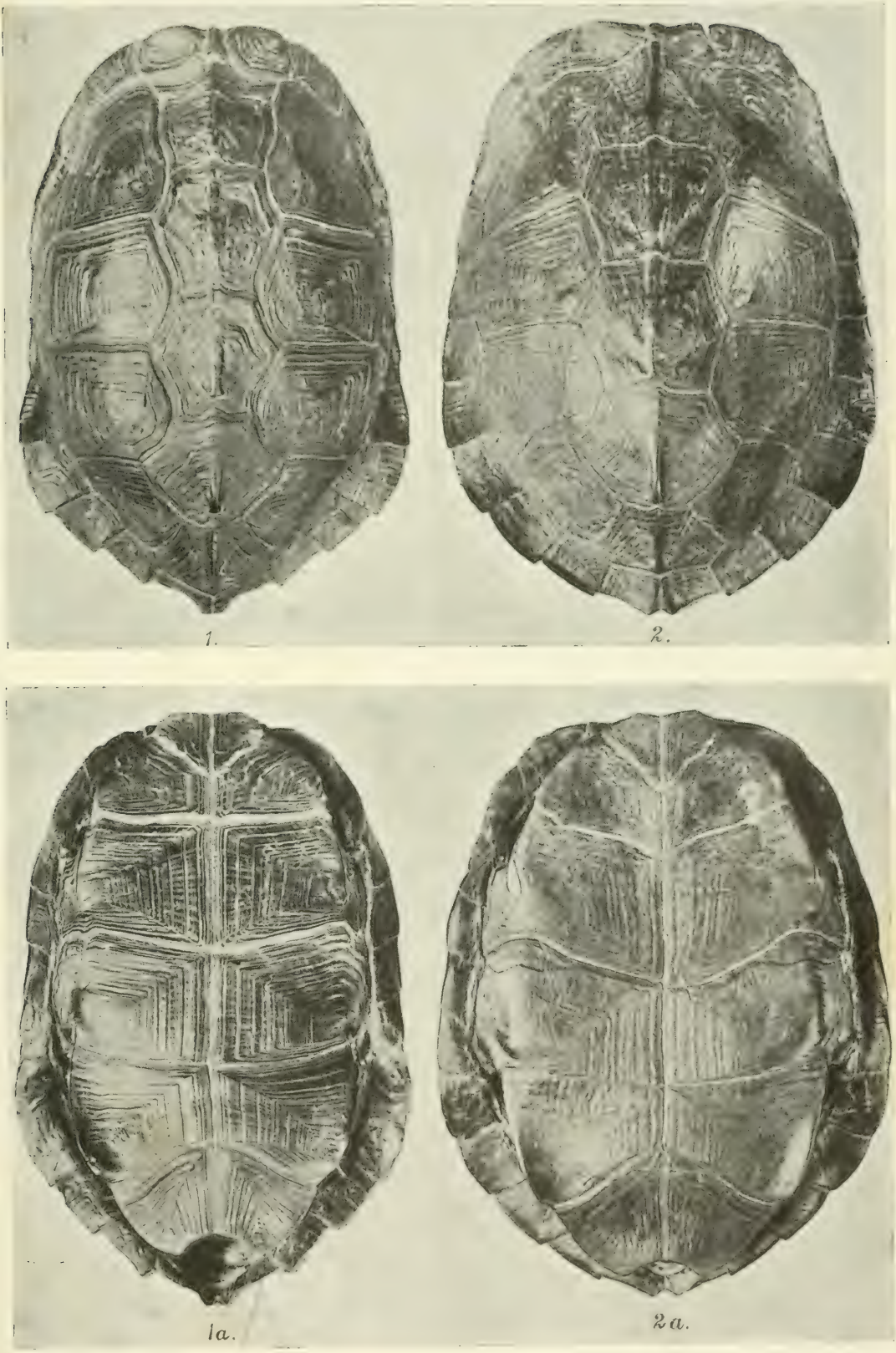
*M. montana* is widely distributed in the Malay Peninsula and Archipelago and Smith [2] states that it is found on most of the hill ranges throughout Siam, but it has not been recorded hitherto from Burma.

[1] *Id., ibid.*, p. 154, pl. vi, fig. 10.
[2] *Journ. Nat. Hist. Soc., Siam*, II, p. 231 (1917).

## EXPLANATION OF PLATE XX.

FIGS. 1, 1*a*.—Shell of male type of *Cyclemys dhor shanensis*, subsp. nov.

FIGS. 2. 2*a*.—Shell of female type of *Cyclemys dhor shanensis*, subsp. nov.




S. C. Mondul, Photo.

CYCLEMYS DHOR SHANENSIS.

Photo-engraved & printed at the Offices of the Survey of India, Calcutta, 1918.

# THE ANATOMY OF A CHIRONOMID LARVA OF THE GENUS *POLYPEDILUM*.

*By* Baini Prashad, *M.Sc., Superintendent of Fisheries, Bengal Fisheries Laboratory, Indian Museum, Calcutta.*

(Plate XXIII).

There has been an unfortunate confusion as to the generic name of the larva here described. The adult fly reared from a similar larva was originally named by Kieffer *Chironomus fasciatipennis* (4), and is referred to under this name by Annandale (2), and also by Gravely (3). Kieffer in a later paper (5) assigned the species to the genus *Polypedilum* Keiff., and it must therefore be known as *Polypedilum fasciatipennis* (Kieff.). It is impossible to be certain with our present knowledge of the Chironomid larvæ whether the form that I am about to discuss is specifically identical with the one from Calcutta, but no difference has been discovered either in structure or in habits, and there is no doubt of the generic identity.

The specimens on which I have based my observations were taken in the Inlé Lake, Southern Shan States, by Dr. N. Annandale and Dr. F. H. Gravely in February 1917. They were living among dense masses of weed (*Ceratophyllum*) in clear water. The habits of the Calcutta form as described by Annandale (1, 2) are as follows :—" In the early stages of its larval life this insect wanders free among communities of protozoa (*Vorticella, Epistylis*, etc.) and rotifers on which it feeds, but as maturity approaches begins to build for itself a temporary shelter of one of two kinds, either a delicate silken tunnel the bottom of which is formed by some smooth natural surface, or a regular tube . . . . The tubuler shelters occasionally found are very much stouter structures than the tunnels, but are apparently made fundamentally of the same materials ; and structures intermediate between them and the tunnels are sometimes produced. The larva as a rule fastens to them branches detached from living colonies of Vorticellid protozoa such as *Epistylis*." In the Inlé form the tube[1] is made of a silky material and is closed at both ends, the larva however can come out of it at any point as the whole structure forms a loose net work. The tube is covered by a thick growth of a protozoan which has been identified as *Epistylis flavicans* by Dr. Ekendranath Ghosh.

The larvæ in their cases on being taken from the lake were put into a bowl of water, and it was observed that they began to devour the *Epistylis*. The protozoa on this broke off from their stalks and swam away. A small caddis-fly, of which vast swarms arose from the lake every evening at the period at which the larvæ were collected, dropped its eggs into the bowl in which the larvæ were living. These eggs were

[1] An enlarged photograph of the tube with its covering of protozoa is reproduced by Dr. Annandale on pl. XXI of this volume.

enclosed in a globule of jelly about the size of a small shot. The globule adhered to the case of a larvæ, which tried to eat them, but was prevented by the jelly from doing so.

The larva preserved in spirit is of a creamy colour when taken out of its tube ; when alive it was semi-transparent without any tinge of red. It is 6·5 mm. in length, and like the ordinary Chironomid larvæ is worm-like in appearance. It differs from the common blood-worms in having no ventral blood-gills on the eleventh segment, and in that the blood lacks red pigment. In one specimen, which was ready for pupation when preserved, the nymphal characters are well developed and can be easily seen in a Canada balsam preparation. It shows that in the nymph, instead of the two groups of respiratory filaments on the pro-thorax, two nymphal trumpets are developed for respiration. The larva is thus of Meinert's *Motitor* group of Chironomus larvæ (6), but differs from other described larvæ of this group in having a small head, and in that the brain lies in the pro thorax instead of the head.

In the body of a young larva the head and the twelve segments of the thorax and abdomen can be easily distinguished (fig. 1). In advanced larvæ, however, fusion takes place in the thoracic region and the segments are not easy to distinguish.

*Head.*—The head is a very small structure with a chitinous covering much thicker than that of the rest of the body. It is of a yellowish colour. In front of the antennæ it is much narrower than behind. The dorsal surface is very convex, descending rapidly to the nearly straight posterior surface, gradually at the outwardly bulging sides, and with a very steep forward slope on the anterior surface (fig. 3). The ventral surface is nearly flat. The dorso-lateral sides of the head are formed by three chitinous pieces, *viz.*, a median process (the clypeus), and two lateral plates. The lateral plates are designated the epicranial plates by Miall and Hammond (7). This, however, is an inappropriate name when applied to the head of this larva, because in it the brain does not lie in the head, and so this part of the head is not the cranium in a strict sense. The lateral plates besides forming the sides also form a little of the dorsal surface, and are continued ventrally to meet each other in the middle line, where a faint suture can be distinguished (fig. 4). From the anterior margin of the pre-antennal portion of the head a shelf-like fold hangs forwards. Its dorsal surface is convex and highly chitinized. The ventral surface slopes sharply inwards and slightly upwards towards the entrance to the buccal cavity. The ventral surface of this pre-antennal shelf is termed the *labrum* (*la*) by Miall and Hammond. It overhangs the mouth-parts, is mobile and can be bent backwards and inwards. On the dorsal surface the shelf bears two setæ, one on either side, while on the ventral surface (*i.e.*, the labrum) there are two simple setæ in the middle line, and two groups of thick setæ ; besides these the chitin on this surface is thickened along two crescentic lines on the sides and a central triangular area. The margins of this triangular area are raised into tooth-like processes.

Ventrally the pre-antennal portion of the head is marked off from the post-antennal by a narrow linear band of thickened chitin arising from

the sides of the labium. Immediately in front of the labium lies the opening of the buccal cavity. Ventrally in the post-antennal region the chitin is thickened to form the *labium* (*lb*) or the lower lip in the middle and two striated flaps (*f*) on its two sides. The flaps bear a large number of setæ, and are brush-like structures which help in closing the mouth opening on the sides.

On the lateral sides of the head two pairs of pigment spots or simple eyes (*e*) are present. The antennæ (*an*) lie in front of the eyes. Each antenna consists of a large basal joint arising out of a cup-shaped depression on the head. No sensory spot can be distinguished on the basal joint of the antennæ. To this basal joint two ramii are attached, the outer one is five-jointed and the inner is a long unjointed hair-like structure.

The mouth-parts consist of a pair of large *mandibles* (*md.*) and two pairs of *maxillae*. The mandibles (fig. 5) are large heavily chitinized structures without any setæ. They are attached by a broad base and have a curved pointed tip ; their inner cutting margin bears a number of teeth. The first pair of maxillæ (*mx.* fig. 6) are two-jointed structures, one on each side of the buccal opening and arising near the base of the mandibles (fig. 4) ; the upper joint is small and setose. The second pair of maxillæ are fused to form the *labium* (*lb.* fig. 4) which forms the lower margin of the funnel shaped buccal cavity. The labium has a toothed anterior margin with the teeth pointing forwards. Above it lies another thin plate. Miall and Hammond call the upper the *mentum* and the lower the *submentum*.

*Thorax.*—In a young larva the first three segments following the head are the pro-, meso-, and metathoracic (*t* 1, *t* 2, *t* 3, fig. 1). These three segments are quite distinct, but in a fully grown adult larva the line separating the mesothoracic from the metathoracic segment is not seen, the two forming a single structure. The notch separating the prothoracic from the mesothoracic segment, however, persists (fig. 2).

The prothoracic segment has a pair of club-shaped feet (*t. f.*) armed with two types of hooks. Both types of hooks are simple without serrations or teeth. One type (fig. 7) is curved like a scythe, whilst the other (fig. 7*a.*) is nearly straight. The curved hooks are arranged on the margins of the knob at the end of the foot, and the straight ones are in the centre. Both types of hooks, especially the curved ones, are of use to the animal in collecting and planting the colonies of *Epistylis* on its tube. The other two thoracic segments do not have any appendages.

*Abdomen.*—The abdomen is formed of nine segments (1-9, fig. 1), all of which are alike except the last one, which bears appendages and other outgrowths. It has a pair of large anal feet (*a.f.* fig. 1) ; these like the thoracic feet bear hooks. The hooks are arranged in concentric circles. The outermost ones have a very broad base and a much bent upper surface (fig. 8*c*), in the inner ones the curve is not so marked (figs. 8*a*, *b*), whilst the centre ones have a much less curved upper portion (fig. 8). Besides the anal feet described above, this segment bears two bunches of five setæ each (fig. 1), arising from conical papillæ on the dorsal

side ; these anchor the larva to the tube. Near the anus two pairs of blood-gills are also present (*b.g.*, fig. 1) ; from the base of each of the upper pair of gills a stout seta is also seen to arise.

*Internal Anatomy.*—No attempt is made to describe the internal anatomy in detail, which would be impossible with the very limited material available ; a few differences, from the form described in detail by Miall and Hammond are, however, noted.

The supra-oesophageal and the sub-oesophageal nerve ganglia lie in the prothoracic segment and not in the head, which as noted above is very small. The rest of the nervous system is essentially the same.

In the alimentary canal the cardiac portion of the stomach (*ca.* fig. 9) and the dilated chamber at the beginning of the small intestine (*ch.*) are poorly developed. The salivary glands (*s. g.*) also lie much more anteriorly, the ducts being relatively small.

The tracheal system has two well developed longitudinal tracheæ one on either side.

In conclusion I have to express my sincere thanks to Dr. N. Annandale for the material and kind help ungrudgingly given at all times. I am also deeply indebted to Mr. T. Southwell, A.R.C.S., F.Z.S., Director of Fisheries, Bengal, and Bihar and Orissa, for permission to undertake and publish this work.

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7. Miall, L. C. and Hammond, A. R.—" *The structure and life-history of the Harlequin fly* (*Chironomus*). Oxford, 1900.

## EXPLANATION OF PLATE XXIII.

FIG. 1.—Side view of young larva showing the nervous system as seen in a Canada balsam preparation.

FIG. 2.—Head and thoracic region of a full grown larva showing the nymphal trumpets, the imaginal wings, the halteres and the three pairs of legs.

FIG. 3.—Side view of the head.

FIG. 4.—Ventral view of the head.

FIG. 5.—Left mandible seen from below.

FIG. 6.—Right first maxilla seen from the ventral surface.

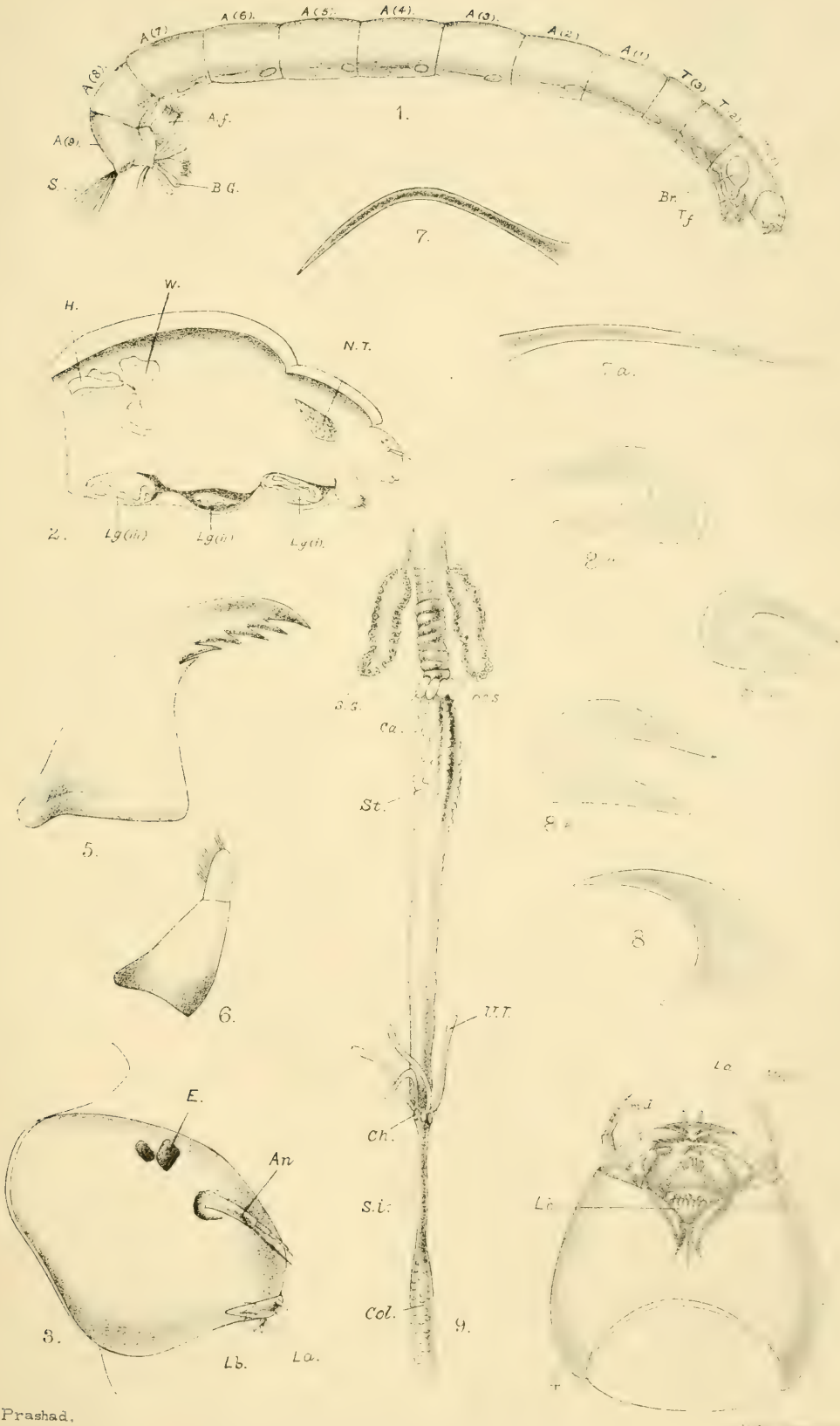
FIGS. 7, 7*a*.—Types of hooks found on thoracic feet.

FIGS. 8, 8*a*, 8*b*, 8*c*.—Types of hooks found on the abdominal feet.

FIG. 9.—Alimentary System of the larva.

## REFERENCES TO LETTERING.

*A* (*1*)—*A* (*9*). Abdominal segments. *A. f.* Abdominal feet. *An.* Antennæ. *B. G.* Blood gills. *Br.* Supra-œsophageal nerve ganglion (brain). *Ca.* Cardiac portion of the stomach. *Ch.* Chamber at the beginning of the small intestine. *Col.* Colon. *E.* Eye. *F.* Flaps on the sides of the labium. *H.* Haltere. *La.* Labrum. *Lb.* Labium. *lg.* (i), *lg.* (ii), *lg.* (iii). Thoracic legs. *Md.* Mandibles. *mx.* (*i*). First maxilla. *N.T.* Nymphall respiratory trumpets. *œs.* Oesophagus. *S.* Setæ. *S.G.* Salivary gland. *S. i.* Small intestine. *St.* Stomach. *T* (*1*)—*T* (*3*) i—iii thoracic segments. *T. f.* Thoracic feet. *U. T.* Urinary or malpighian tubules. *W.* Wings.




B. Prashad.
& D. Bagchi del.

ANATOMY OF A CHIRONOMID LARVA.

# SPONGES, HYDROZOA AND POLYZOA OF THE INLE LAKE.

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

With Plate XXI.

The Porifera, Hydrozoa and Polyzoa of the Inlé Lake belong without exception to species also found in India proper and only in one instance, that of the cosmopolitan *Ephydatia fluviatilis*, can differences be found even sufficiently great for varietal separation. The most remarkable feature of the fauna so far as these groups are concerned lies in its deficiencies, above all in the apparently complete absence of Phylactolaematous Polyzoa. The three groups, therefore, cast no light on the origin of the fauna and are of less interest than was perhaps anticipated.

## PORIFERA.

Only three species of sponges, all of them cosmopolitan as species, are represented in our collection. They are *Spongilla lacustris*, *Spongilla fragilis* and *Ephydatia fluviatilis*, perhaps the three commonest species in the Holarctic Zone. The first two, however, occur as varieties only known from the Oriental Region, while the last differs somewhat both from the *forma typica* and from the Indian race *himalayensis*. I have, therefore, recognized it as a new variety under the name *intha* (*i.e.*, literally, " son of the lake " in Burmese).

### **Spongilla lacustris** var. **proliferens,** Annandale.

1911. *Spongilla proliferens*, Annandale, *Faun. Brit. Ind., Freshw. Sponges, etc.*, p. 72, fig. 9.
1915. *Spongilla lacustris* var. *proliferens*, *id.*, *Mem. Ind. Mus.* V, p. 28.

This sponge was found in abundance in February and March in a pond a few miles east of the town of Yawnghwe. Specimens were also taken near the western shore of the Inlé Lake and in rice-fields west of that shore. They agree with specimens from Calcutta and have the characteristic buds well developed. Gemmules were also present in most specimens.

This form of the cosmopolitan *Spongilla lacustris* has been found at many places in the Indo-Gangetic Plain, Peninsular India and Burma.

### **Spongilla fragilis** var. **calcuttana,** Annandale.

(Plate XXI, fig. 1).

1911. Annandale, *op. cit.*, p. 96, fig. 15.

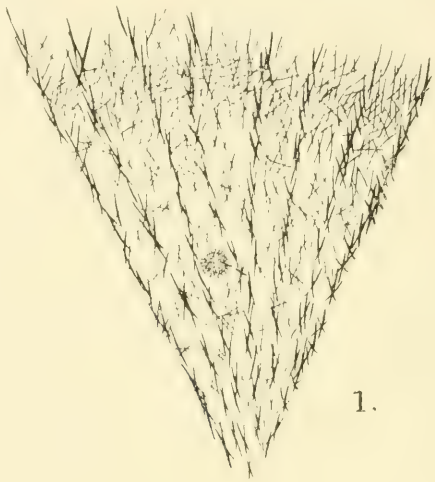
Dried specimens of this sponge were found coating the house-posts of the monastery guest-house at Thalé-u on the eastern side of the lake.

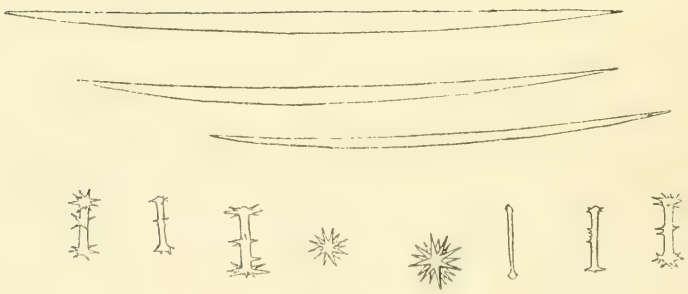
They covered the wood for some inches above the water-level of the time (the end of February) in a uniform layer 3·5 to 4 mm. thick. The variety has been found hitherto only in the Museum tank in Calcutta.

**Ephydatia fluviatilis** var. **intha,** var. nov.

(Plate XXI, figs. 2, 3).

The sponge forms spherical or irregular masses not more than 5 cm. in diameter attached to lax water-plants such as *Ceratophyllum*, and occasionally flat, somewhat mound-shaped growths on bamboo posts. In each mass there is as a rule a single large circular depression or a




*Ephydatia fluviatilis* var. *intha*, nov.

Fig. 1.—Part of a transverse section through a small sponge (×8), showing the regular and well defined radiating spicule-fibres and a single gemmule *in situ*.

Fig. 2.—Spicules, ×250. Several young gemmule-spicules not yet fully developed are shown as well as fully developed spicules of the same order and skeleton-spicules.

group of such depressions into which several wide exhalent channels open. Smaller exhalent channels, however, open directly on the surface. The consistency of the sponges is always very soft, often quite unusually

so. The surface is fairly smooth but minutely hispid. The colour is usually bright green, but sometimes, without apparent cause, the chlorophyl bodies that produce this colour are absent and it is not uncommon for the upper half of a sponge to be green and the lower half yellowish white. Sponges on bamboo posts are brownish yellow.

The skeleton, as might be expected from the softness of the sponge, is very sparse and the number of spicules smaller than usual in the Spongillidae. Slender spicule-fibres can, however, be detected forming an open and fairly even network in the parenchyma. The radiating fibres are more clearly defined than the connecting fibres and can be traced from near the centre of the sponge to the surface. They bifurcate at fairly regular intervals. On the surface they support the epidermal membrane over a fairly extensive subdermal space and project through it as microscopic spines.

There are no "bubble-cells."

The skeleton-spicules are slender and sharply pointed. Though often a little irregular in outline, they never appear, even under the highest powers of the microscope, granular or spiny. Abnormal macroscleres of cruciform or bifid outline are not uncommon.

There are no free microscleres.

The gemmule-spicules are of the type normal in the species, with shafts considerably longer than a single rotule. They bear few but often very stout and long spines, which project at a right angle. These spines are often arranged in a circle round the middle of the shaft. The rotules are unevenly and deeply denticulate but well-developed and normal.

The gemmules are very small, spherical and of a bright yellow colour. Their pneumatic layer is relatively thin and they are surrounded by a single row of gemmule-spicules. The microphyle is crateriform viewed from outside but contains a small tubule that projects at right angles.

*Measurements* (*in millimetres*).

| | |
|---|---|
| Length of skeleton spicule ... ... ... | 0·238—0·357 |
| Diameter of skeleton spicule ... ... ... | 0·012 |
| Length of gemmule spicule ... ... ... | 0·028—0·032 |
| Diameter of rotule ... ... ... ... | 0·02 |
| Diameter of gemmule ... ... ... | 0·6 |

*Type-specimen.*—No. P. 30/1, Zoological Survey of India (*Indian Museum*).

The most noteworthy features of this variety are the extreme softness of the sponge, which often collapses in drying into a mere slimy layer, and the regularity of the arrangement of the radiating fibres of the skeleton. The first of these characters, though always well marked, is variable in degree. All the sponges from any one spot as a rule are similar in respect to it, but I was unable to correlate extreme softness with any factor in the environment.

The skeleton-spicules differ from those of the Himalayan form[1] of the species in that they are not at all granular or spiny.

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[1] *Ephydatia fluviatilis* subsp. *himalayensis*, Annandale, *Rec. Ind. Mus*, VII, p. 138, fig. 1 (1912). See also *Journ. As. Soc., Bengal*, XI, p. 445 (1915).

*Habitat.*—Intermediate zone of the Inlé Lake and canals of clear water in the neighbourhood.

Sponges were often extremely abundant among thickets of *Ceratophyllum* not far removed from the edge of the lake. None were, however, found in similar thickets in the central region. They appeared to have become more abundant at the beginning of March than they were in February and to have grown considerably in size.

The canals of this sponge shelter quite a little fauna of annelids and insects. No less than three species of the genus *Chaetogaster* (Oligochaeta)[1] were found in them, namely *Ch. bengalensis*, Annandale, *Ch. annandalei*, Stephenson, and ? *Ch. limnaei*, Baer, the identity of the last, a common European species, being a little doubtful. All the insects found in the canals were in a larval state. They included at least two species of Chironomidae (Diptera) a *Sisyra* (Neuroptera) and a Trichopteron. The last lived free without constructing a case to protect itself. The worms were living in young and flourishing sponges, as was the case with the type-specimens of *Ch. annandalei*[2] in Japan. The original examples of *Ch. bengalensis*[3] were, on the other hand, attached to the bodies of molluscs of the genus *Limnaea*, on which also *Ch. limnaei*[4] has been found both in Europe and in the Kumaon lakes in the Himalayas.

## HYDROZOA.

The only Hydrozoon found in the Inlé Lake was *Hydra vulgaris*, Pallas. Numerous specimens were collected from a bamboo house-post in the intermediate zone near Fort Stedman. The post were overgrown with sponges and Polyzoa. The specimens of *Hydra* were moderately small and of a yellowish brown colour. They had five tentacles and not more than two buds. None were sexually mature.

## POLYZOA.

The only specimens of Polyzoa of which I was able to find any trace belonged to the Ctenostomatous genus *Hislopia*. The weed-thickets so characteristic of the central region and the intermediate zone seemed to provide ideal quarters for *Fredericella* and certain species of *Plumatella*, but a very careful and prolonged search at a number of places failed to reveal even a single statoblast.

### **Hislopia lacustris,** Carter.

(Plate XXI, fig. 4).

1858. *Hislopia lacustris*, Carter, *Ann. Mag. Nat. Hist.*, III, p. 170, pl. vii, figs. 1—3.
1911. *Hislopia lacustris*, Annandale, *Faun. Brit. Ind.*, *Freshw.-Sponges, etc.*, p. 202.
1917. *Hislopia lacustris, id.*, *Mem. As. Soc., Bengal,* VI, pt. 1, p. 34.

*Hislopia lacustris* occurs in very great abundance in all parts of the Inlé Lake except in foul water in the marginal zone. It grows in uniform

[1] Stephenson, *Rec. Ind. Mus.*, XIV, pp. 9—11 (1918).
[2] Stephenson, *Mem. As. Soc., Bengal*, VI, p. 88 (1917).
[3] Annandale, *Journ. As. Soc., Bengal* (n. s.) I, p. 117 (1905).
[4] Michaelson, *Mem. Ind. Mus.*, I, p. 113 (1909).

layers of great extent over house-posts and fishing-poles. I figure a young colony just starting to spread over a bamboo. In this condition the zooecia are regular in shape and uniform in size, but as the colony becomes congested many of them are distorted or dwarfed. This is the case to a still greater extent on the shells of Gastropod molluscs (*Hydrobioides nassa*, *H. physcus*, *Taia intha*, *T. elitoralis* and *T. shanensis*), a considerable proportion of which are completely covered by its growth. The four spines at the corner of the aperture are usually well developed and the aperture more or less quadrate. In this respect the colonies from the Inlé Lake are more like those of the specimens figured by Carter in his original description than any I have seen elsewhere.

The species has probably a wide range in northern India and Burma.

### **Hislopia malayensis,** Annandale.

1917. *Hislopia malayensis*, Annandale, *op. cit.*, p. 35, pl. i, fig. 9; pl. ii, figs. 1, 1*a*.

A single colony of this species, easily recognized by its fan-shaped buds, was found on the stem of a reed in the intermediate zone of the lake near Fort Stedman. I have recently found it growing in abundance on the lower surface of bricks and tiles at the edge of the river Hughli near Calcutta. It was originally described from a small lake at Jalor in the Siamese Malay States.

## EXPLANATION OF PLATE XXI.

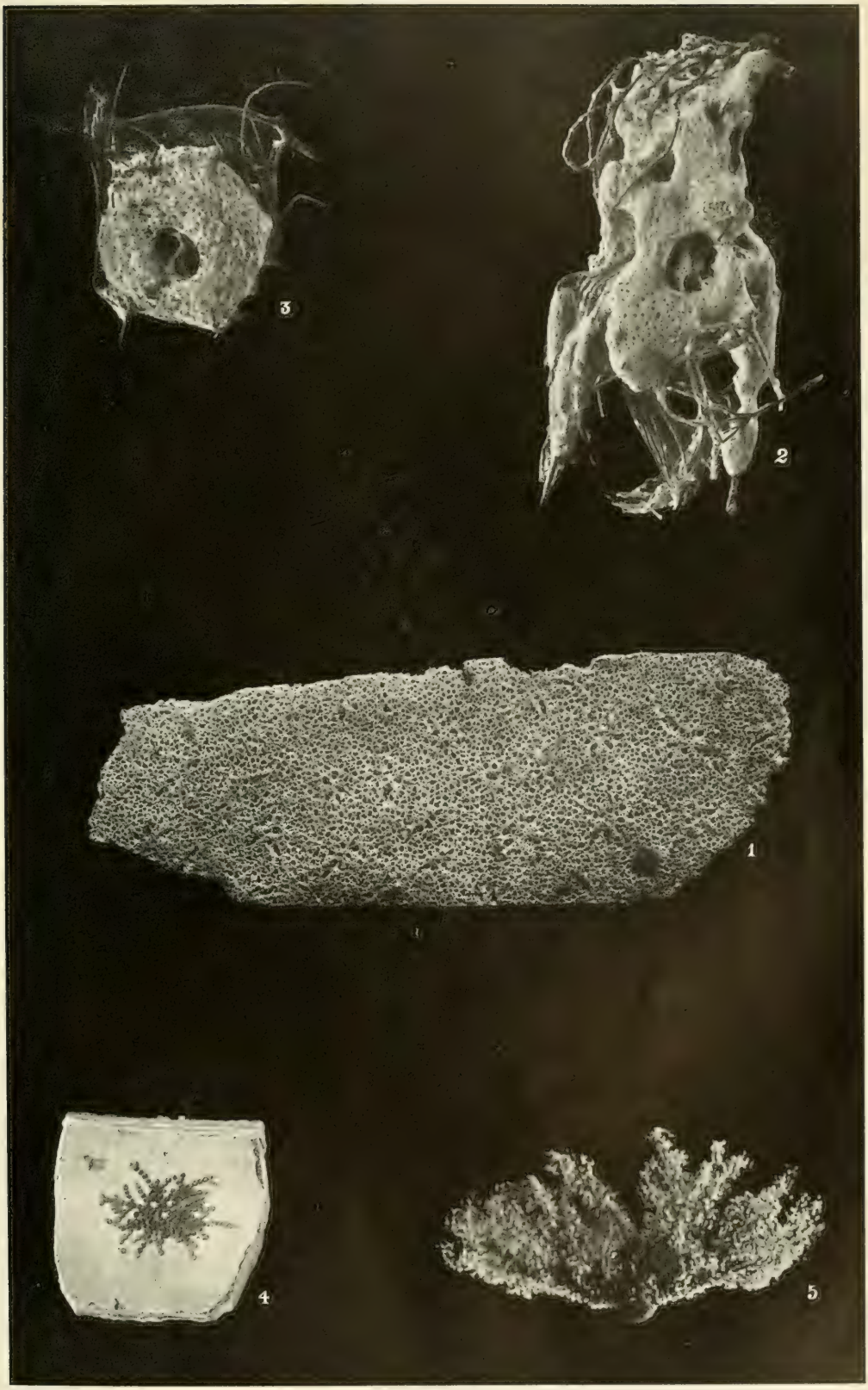
FIG. 1.—*Spongilla fragilis* var. *calcuttana*, Annandale. Dried specimen from the Inlé Lake. × 1.

FIGS. 2, 3.—*Ephydatia fluviatilis* var. *intha*, var. nov. Specimens preserved in alcohol. × 1.

FIG. 4.—*Hislopia lacustris*, Carter. A young colony on the inner surface of a bamboo house-post. From a specimen preserved in alcohol. × 1.

FIG. 5.—Protective case of the larva of a *Polypedilum* (Chironomid Diptera) covered with the Protozoan *Epistylis flavicans*, Ehr. From a specimen from the Inlé Lake fixed in hot formalin. × 10.

The case of the Dipterous larva is figured to show its resemblance to certain species of Phylactolaematous Polyzoa. When seen living it was mistaken for a colony of this group until a microscopic examination had been made. The larva is described by Mr. Baini Prashad in a separate paper included in this volume.




SPONGES, &c. OF THE INLE LAKE.

Photo-engraved & printed at the Offices of the Survey of India, Calcutta, 1918

# CRUSTACEA DECAPODA OF THE INLE LAKE BASIN.

*By* Stanley Kemp, *B.A., Superintendent, Zoological Survey of India.*

Plates XXIV, XXV.

The collection of Decapod Crustacea made by Dr. Annandale and Dr. F. H. Gravely in and near the Inlé Lake in the Southern Shan States comprises representatives of the following seven species :—

Potamonidae.

*Potamon* (*Potamon*) *browneanum*, sp. nov.
*Potamon* (*Potamon*) *acanthicum*, sp. nov.
*Potamon* (*Potamon*) *curtobates*, sp. nov.

Palaemonidae.

*Palaemon naso*, sp. nov.
*Palaemon hendersoni*, de Man.

Atyidae.

*Caridina annandalei*, sp. nov.
*Caridina weberi*, prox. var. *sumatrensis*, de Man.

That five of these species should prove to be undescribed is remarkable, and particularly that three of the new forms should be Potamonidae, for the Indian species of this family have been described by Alcock from a great abundance of material, including the late Dr. John Anderson's collection from Upper Burma.

The general results derived from an examination of the Decapod fauna of the district agree with those obtained in other groups, especially the Fishes and the Mollusca :—the fauna is in a large measure endemic and, in consideration of the past history of the region (see the introduction to this volume, p. 6), must be regarded as including a large proportion of peculiar species some of which once spread over a much greater area. Like other groups of aquatic animals the Decapods of the district appear for the most part to be specialized rather than primitive.

Of the two prawns hitherto known, *Palaemon hendersoni* has a range extending from the Darjiling district along the Eastern Himalayas to Burma ; it is also abundant in the hills of Assam, south of the Brahmaputra. The Burmese specimens differ slightly from those found in the Himalayan regions and in Assam and possibly represent a distinct race. De Man's *Caridina weberi*, described from Flores, Celebes and Saleyer is represented in the Shan States by a form similar in some respects to the var. *sumatrensis* from the east coast of Sumatra, but in all probability subspecifically distinct. Races of this species, some of which undoubtedly deserve nominal recognition, occur over the whole of the Indian Empire, but until it has been possible to make a detailed study

of material from many different localities, it seems best to postpone further consideration of the point.

The affinities of the undescribed species are with Burmese and Assamese forms. To this there is, however, one exception, *viz.*, *Palaemon naso*, a species which perhaps differs from the others in being primitive. The relationships of this prawn are by no means clear ; the unusually weak development of the second legs suggests alliance with such forms as *P. lamarrei*, Milne-Edwards, and *P. lanchesteri*, de Man, both of which are found in coastal districts.

*Caridina annandalei* seems to be the representative in the Salween watershed of a curious little group of species in which the number of epipods is diminished. The only other two species of this group at present known inhabit streams at the base of the Eastern Himalayas.

Of the Potamonidae *P. browneanum* is allied to *P. andersonianum* (Wood-Mason), a species of wide distribution in the mountains of Burma and Yunnan. *P. curtobates* is related to *P. pealianum* (Wood-Mason), hitherto known only from N. E. Assam and from the Kakhyen Hills on the frontiers of Burma and China.

*Potamon acanthicum* is a very remarkable form, quite unlike any other Burmese species. It appears, however, to be a highly specialized offshoot of the same stock as *P. andersonianum*. The species is interesting in its approximation to the subgenus *Acanthotelphusa*.

According to the observations made by Dr. Annandale Decapod Crustacea are of greater economic importance in the Shan States than in most inland parts of India. All the species mentioned in this paper are used as food. In the State of Yawngwhe, in which the Inlé Lake is situated, the Potamonidae are caught by the hill tribes and brought down into the village bazaars, in which *Palaemon naso* is sometimes also on sale. The former are sold roasted, the latter raw and often alive. The Atyidae, however, in spite of their small size, are of greater consequence, for very large quantities are collected both for local consumption and for export to other parts of Burma and even, it is said, to Siam. They are captured, chiefly as the water sinks in autumn, in small traps of basket-work and in flat baskets inserted under floating vegetation ; dried in the sun on bamboo mats and packed in large deep baskets, each of which is two men's load. They are carried by porters over the He-Ho pass to the railway and on pack mules inland to the Siamese frontier. One of the baskets used in their capture is figured on Plate vii, fig. 1 of this volume, while one of those in which they are stored and transported is shown in the photograph reproduced as fig. 3, pl. xliii, in vol. V of the Memoirs of the Asiatic Society of Bengal.

## Family POTAMONIDAE.

### **Potamon (Potamon) browneanum,** sp. nov.

Plate xxiv, figs. 1, 2.

This species is closely allied to *Potamon* (*P.*) *andersonianum* (Wood-Mason), but differs from it and from all its varieties in a number of well-marked features.

The length of the carapace is about four-fifths its greatest breadth, its outline in dorsal view being much the same as in *P. andersonianum*; it is, however, much deeper, the depth being almost or quite three-fifths of the length. The greater depth is, in the main, due to the fact that the upper surface between the epigastric crests and the posterior margin is decidedly convex, whereas it is quite flat in typical *P. andersonianum* and almost flat in the var. *rangoonense* of that species (pl. xxiv, figs. 1, 2).

The areolation of the upper surface is faint. The mesogastric areola is defined anteriorly by the bifurcation of the frontal groove and posteriorly by the cervical groove; its antero-lateral boundaries are altogether invisible. The cervical groove is deeply graven posteriorly and is distinct where it cuts the post-orbital crests, but between these two limits is very broad and shallow. Traces also exist of a groove (very distinct in *P. andersonianum*) on the epibranchial region, more or less parallel with the cervical groove. The greater part of the upper surface of the carapace is smooth, but in some specimens fine rugae are visible behind the epigastric and post-orbital crests. The epibranchial regions are strongly tuberculous, the tubercles being fewer, larger and sharper than in the related species. The side-walls bear oblique rugae which extend over the postero-lateral border and are visible from above.

The epigastric and post-orbital crests are similar to those of *P. andersonianum*; the former are obliquely truncate anteriorly and extend forwards in advance of a line joining the posterior borders of the orbits. The post-orbital crests are straight, undermined and irregularly crenulate.

The surface of the front is coarsely granular; its margin, like the upper border of the orbit, is crenulate and in dorsal view is very deeply

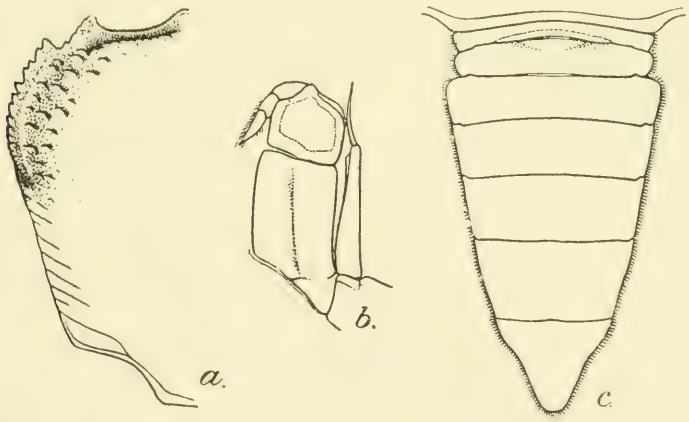



FIG. 1.—*Potamon* (*Potamon*) *browneanum*, sp. nov.
*a.* Outline of left side of carapace.
*b.* Third maxillipede.
*c.* Abdomen of male.

bilobed. This last character will at once distinguish it from *P. andersonianum* or any of its varieties. The external orbital tooth is sharp and is separated from the serrate lower border of the orbit by a deep notch.

The antero-lateral border (text-fig. 1*a*) is sharper and much more strongly reflected upwards than in *P. andersonianum*. It is separated from the coarsely granular epibranchial region by a deep smooth groove and its margin, instead of being serrulate, is spinulose. At the posterior end of the border the spinules are small and closely packed ; anteriorly they are larger and more widely spaced ; the foremost is a large epibranchial tooth which frequently bears one or more granules on its edges.

The antennular fossae and epistome are much as in the related form. The ischium of the outer maxillipedes (text-fig. 1*b*) bears the usual groove ; the merus is as long as broad and is rounded in outline, rather than irregularly hexagonal as in typical specimens of *P. andersonianum*.

The chelae are more or less of a size. The merus is similar to that of *P. andersonianum*, but the granulation is much crisper, the serrated margin being spinulose and the tooth near the distal end of the inner face becoming a sharp spine with accessory spinules at the base. The carpus is smoother above and is not, or not appreciably, umbilicate. On the upper surface of the palm there are some small and inconspicuous tubercles which extend a little way down the outer face ; the lower half of the outer surface is quite smooth. The fingers are more compressed than in the allied species and the teeth on their inner margins are much larger. The dactylus is grooved in the usual way and bears some sharp tubercles at the base of its upper surface.

The walking legs are rather more slender than in *P. andersonianum*, but the anterior margin of the propodus, as in hat species, is double-edged. The propodus of the penultimate leg is two and a half times, and that of the last leg twice as long as broad.

In the abdomen of the male (text-fig. 1*c*) the length of the sixth segment is rather more than half its greatest breadth ; the seventh is a little broader than long.

The carapace in six specimens yields the following measurements (in mm.).

| Sex | ♂ | ♂ | ♂ | ♂ | ♀ | ♀ |
|---|---|---|---|---|---|---|
| Length | 41·8 | 38·5 | 36·2 | 30·5 | 38·7 | 33·5 |
| Breadth | 52·3 | 49·3 | 46·5 | 38·2 | 49·2 | 45·0 |
| Depth | 25·3 | 23·5 | 21·0 | 17·7 | 22·0 | 18·0 |

The eggs borne by an ovigerous female are very large, about 3 mm. in diameter.

*Potamon browneanum* may be distinguished from *P. andersonianum* (i) by its more convex upper surface, (ii) by the incompletely circumscribed mesogastric areola, (iii) by the deeply bilobed front, (iv) by the granulation, which, except on the chelae, is everywhere crisper—particularly on the antero-lateral borders of the carapace, the lower borders of the orbits and the merus of the chelipedes, (v) by the smooth outer surface of the chelae and larger dactylar teeth and (vi) by the more slender propodus of the walking legs. From *P. pealianum* (Wood-Mason), which it resembles in the convexity of the upper surface of the carapace, *P. browneanum* is distinguished by the stronger curve and sharper spinulation of the antero-lateral borders, by the more deeply bilobed front and the much less conspicuous frontal eminences.

Dr. Annandale has given me the following notes on the colouration of living specimens of this species. "Dorsal surface dark olive; upper surface of walking legs marbled with a paler shade. Tips of fingers of large claw and of large spine on same appendages white. Frontal and orbital margins reddish brown. Ventral surface of body yellowish white."

The species, which is named after Mr. C. E. Browne, Political Adviser in the Yawnghwe State, is apparently not uncommon in the vicinity of the Inlé Lake, but was not found in the lake itself. The specimens are from the He-Ho stream, 3800 ft., from the Hsin Dawng stream, near Yawnghwe, 3300 ft., and from the neighbourhood of the Ngot bat cave, 4000 ft. They were found in February and March 1917, under stones at the edge of running water and in holes in the banks of small streams.

The type specimens are from the He-Ho stream and bear the number 9763/10, *Zool. Surv. Ind.*

### **Potamon (Potamon) acanthicum,** sp. nov.

Plate xxiv, figs. 3, 4.

The carapace is short and broad, the length being a little less than three-quarters the greatest depth. The distance in the middle line between the cervical groove and the posterior border is conspicuously less than the distance between the cervical groove and the epigastric crests. The upper surface is strongly convex in both directions, the depth being about half the greatest breadth (pl. xxiv, figs. 3, 4).

The areolation of the carapace is incomplete. The cervical groove is visible only in the posterior part of its course and at the point where it cuts the post-orbital crests; between these limits it is altogether indistinguishable in adults, though sometimes obscurely defined in young specimens. As in *P. browneanum* the antero-lateral boundaries of the mesogastric areola are wanting. In the middle line behind the cervical groove a pair of small lobules are distinguishable and behind these again are faint lateral grooves partially defining a cardiac areola. There is no trace of an epibranchial groove. The surface is for the most part free from any granulation, but is sparsely and coarsely pitted. As a rule a pair of large and shallow pits are conspicuous on either side, placed in a transverse line in front of the posterior portion of the cervical groove. Close to the antero-lateral margin in the vicinity of the epibranchial tooth there is a small number (usually not more than half a dozen) of rather large tubercles. On the side-walls of the carapace there are inconspicuous oblique rugae which pass over the postero-lateral margins and are usually visible from above.

The epigastric and post-orbital crests are well defined and together form a common curve; the former extend rather far forwards and would touch a line joining the posterior limits of the orbits. The edges of the crests are coarsely pitted and have a rugose appearance; they are not undermined. The cervical groove cuts the post-orbital crests at an exceptionally oblique angle. The fissures between the epigastric and post-orbital crests are deep.

The frontal and post-orbital regions are smooth, save for a large and deep pit on the latter behind the cornea of the eye. There are two low eminences on the front which do not conceal the margin when the carapace is viewed from above. The front, in a true dorsal view, is seen to be deeply and widely emarginate in the middle, with the outer angles a trifle produced ; it is thus very obscurely quadrilobate. The upper orbital border is smooth ; the outer orbital angle is large and rectangular and is separated from the obscurely crenulated lower border by a wide notch.

The antero-lateral border is strongly curved and very much shorter than the postero-lateral, and is characteristic in structure. In the posterior part of its course the border is defined as a ridge bearing serrations which gradually assume the form of spinules from behind forwards. In front of these serrations the margin is not defined as a crest, but its position is indicated by a variable number of very sharp isolated spines, the foremost being the largest. As a rule there are three of these spines, less commonly two or four (text-fig. 2*a*, *b*) ; they vary considerably in relative size and position and some of them occasionally bear a subsidiary denticle.

The median tooth on the lower edge of the epistome is rather narrower than usual. The surface of the epistome, together with a small portion of the carapace on the outer side of each efferent branchial opening, bears some coarse hairs. The ischium of the external maxillipedes is grooved as usual and the merus is rounded in outline and as long as broad (text-fig. 2*c*). On both ischium and merus there are some short hairs.

The chelae are unequal in both sexes. The two lower margins of the merus are tubercular and the customary tooth is present on the lower surface near the carpal articulation ; on the upper surface there are some transverse rugae. The carpus is very coarsely and irregularly pitted above and there is usually a distinct depression or umbilication near the chela. The inner margin of the upper surface, above the large carpal spine is defined anteriorly by a blunt ridge and posteriorly by a row of four to six tubercles. In old females [1] the larger chela is deep, little more than twice as long as broad in lateral view, the lower border is sinuous, being emarginate at the distal end of the palm, the fixed finger is strongly curved with its lower edge convex and the fingers gape very widely at the base (text-fig. 2*d*). In young examples of both sexes, and in the smaller chelae of large females, the length of the chela is more than two and a half times its breadth, the lower border is nearly straight and the fingers gape but little when the claw is closed. The palm bears some transverse rugae on its upper surface, but is otherwise smooth both within and without, except for scanty pitting. On the outer side of the palm near the upper border there is a longitudinal depression. There are longitudinal rows of pits on the fingers but no distinct grooves. The teeth on the inner margins are conspicuous in small specimens and in the smaller chelae of large individuals. In the larger chelae of well grown examples they tend to become obsolete at the base. The pits on all the segments of the chela are sometimes found

[1] I have not examined any large males.

to contain short stiff bristles, but these are completely worn away in the majority of the specimens.

The second pair of walking legs is a little less than twice the length of the carapace. The propodites show only indistinct traces of the double anterior margin found in *P. andersonianum* and other species; those of the penultimate pair vary from $2\frac{1}{4}$ to about $2\frac{3}{4}$ times as long as broad. The posterior margin of each propodus is armed with from two to four spinules and ends in a sharp spine.

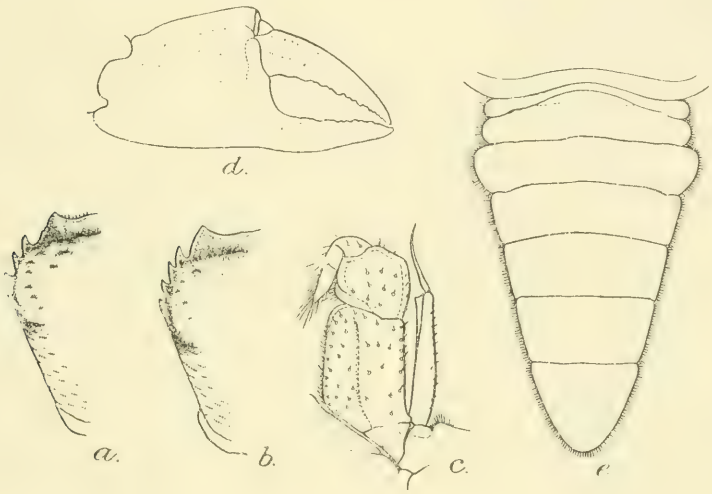



FIG. 2.—*Potamon* (*Potamon*) *acanthicum*, sp. nov.
*a, b.* Outline of left side of carapace.
*c.* Third maxillipede.
*d.* Chela of old female.
*e.* Abdomen of male.

In a male (not perhaps fully adult) the sixth abdominal somite is half as long as broad at the base, while the seventh, which is triangular is a little broader than long (text-fig. 2*c*).

The measurements (in mm.) of the carapace in eight specimens are as follows :—

| Sex | ♂ | ♂ | ♀ | ♀ | ♀ | ♀ | ♀ | ♀ |
|---|---|---|---|---|---|---|---|---|
| Length | 22·7 | 19·5 | 25·4 | 25·0 | 24·9 | 23·5 | 21·7 | 19·2 |
| Breadth | 30·4 | 26·6 | 35·5 | 35·7 | 34·8 | 32·3 | 30·2 | 25·5 |
| Depth | 15·5 | 13·8 | 16·7 | 16·9 | 16·4 | 15·5 | 14·1 | 12·5 |

*Potamon acanthicum* may be distinguished at a glance from all other Indian Potamonidae by the character of the antero-lateral border of the carapace. The sharp isolated spines with which the anterior part of this border is provided appear to be an extreme modification of the serrate or crenulate margin seen in most species of the subgenus *Potamon*; they differ widely in character from the large flat teeth found in Indian species of *Acanthotelphusa*. In *Potamon niloticum*,[1] however, the type species of the subgenus *Acanthotelphusa* (and in a few other species all found in Africa or Madagascar) the teeth are small, conical and irregular,

[1] *Potamon* (*Paratelphusa*) *niloticus* (M.-Edw.), Rathbun, *Nouv. Arch. Mus. Paris* (4), VII, p. 263, pl. xii, fig. 15 (1905).

much resembling those of *P. acanthicum*, whilst among accepted species of the subgenus *Potamon*, Miss Rathbun's *P. shensiense*,[1] from China, may be cited as an instance of a form in which the crenulations of the antero-lateral margin have become spiniform, though not to the same extent as in the species from the Shan States.

The species seems then, so far as the antero-lateral border of the carapace is concerned, to have undergone modification on the same lines as *P.* (*Potamon*) *shensiense* and *P.* (*Acanthotelphusa*) *niloticum* and its allies, though it is, in my opinion, clear that it is not closely related to either. Except in the matter of the antero-lateral border *P. shensiense* shows the closest affinity with *P. denticulatum* (Milne-Edwards); it differs widely from *P. acanthicum* in the form of the epigastric and post-orbital crests. In *P. niloticum* the longitudinal groove on the ischium of the third maxillipedes (found in *P. acanthicum* and most Potamonidae) is absent, and there are great differences in the form of the carapace and its areolation.

*P. acanthicum* must, I think, be regarded as a highly specialized offshoot of the ancestral stock that gave rise to *P. andersonianum* and its allies. So far as I can discover no closely related forms are known to exist, and the evidence obtained by Dr. Annandale regarding the other elements of the fauna of the Inlé system points to the conclusion that it evolved in the locality in which it is now found. The development of spines in place of serrations on the antero-lateral border of the carapace appears to have originated independently in *P. acanthicum*, *P. shensiense* and *P. niloticum*, and is thus an instance of convergence.[2]

The colouration of living specimens of *P. acanthicum* is very striking; Dr. Annandale has kindly supplied me with the following note. "The dorsal surface is black or very dark green, except that the deep groove running across behind the orbits is pale greenish yellow with a blackish margin in front. The upper half of the chelae, including the whole of the movable finger, is densely marbled with pale olive and greenish black; the lower half, including the immovable finger, is pale yellowish. This particoloured character extends to the whole appendage. The articular membrane at the base of the claw is scarlet. The walking legs

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[1] Rathbun, *Nouv. Arch. Mus. Paris* (4), VI, p. 262, pl. ix, fig. 8 (1904).

[2] There is one other point, not perhaps altogether disassociated from a discussion of the affinities of *P. acanthicum*, to which I would like to refer. It concerns the status of *Acanthotelphusa* as defined by Alcock. That the members of this subgenus have been evolved from *Potamon, s. s.*, will I think be generally admitted, but I am not convinced that the dividing line between the two subgenera is rightly placed. The characters of *Acanthotelphusa* given by Alcock are two,—"that the antero-lateral borders of the carapace are cut into large teeth or spines, and that the upper border of the merus of the chelipeds bears a subterminal spine." This description is in perfect agreement with the Indian species, but applies less well to *Potamon niloticum*, the type of the subgenus. In the Egyptian species the teeth of the antero-lateral border, as has already been pointed out, are small and irregular in their disposition and the subterminal spine on the upper border of the merus of the chelipedes is, in females at any rate, non-existent. On the other hand the groove on the surface of the ischium of the third maxillipedes is absent in *P. niloticum*, as it is in certain of the Indian species, and this is a rare character in Potamonidae. Judging from the limited material at my disposal I am inclined to think that the Indian species referred by Alcock to *Acanthotelphusa* differ more widely from *P. niloticum* than the latter does from typical species of *Potamon, s. s.* If this proves to be the case, *Acanthotelphusa* must once more revert to the synonymy of *Potamon*, while a new subgeneric name will be necessary for the Indian species and their allies. (*See* Postscriptum, p. 101.)

are dull olivaceous speckled with black. The ventral surface is yellowish and the mouth-parts are stained with dull olive. Individuals from the Inlé Lake are usually more brightly coloured than those from streams in the same district."

This is apparently the only crab that makes its way into the central region of the Inlé Lake, on the bottom of which it is occasionally found. It is more abundant among the roots of the floating islands at the edge of the lake, and also frequents small hill-streams.

The specimens in the collection are from Yawnghwe State: from the Inlé Lake, 3000 ft., and from He-Ho stream, 3800 ft. The types, which are from the former locality, bear the number 9771/10, *Zool. Surv. Ind.*

**Potamon (Potamon) curtobates,** sp. nov.

Plate xxiv, figs. 5, 6.

This species is allied to *P. abbotti*, Rathbun, *P. inornatum*, Rathbun, and *P. pealianum* (Wood-Mason), but differs from all in the extreme depth and convexity of the carapace.

The length of the carapace is a trifle less than three quarters its greatest breadth; it is thus comparatively short and broad. The depth is always conspicuously more than half the greatest breadth (pl. xxiv, figs. 5, 6).

The cervical groove is well defined posteriorly and the point where it cuts the post-orbital crests is usually clear; in the intermediate part of its course it is exceedingly obscure. The mesogastric areola is remarkably broad, its greatest breadth being almost or quite equal to one-third

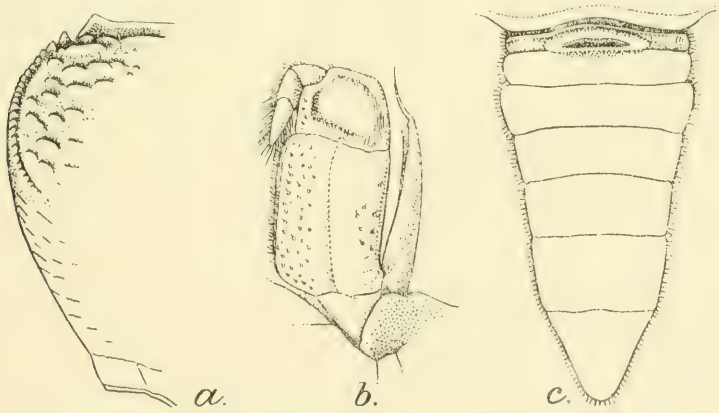


FIG. 3.—*Potamon (potamon) curtobates*, sp. nov.
*a.* Outline of left side of carapace.
*b.* Third maxillipede.
*c.* Abdomen of male.

the breadth of the carapace. (In *P. pealianum* it is only one quarter the breadth.) The antero-lateral boundaries of the areola are usually obsolete in specimens of medium size, but are visible in a very old male. The two small lobules behind the posterior limit of the cervical groove are not as a rule completely defined. The upper surface of the carapace is very strongly convex fore and aft and slightly so from side to side;

it is for the most part smooth and shining with a very fine microscopic granulation. Near the antero-lateral borders it is conspicuously tubercular, the tubercles taking the form of short transverse rugae, rather larger than in *P. pealianum*. In the latter species the sub-branchial regions are not visible in dorsal view beyond the antero-lateral border. In *P. curtobates*, much as in *P. abbotti* and *P. inornatum*, these regions are inflated and are visible from above up to the point where the carapace is broadest. The sub-branchial regions are covered with coarse rugae that extend a short distance over the postero-lateral border.

The epigastric and post-orbital crests together form a common curve. The former are swollen and are rounded in front, without the sharp edge seen in *P. pealianum*. They are almost entirely smooth and extend further forwards than in the allied species, projecting considerably beyond a transverse line joining the posterior limits of the orbits. The post-orbital crests are separated from the epigastric by a conspicuous furrow and are very deep in frontal view ; they are obscurely rugose near the cervical groove and beyond this point break up into coarse rugae, the foremost of those on the epibranchial region. The post-orbital crests are situated very close to the orbits, the base of the declivity almost touching the inner corner of the upper orbital margin.

The front is strongly deflexed with a broad and shallow median emargination. The edge itself, as in *P. pealianum*, is concealed in dorsal view by a pair of large post-frontal eminences. These eminences are coarsely pitted and bear fine transverse grooves, they are not, however, tubercular. The median longitudinal furrow that separates the epigastric crests is continued forwards on to the front.

The antero-lateral border of the carapace (text-fig. 3*a*) is more strongly arched than in *P. pealianum* and is closely serrate throughout with a prominent epibranchial tooth.

Both upper and lower orbital borders are smooth. The external orbital tooth is small but acute and is separated from the lower orbital border by a wide and inconspicuous emargination. The antennular fossae are narrower and more cramped than in *P. pealianum*. The ischium of the external maxillipedes (text-fig. 3*b*) is grooved in the usual way and is covered with coarse pits bearing stiff hairs. The merus is similarly pitted, especially on its thickened postero-internal margin ; it is about as long as broad, narrowed anteriorly and obscurely angled antero-laterally.

The chelipedes are unequal in both sexes. The merus is finely rugose externally and, of its two lower edges, the inner is tuberculate and the outer finely serrate (coarsely tuberculate in *P. pealianum*). In the chelae the lower half of the outer surface of the palm is nearly smooth except for some coarse pitting ; the upper surface is strongly rugulose. The dactylus bears a few tubercles on its dorsal surface near the base. The teeth on the inner margins of the fingers are conspicuous. In the larger chela the fingers gape considerably at the base in all the specimens, but not to the extent seen in *P. acanthicum*.

The legs are normal in length, those of the second pair being about twice the length of the carapace. They are rather stout, the propodus of the penultimate leg being about two and-a-quarter times and of the

ultimate leg a little less than twice as long as broad. The anterior and posterior borders of the propodi are rounded, not keeled as in *P. pealianum* and the spinules on the posterior border are very small and inconspicuous.

In the male abdomen the length of the sixth segment is from one-half to two-thirds the basal breadth. The seventh segment is triangular, a little broader than long (text-fig. 3*c*).

The measurements (in mm.) of the carapace in four specimens are as follows :—

| | | | | | | |
|---|---|---|---|---|---|---|
| Sex | ... | ... | ♂ | ♂ | ♂ | ♀ |
| Length | ... | ... | 40·5 | 32·2 | 28·0 | 32·5 |
| Breadth | ... | ... | 57·6 | 44·8 | 38·4 | 44·8 |
| Depth | ... | ... | 31·7 | 26·2 | 22·2 | 25·0 |

I have compared this species with specimens of *P. pealianum* and have pointed out numerous differences in the course of the description given above. *P. abbotti*, Rathbun,[1] and *P. inornatum*, Rathbun,[2] which I have not seen, appear to be more closely allied, especially the latter.

In *P. abbotti*, which occurs in the Malay Peninsula, the carapace is proportionately narrower than in *P. curtobates*, about four-fifths as long as broad, the post-frontal crest is tuberculate, the median suture is not defined in front of the epigastric lobes, the palms of the chelae are rougher externally, the legs are more slender and the penultimate segment of the abdomen of the male is shorter. *P. inornatum* differs in its narrower carapace, more strongly inflated laterally, in the merus of the external maxillipedes which is more square in outline, and in the much broader terminal segments of the abdomen of the male. Other distinctions will doubtless be found on actual comparison of specimens.

Four specimens of *P. curtobates* are in the collection, obtained for Dr. Annandale by Mr. C. E. Browne. They were found in rice-fields near Yawnghwe. The types bear the number 9775/10, *Zool. Surv. Ind.*

## Family PALAEMONIDAE.

### Subfamily *PALAEMONINAE*.

### **Palaemon naso,** sp. nov.

Plate xxv, figs. 1-5.

The rostrum in this species is unusually long, in individuals that are apparently full-grown extending beyond the end of the antennal scale by about one-third of its length (pl. xxv, figs. 1, 2). In specimens between 30 and 40 mm. in length it is proportionately rather shorter, reaching beyond the scale by about one quarter its length. In its proximal half the rostrum is straight, but towards the apex is very strongly reflected upwards : the upper margin is always conspicuously concave in front of the eye. There are, in all, from 8 to 11 dorsal teeth (nearly always 9 or 10)[3] and from 5 to 8 ventral teeth (usually

[1] Rathbun, *Proc. Biol. Soc. Washington*, XII, p. 27, pl. 1 (1898).

[2] Rathbun, *Nouv. Arch. Mus. Paris* (4), VI, p. 311, pl. xiv, fig. 1 (1904).

[3] Of fifty specimens four have 8 dorsal teeth, twenty-four have 9, twenty have 10 and two have 11.

5 or 6, very rarely 8).[1] The rostrum begins as a dorsal crest a little in front of the middle point of the carapace. The dorsal teeth are large and in front of each there is a fringe of five setae. The three posterior teeth are, as a rule, situated on the carapace; occasionally the third tooth is placed immediately over the orbit. The posterior teeth are rather widely spaced; the three or four on the basal half of the rostrum proper are a little closer together. Near the apex there are from one to three rather small dorsal teeth, which are sometimes so close to the tip as to give it a bifid or even trifid appearance, and between these and the teeth on the proximal part of the rostrum there is usually one tooth, remote from those before or behind it. On the lower border the teeth are large, with fringes of setae as on the upper margin; they are rather crowded at the base, but more distantly spaced towards the apex. There is no well marked lateral keel on the rostrum.

The carapace is smooth, without trace of roughness or spinulation. The antennal tooth is situated a little behind the frontal margin. The hepatic tooth is below the level of the antennal; beneath and behind it there is a deep longitudinal depression.

The eye is short and broad; the breadth of the cornea is about one and a half times the dorsal length of the stalk. The ocellus is well marked as usual.

The antennular peduncle is normal in form. The lateral process of the basal segment ends in a tooth that reaches beyond the middle of the second segment. The dorsal lengths of the second and third segments are about equal. The shorter ramus of the outer antennular flagellum is fused basally with its fellow for a distance equal to less than one-fifth of its total length, the fused portion comprising some eight or nine segments. The shorter ramus, viewed from above, is strongly serrate externally. The antennal scale is parallel-sided, with the outer margin nearly straight; it is about three and a half times as long as broad.

The mandibular palp is composed of three segments. The third maxillipedes reach almost to the end of the second segment of the antennular peduncle.

The first peraeopods extend to the end of the antennal scale in specimens of moderate size. In large individuals they are proportionately a little longer, reaching beyond the scale by half or more of the chela. The merus is little more than three-quarters the length of the carpus. The carpus is about two and a half times as long as the chela and the fingers, which bear tufts of setae, are about equal in length with the palm.

The second peraeopods (pl. xxv, fig. 3) are almost or quite equal; they are smooth, slender, and do not differ in the two sexes. They are never more than half the total length of the animal and apparently do not attain the extreme development met with in many species of the genus. In well grown individuals they reach beyond the antennal scale by the chela and sometimes by a small portion of the carpus also, reaching beyond the end of the rostrum by a portion of the finger-length.

[1] Of fifty specimens eighteen have 5 ventral teeth, twenty-six have 6, five have 7 and one has 8.

In examples between 30 and 40 mm. in length they are a little shorter. The proportions of the different segments may be deduced from the measurements given below. The carpus is longer than the merus and the merus than the ischium. The dactylus is a shade shorter than the palm and the entire chela is a little longer than the carpus. The chela is slightly curved and the fingers are without any trace of teeth on their inner margins.

The last three pairs of peraeopods are slender and similar in length, the fifth being slightly the longest. When stretched forwards they all reach beyond the antennular peduncle, but fall short of the apex of the scale. The merus of the third pair is a little more than nine times as long as broad and is about one and a third times the length of the carpus. The propodus is slightly shorter than the merus and is very nearly four times the extreme length of the dactylus. In the fifth pair of legs the propodus is proportionately longer and is about one and a sixth times as long as the merus and seven times the length of the dactylus. The merus is rather less stout than in the third pair and is one fifth longer than the carpus. There are series of spinules on the posterior border of the propodi of all three pairs, but none on the merus. At the distal end of the fifth propodus there is a thick fringe of setae. There are setae also on the dactylus, which is simple, slightly curved and with a large terminal claw (pl. xxv, fig. 4). The branchial formula is the same as that of other species of the genus.[1]

The sixth abdominal somite, measured dorsally, is about one and half times the length of the fifth and about two-thirds as long as the telson. The telson bears the usual two pairs of dorso-lateral spinules and ends in a rather broad apex which is produced to an acute point. The innermost of the two pairs of terminal spinules are very long, exceeding the produced apex of the telson by at least two-thirds of their length (pl. xxv, fig. 5).

The appendix masculina is fully developed in specimens less than 35 mm. in length. The largest individual is a male 72 mm. in length. Unfortunately none of the females are ovigerous. Seven specimens yield the following measurements :—

| Sex. | Total length. | Length of rostrum and carapace. | Length of carapace. | Length of 2nd peraeopod. | Second peraeopod: length of | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ischium. | Merus. | Carpus. | Palm. | Dactylus. |
| ♂ | 72 | 36·5 | 17·8 | 36 | 7·2 | 7·9 | 9·1 | 5·2 | 5·1 |
| ♂ | 67 | 34·5 | 16·4 | 31 | 5·7 | 6·7 | 8·1 | 4·7 | 4·3 |
| ♂ | 66 | 34·2 | 16·3 | 32 | 5·9 | 6·8 | 8·2 | 4·7 | 4·4 |
| ♂ | 58·5 | 28·7 | 13·8 | 28 | 5·5 | 6·3 | 7·2 | 4·2 | 4·1 |
| ♀ | 57 | 27·4 | 13·2 | 26 | 5·1 | 5·3 | 6·2 | 3·4 | 3·3 |
| ♀ | 54 | 25·5 | 12·5 | 24 | 4·8 | 5·5 | 6·1 | 3·3 | 3·1 |
| ♂ | 33·5 | 15·8 | 7·8 | 15·5 | 3·0 | 3·6 | 4·2 | 2·3 | 2·0 |

[1] As tabulated by Coutière, *Ann. Sci. Nat., Zool.* (8), XII, p. 270 (1891).

In a series of several hundred specimens, which includes many males with the appendix masculina fully developed, the second peraeopods are slender and invariably short, not exceeding half the total length; it may be assumed, I think, that they never attain any greater development. In this respect the species appears to be primitive and resembles such forms as *Palaemon lamarrei*,[1] Milne-Edwards, and *P. lanchesteri*,[2] de Man. With these it has perhaps some real affinity, but it is readily distinguished from both by the characters of the rostrum and by the proportions of the different segments of the legs. The development of the rostrum is unusual and should probably be taken as evidence of specialization.

The single male, 66 mm. in length, described by de Man from Hollandia in North New Guinea as *Palaemon* (*Eupalaemon*) sp.[3] appears to be closely related to *P. naso*. The rostrum, with 11 teeth above and 5 below, is similar, except that it is not quite so deep in lateral view. The second peraeopods are short; but the proportionate lengths of the different segments are rather different (merus 7·5, carpus 10, palm 4·5, fingers 6·5), the fingers being nearly one and a half times the length of the palm. The fifth legs are much longer, reaching beyond the antennal scale by the dactylus and the distal third of the propodus.[4]

*Palaemon multidens*,[5] Coutière, from Madagascar, differs in its shorter rostrum with more numerous dorsal teeth and fewer ventral teeth. The second peraeopods are proportionately much longer and the palm is shorter than the fingers. The fifth legs reach beyond the apex of the rostrum.

De Man's *P. singtangensis*,[6] from Borneo, differs widely in the form of the rostrum and the second peraeopods are greatly developed in adults, their length equalling that of the body in males only 57 mm. in length. The segments bear spinules in adults and in their proportionate lengths differ somewhat from those of *P. naso*; there are some small teeth on the inner edges of the fingers.

Dr. Annandale has given me the following note on the colouration of living specimens of *P. naso*. "General colour greyish. Rostrum dark grey. Antennae and antennules reddish. Fingers of chelae tinged with red; a reddish ring on each joint of the large claw-legs. Dorsum of thorax clouded with grey; a small grey spot at each side near the upper limits of the lateral surface on a level with the base of the rostrum. An irregular grey bar sloping backwards and downwards from the lower orbital margin; another, still more irregular and broader, parallel to it a short distance posteriorly; a backwardly directed lunate mark of the same shade about the same distance behind the second bar, and finally a third irregular bar directed straight downwards partly within the lunate mark, a short distance in front of the posterior margin

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[1] De Man, *Rec. Ind. Mus.*, II, p. 222, pl. xix, fig. 4 (1908).

[2] De Man, *Notes Leyden Mus.*, XXXIII, p. 264 (1911); *nom. nov.* for *P. paucidens*, Lanchester, *Proc. Zool. Soc. London*, 1901, p. 568, pl. xxxiii, fig. 4.

[3] De Man, *Zool. Jahrb. Syst.*, p. 427, pl. xxix, figs. 10-12 (1915).

[4] The word "carpus" in the last line of de Man's description is evidently a misprint for "propodus."

[5] Coutière, *Ann. Sci. Nat. Zool.* (8), XII, p. 327, pl. xiv, figs. 40, 40*a* (1901).

[6] De Man, *Notes Leyden Mus.*, XX, p. 138, pl. vi (1898).

of the thorax. A greyish spot on each side of the posterior margin of each abdominal segment and above it a bar of the same colour extending across the dorsal surface. Telson irregularly cross-barred; uropods mottled or clouded."

"The Intha fishermen deny that they are acquainted with any prawns of larger size and state that these are never found in the lake, only in streams and rivers. They say that in cold weather prawns are attracted in large numbers to spots where hot springs flow into the river, but it is uncertain whether their statement refers to this or to the succeeding species."

The larger specimens in the collection, several hundred in number, were obtained alive in the market at Nan-Pan. They were said to have come from Sizon in the Tang-do circle of Yawnghwe State in the river that runs south from the Inlé Lake. A small specimen was obtained in a spring of slightly warm water close to Fort Stedman, within about half a mile of the lake. The types bear the number 9777/10, *Zool. Surv. Ind.*

### **Palaemon hendersoni,** de Man.

1907. *Palaemon* (*Parapalaemon ?*) *hendersoni*, de Man, *Trans. Linn. Soc. Zool.* (2), IX, p. 446, pl. xxxiii, figs. 66-68.
1910. *Bithynis* (*Parapalaemon*) *hendersoni*, Rathbun, *Bull. Mus. Comp. Zool., Harvard*, LII, p. 316, pl. v, fig. 3.
1913. *Palaemon hendersoni*, Kemp, *Rec. Ind. Mus.*, VIII, p. 303, pl. xix, figs. 19-23.

Four specimens of this species were obtained by Dr. Annandale in the He-Ho stream, Yawngwhe State, at an altitude of 3800 ft. The largest individual is a full grown male 65 mm. in total length and with carapace 19 mm. in length.

The rostrum is longer than in typical specimens from the Darjiling district, reaching a little beyond the end of the antennular peduncle. It bears from 9 to 11 dorsal teeth, of which 3 (in one case only 2) are on the carapace. There are in each case 3 ventral teeth.

In the large male the longer chelipede of the second pair is about 60 mm. in length, extending beyond the apex of the antennal scale by the chela and one half of the carpus. The ischium is 10 mm. in length, the merus 11 mm., the carpus 9 mm., the palm 16·7 mm. and the fingers 15·4 mm. The carpus is 4·4 mm. broad at the distal end and the palm 6·0 mm. in breadth and 4·9 mm. in thickness. In this individual, as well as in a smaller example only 40 mm. in total length, the fluting of the fingers of the second peraeopod is clearly shown.

In the length, number and position of the rostral teeth the Inlé specimens differ slightly from those described by de Man and from those recorded from the Abor country, and examination of series from the Darjiling district, the Abor country, the Garo Hills and the Swa Reserve Forest in Burma seems to indicate that in respect of the rostrum there is a small but constant difference between Burmese specimens and those from Assam and the Eastern Himalayas. I defer further discussion of this point until I have had the opportunity of examining in detail the large accumulation of unnamed Palaemonidae in the Indian Museum.

*Palaemon hendersoni* is usually of an olivaceous colour in life, with or without darker markings. The colouration of specimens from the Dar-

jiling district is described by Dr. Annandale thus.—" Pale translucent yellowish olive. A dark brown vertical bar on each side of the first abdominal segment and a mid-dorsal streak of the same colour on the first three abdominal segments." The smaller specimens from the He-Ho stream were " of a uniform dark greyish olive," but the large male was strikingly different. Dr. Annandale notes that " it was dark blue like a lobster, except for pale bars on the walking legs, pale edges to the outer uropods, pale tips to all the uropods and the telson and the pale fingers of the chelae, the tips of which were reddish. Dr. Annandale's observations on *P. hendersoni* in the Darjiling district and my own in the Abor country and in the Garo Hills indicate that the deep blue colour seen in this individual does not occur even in the largest males found in Assam and the Eastern Himalayas.

### **Palaemon** sp.

A number of small specimens of *Palaemon* were found among weeds in a small spring of warm water near Fort Stedman, together with numerous examples of *Caridina weberi* prox. var. *sumatrensis* and one young individual of *Palaemon naso.* The specimens, the largest of which is a male 30 mm. in length with the appendix masculina to all appearances fully developed, agree in general appearance with *P. hendersoni.* The rostrum is similar with 9 to 11 teeth above (2 or 3 of which are on the carapace) and with 3, 4 or 5 below. The carpus of the second peraeopods is, however, of much greater proportionate length, being in every instance considerably longer than the palm. In the male 30 mm. in length the second peraeopods are well developed reaching beyond the antennal scale by the chela and a portion of the carpus.

At present our knowledge of the Burmese species of Palaemonidae is very scanty and I am unable to say whether these specimens belong to a small species of *Palaemon*, hitherto undescribed, or whether they represent a dwarfed race of some known form.

## Family ATYIDAE.

### **Caridina annandalei,** sp. nov.

Plate xxv, figs. 6-15.

The rostrum usually reaches about to the end of the second segment of the antennular peduncle ; in young individuals it is shorter, sometimes extending only to the end of the first segment, while in very large specimens it may reach beyond the middle of the ultimate segment. In lateral view the rostrum is rather strongly depressed, but the tip is frequently a little upturned (fig. 6). On the upper border, which is strongly convex, there are from 11 to 26 teeth (usually 14 to 23)[1] ; in most instances these teeth stretch uninterruptedly from base to apex, but not

[1] Of one hundred specimens two have 11 dorsal teeth, one has 12, five have 14, seven have 15, eight have 16, fourteen have 17, eleven have 18, fourteen have 19, fifteen have 20, five have 21, six have 22, five have 23, two have 24, two have 25 and three have 26.

infrequently the distal sixth or seventh of the rostrum is unarmed. The teeth in the middle of the series are the most crowded and the posterior 2 to 4 (usually 3) are situated on the carapace behind the orbit. The lower margin of the rostrum bears from 2 to 6 small teeth (usually 2 to 5, very rarely 1),[1] situated in the distal third of its length.

At the lower angle of the orbit there is a narrow projecting lobe, furnished with setae, and immediately below a sharp antennal spine. The antero-inferior angle of the carapace is rounded.

The eyes are normal. The antennular somite is not dorsally carinate. The antennular peduncle (fig. 7) reaches to, or a little beyond the tip of the spine on the antennal scale. The lateral process does not nearly reach the end of the basal segment. The second segment is long and slender ; in dorsal view its length is quite two and a half times its basal breadth. The antennal scale (fig. 8) is slender, from three and a half to rather more than four times as long as broad ; its outer margin is distinctly concave.

The epipod of the third maxillipedes is short and pointed.

The carpus of the first peraeopods (fig. 9) is from 3·0 to 3·4 times as long as its distal breadth ; rarely it is stouter, sometimes only 2·4 times as long as broad. The segment is remarkable for the entire absence of the excavation at the distal end. The second peraeopods (fig. 10) are slender and reach a little beyond the middle of the second segment of the antennular peduncle. The carpus is from $7\frac{1}{2}$ to more than 8 times as long as its distal breadth ; the chela is from $4\frac{1}{2}$ to 5 times as long as wide with the fingers from $1\frac{1}{3}$ to $1\frac{1}{2}$ times the length of the palm.

In the third peraeopods which reach about to the end of the antennular peduncle, the propodus is from 2·7 to 3·2 times the length of the dactylus (fig. 11). The latter segment is slender and bears from 8 to 12 spines (fig. 12). The fifth peraeopods are about the same length as the third, but the dactylus is proportionately longer, the propodus being from 2·2 to 2·5 times its length (fig. 13). The spinules on the dactylus vary in number from 44 to 66 (fig. 14) and appear to be least numerous in males.

There are as usual eight branchiae and, in addition, the distal end of the epipod of the second maxillipede is divided into a small number of plumes which doubtless have the function of gills. The epipods on the first two peraeopods are fully formed ; that on the third pair is small and rudimentary and that of the fourth pair is entirely absent.

The form of the endopod of the first pleopod of the male is shown in fig. 15.

The telson is a little longer than the sixth somite ; its apex is broadly truncate and bears 6, 7 or 8 slender spines between the small spinules at its lateral angles. In addition there are from 3 to 5 pairs of dorso-lateral spinules. The spinules on the outer uropod vary in number from 9 to 13.

The eggs are very large ; when freshly extruded they are about 0·9 mm. in length and 0·55 mm. in breadth. When about to hatch

[1] Of one hundred specimens one has only 1 ventral tooth, fourteen have 2 teeth, thirty-one have 3, thirty-two have 4, fifteen have 5 and seven have 6.

they are about 1·0 mm. by 0·6 mm. Ovigerous females carry only from 15 to 25 eggs.

Large specimens reach a total length of about 17 mm.

*Caridina annandalei* is allied to *C. excavata*, Kemp,[1] and *C. hodgarti*, Kemp,[2] from Assam, the three species differing so far as is known from all other members of the genus in the absence of the epipod at the base of the fourth legs. In other respects also they show signs of close affinity. Classified according to the scheme outlined by Bouvier in 1913 [3] all three would take a position near *Caridina nilotica*, from which, however, they differ in a number of conspicuous features. In addition to the absence of the epipod on the fourth legs the species resemble each other in their slender build, in the comparatively great proportionate length of the antennular peduncle, in the slightly marked or non-existent excavation at the distal end of the carpus of the first pair of legs and in the possession of large eggs. The species may be distinguished thus :—

I. Rostrum long, extending at least beyond end of antennular peduncle, the distal part of its upper margin without teeth ; 2nd segment of antennular peduncle not more than twice as long as its basal breadth ; carpus of 1st peraeopod slightly excavate distally, that of 2nd peraeopod less than 6 times as long as broad ; dactylus of 5th leg about one-third the length of propodus.

A. Rostrum reaching beyond antennal scale, with a small subterminal tooth on upper border ; orbital notch not unusually deeply excavated ; antennal scale 4½ times as long as broad ; carpus of 1st peraeopods about 1½ times, that of 2nd about 3 times as long as broad ; dactylus of 3rd peraeopod with 6 or 7 teeth, that of 5th with about 25 teeth ; eggs 0·8 mm. in length ... ... *C. hodgarti.*

B. Rostrum not reaching beyond antennal scale, without a subterminal dorsal tooth ; orbital notch very deeply excavated ; antennal scale about 3 times as long as broad ; carpus of 1st peraeopod about 3 times, that of 2nd about 5½ times as long as broad ; dactylus of 3rd peraeopod with 8-10 teeth, that of 5th with 40-50 teeth ; eggs about 1 mm. in length ... ... ... *C. excavata*

II. Rostrum short, not reaching end of antennular peduncle, with teeth throughout the length of its upper border ; 2nd segment of antennular peduncle 2½ times as long as its basal breadth ; carpus of 1st peraeopod not excavate distally, 3 to 3½ times as long as broad, that of 2nd more than 7 times as long as broad ; dactylus of 5th leg less than one third the length of propodus. [Antennal scale 3 to 3½ times as long as broad ; dactylus of 3rd peraeopod with 8–12 teeth, that of 5th peraeopod with 44-66 teeth ; eggs 0·9–1·0 mm. in length] ... *C. annandalei.*

*Caridina annandalei* is very abundant among green weeds in all parts of the Inlé Lake [4] and is also common in flooded rice-fields and waterways in the Yawngwhe plain. In these localities it occurs at an altitude of 3000 ft. It was also found, though less plentifully in the

[1] Kemp, *Rec. Ind. Mus.*, VIII, p. 306, pl. xx, figs. 32-35, pl. xxi, figs. 36, 37 (1913).
[2] Kemp, *ibid.*, p. 309, pl. xx, figs. 29-31, pl. xxi, figs. 38, 39 (1913).
[3] Bouvier, *Trans. Linn. Soc.* (2), *Zool.*, XV, p. 462 (1913).
[4] Ovigerous females were found only in the lake.

He-Ho river, at 3800 ft., among the roots of trees and under floating leaves and twigs.

Dr. Annandale has supplied me with the following notes on the colouration of living specimens.—" Individuals from the open part of the lake were translucent but speckled more or less densely with dark olive green and shining white. On the sides of the thorax the dark specks tended to congregate in three broad vertical bars, but in this respect the colouration was variable. In darker individuals somewhat indefinite cross bars could also be detected on the posterior margin of each abdominal segment. Individuals from the black water of the He-Ho river were speckled with black or very dark purple, and had no white specks. There was a slanting dark bar a little behind the middle of the thorax and usually another, less distinct, in front of it. There was also an irregular dark mark near the posterior margin of the carapace. A dark spot was always present at the base of each pleopod and there was sometimes a round dark spot at each side of each abdominal segment near the dorsal surface.

The aberrant Trematode *Caridinicola* is usually to be found in the gill-chambers of individuals from the lake, and the Protozoon *Cothurnia* is abundant on their uropods and other appendages."

In addition to the specimens from the Shan plateau, there are in the Indian Museum five specimens (two of which are ovigerous) obtained by Wood-Mason from " Upper Tenasserim," and two (one of which is ovigerous) found by Dr. Annandale in a swampy lake at Kawkareik, in level country in the interior of the Amherst district, Tenasserim, in March, 1908.

The types, which are from the Inlé Lake, bear the number 9783/10, *Zool. Surv. Ind.*

### **Caridina weberi,** de Man.

1892. *Caridina weberi*, de Man, in *Weber's Zool. Ergebn. Reise Nied. Ost.-Ind.* II, p. 371, pl. xxii, fig. 23.

### prox. var. **sumatrensis,** de Man.

1892. *Caridina weberi* var. *sumatrensis*, de Man, *ibid.*, p. 375, pl. xxii, fig. 23*g*.

The commonest *Caridina* of the plains of India and Burma is a form allied to de Man's *C. weberi* var. *sumatrensis*. A cursory examination of the Museum collection, which contains samples from many widely distant localities, shows that there are in India a great number of local races, some of which will probably be found to deserve recognition in nomenclature. I will therefore in this account of the Inlé Decapoda content myself with a few remarks on the characteristics of the Shan race and on the features in which it differs from that found in Sumatra. The differences, though considerable, do not appear to be specific.

The rostrum reaches to the middle or end of the second segment of the antennular peduncle. Its straight or slightly convex upper border bears from 12 to 20 teeth (usually 13 to 18),[1] distributed throughout its length, and of these, 3 or 4 (rarely 2) are placed on the carapace

[1] Of one hundred specimens three have 12 dorsal teeth, ten have 13, seventeen have 14, thirty-seven have 15, fifteen have 16, eleven have 17, six have 18 and one has 20.

behind the orbit. The lower border bears from 0 to 5 teeth (usually 1 to 3).[1]

The antero-lateral angle of the carapace is produced and forms a small tooth. This character is apparently not found in typical *C. weberi*, nor (according to specimens from Deli in Sumatra, preserved in the Indian Museum) in typical var. *sumatrensis*. The character is an unusual one in *Caridina* and in some species (*C. denticulata*, de Haan, for instance) appears to be of considerable specific importance. In the specimens from the Shan States the tooth is invariably present, but in samples of very closely related forms from other parts of India it is inconstant in its development.[2] For the present, at least, I am not able to regard the character as having specific value in the *C. weberi* group.

The second segment of the antennular peduncle is short and stout, intermediate in form between de Man's figs. 23 and 23*f* (*loc. cit.*). The antennal scale is about two and three-quarter times as long as broad.

The carpus of the first pair of peraeopods is deeply excavate and from 1·6 to 1·75 times as long as broad ; that of the second pair is from 4·5 to 5·5 times as long as broad. The fingers in the second pair are scarcely one and a half times as long as the palm. The propodus of the third peraeopods is from 3·2 to 3·8 times as long as the dactylus (rarely shorter : 2·8 times), the latter segment bearing 6 or 7 teeth. In the fifth peraeopods the propodus is from 2·9 to 3·2 times the length of the dactylus, the dactylus bearing from 27 to 33 spinules.

There are from 13 to 18 movable spines on the outer uropod.

Exceptionally large specimens reach a length of 19 mm. ; the majority of those in the collection are smaller, not exceeding 15 mm. The eggs are very large, about 1·1 mm. by 0·7 mm. in longer and shorter diameter. Ovigerous females carry very few eggs, the numbers in two instances in which they were removed and counted being 19 and 26.

This form differs from *C. weberi* var. *sumatrensis* in a number of particulars which are apparently of subspecific importance : (*i*) both dorsal and ventral teeth of the rostrum are rather less numerous, (*ii*) the antero-inferior angle of the carapace is toothed, (*iii*) the fingers of the second peraeopod are proportionately shorter in relation to the palm and the propodus of the third peraeopod shorter in relation to the dactylus and (*iv*) the eggs are very much larger.

Dr. Annandale found a number of specimens in small streams running into the Inlé Lake at an altitude of 3000 ft., and in those on the He-Ho plain at 3800 ft. It was occasionally found in the lake itself, near the edge, but never in the central region.

The colouration of living specimens is described by Dr. Annandale as follows :—" In individuals from among green weeds in a small stream

[1] Of one hundred specimens two have no ventral teeth, twenty-four have 1 tooth, forty-three have 2 teeth, twenty-three have 3, six have 4 and two have 5.

[2] Thus in a hundred specimens of a form closely allied to that obtained by Dr. Annandale, found at Tinnevelly in South India, the antero-lateral angle bears an acute tooth in 18 per cent. of the specimens, is rectangular or obtusely angled in 19 per cent. and is rounded in 63 per cent. This form is intermediate between typical var. *sumatrensis* and the Shan race in the size of the eggs, which are 0·7 mm. in length and 0·45 mm. in breadth.

near Fort Stedman the whole of the body was more or less darkened with green chromatophores and was sometimes almost black. A pale mid-dorsal line was usually present, and sometimes white specks could be detected on the thorax, abdomen and telson. In paler individuals there was a small dark spot at the base of each pleopod. The fingers of the chelae were darkened, but the bunch of hairs at the tip was often white. Individuals from the He-Ho stream, the water of which has a peculiar blackish colour owing to the large amount of fragments of carbonized vegetation it contains, were rather dark but had three parallel colourless bars slanting along each side of the carapace. There was a pale cross-bar on each abdominal segment and a colourless mid-dorsal line."

## POSTSCRIPTUM.

### Acanthopotamon,

*nom. nov.* for *Acanthotelphusa* Alcock *nec* Ortmann.

While this paper was still in the press Calman published an account of *Potamon* (*Potamonautes*) *warreni*,[1] a new river crab from the Transvaal. The affinities of this species, which are discussed by Calman, throw much light on the position of *Acanthotelphusa*.

*P.* (*Potamonautes*) *warreni* has an extremely close affinity with the common South African *P.* (*P.*) *perlatum*, differing from that species only in the fact that the granules of the antero-lateral margin are replaced by spiniform teeth. The species thus affords, in the subgenus *Potamonautes*, an instance of evolution exactly parallel to that which I believe to have occurred on at least two independent occasions in the subgenus *Potamon*, *viz.* in *P.* (*P.*) *shensiense* and *P.* (*P.*) *acanthicum* (see p. 85).

As Calman has remarked *P.* (*Potamonautes*) *warreni* on any of the current schemes of classification would be separated generically or subgenerically from *P.* (*P.*) *perlatum*. Were it not for the proofs of its affinity that Calman has brought forward, it is almost certain that it would have been referred to *Acanthotelphusa*, for it closely resembles *P.* (*Acanthotelphusa*) *niloticum* in the character of the antero-lateral margin.

There is, as Calman has hinted, reason for the belief that *P. niloticum* has originated, in much the same way as *P. warreni*, from some East African species with normally constituted antero-lateral border. But, however this may be, it is clear that its affinities are not with the well-defined group of Asiatic species to which Alcock has applied the name *Acanthotelphusa*. Since *P. niloticum* is the type of the latter subgenus, it is evident that a new name is necessary for the Asiatic forms. I suggest *Acanthopotamon*, distinguished from *Potamon s.s.* by two characters,—the antero-lateral borders of the carapace are cut into three or four large teeth,[2] and (ii) the upper border of the merus of the chelipedes bears a sub-terminal spine.

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[1] Calman, *Ann. Mag. Nat. Hist.* (9), I, p. 224 (1918).
[2] Exclusive of the external orbital tooth.

*Type,—Potamon martensi* (Wood-Mason).[1]

The species of this subgenus bear a close general resemblance to those of *Paratelphusa s.s.*, but are distinguished by the different form of the mandibular palp. In Miss Rathbun's monograph [2] *Paratelphusa* is regarded as a subgenus of *Potamon* and comprises species belonging both to *Paratelphusa s.s.*, as defined by Alcock and to *Acanthopotamon*. It also includes *P. niloticum* and two allied forms, which are perhaps derivatives of *Potamonautes*, and *P. antongilensis* which appears to have been evolved from *Geotelphusa*.

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[1] *Potamon* (*Acanthotelphusa*) *martensi*, Alcock, *Cat. Indian Decap. Crust.*, *Potamonidae*, p. 68, fig. 52 (1910).

[2] Rathbun, *Nouv. Arch. Mus. Paris* (4) VII, p. 228 (1905).

## EXPLANATION OF PLATE XXIV.

*Potamon* (*Potamon*) *browneanum*, sp. nov.

Figs. 1, 2.—Dorsal and frontal views of a male 52·3 mm. in breadth.

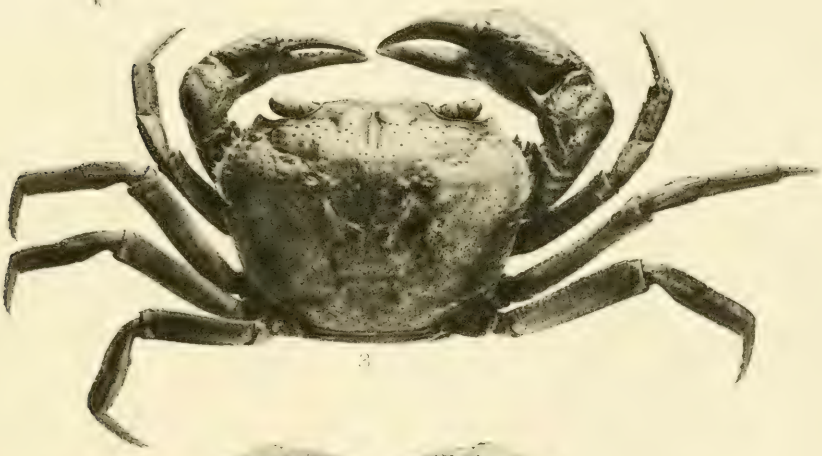
*Potamon* (*Potamon*) *acanthicum*, sp. nov.

Figs. 3, 4.—Dorsal and frontal views of a female 32·3 mm. in breadth.

*Potamon* (*Potamon*) *curtobates*, sp. nov.

Figs. 5, 6.—Dorsal and frontal views of a male 44·8 mm. in breadth.

1



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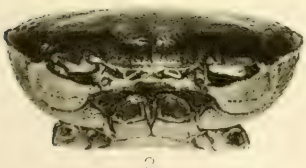

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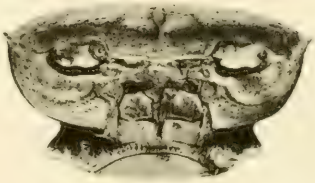

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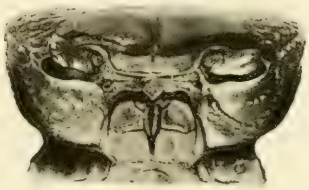

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DECAPODA FROM THE [illegible] STATES.

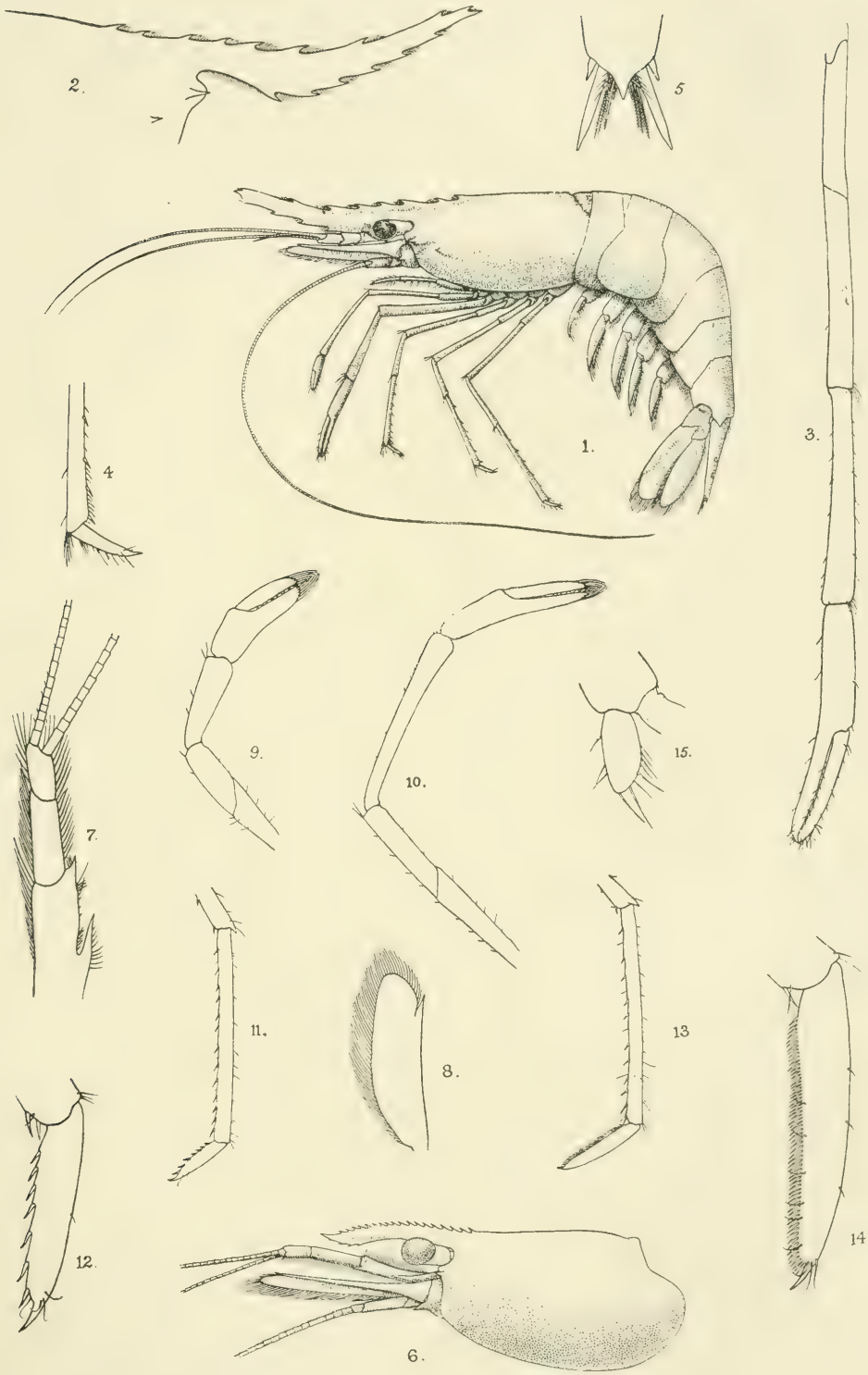
## EXPLANATION OF PLATE XXV.

*Palaemon naso*, sp. nov.

Fig. 1.—Lateral view of an adult male, enlarged.
,, 2.—Rostrum of another specimen.
,, 3.—Second peraeopod.
,, 4.—End of propodus and dactylus of third peraeopod.
,, 5.—Apex of telson.

*Caridina annandalei*, sp. nov.

Fig. 6.—Carapace, rostrum, etc., in lateral view, enlarged.
,, 7.—Antennule in dorsal view.
,, 8.—Antennal scale.
,, 9.—First peraeopod.
,, 10.—Second peraeopod.
,, 11.—Propodus and dactylus of third peraeopod.
,, 12.—Dactylus of third peraeopod, further enlarged.
,, 13.—Propodus and dactylus of fifth peraeopod.
,, 14.—Dactylus of fifth peraeopod, further enlarged.
,, 15.—Endopod of first pleopod of male.




A. C. Chowdhary del.

DECAPODA FROM THE S. SHAN STATES.

# AQUATIC MOLLUSCS OF THE INLE LAKE AND CONNECTED WATERS.

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

(Plates X—XIX.)

TABLE OF CONTENTS.



## INTRODUCTION.

The following paper is based on the collection of Mollusca made in the Inlé Lake and the surrounding district by Dr. F. H. Gravely and myself in February and March, 1917.

The district is one of great interest to students of the freshwater Mollusca because it is one of those in which the fauna, apparently isolated for a long period, has proved extraordinarily plastic, with the result that large numbers of peculiar forms have been evolved. It is not necessary here to describe its physical characters as this has already been done in the Introduction to the volume, but there are a few points that it is of importance to remember. In the first place, the Inlé Lake, which lies on the Shan Plateau at an altitude of 3,000 feet above sea-level, occupies a basin that it has dissolved for itself out of limestone. Its water, therefore, contains abundant salts of lime

and also of magnesium. Though now shrunken and shallow, the lake is the last relic of a once extensive lake-system and was at a period geologically not remote both larger and much deeper than it is at the present day. The water of its central region is remarkably clear and its bottom covered with a peculiar semi-liquid mud formed of calcareous particles and fragments of decayed vegetable refuse. Round the margin there is a curious rim of floating islands composed of dead and living plants, and the formation of peat is proceeding with great activity. The water of the marginal zone is, therefore, much contaminated. Considerable differences exist in the fauna of the two regions. Certain peculiarities can also be observed in that of the intermediate zone between the two. As there are no rocks or stones in the lake rupicolous molluscs are absent.

Many of the specimens from the lake were obtained by dredging, others by the careful examination of masses of weeds. We also searched several of the small streams that flow into the lake, as well as the larger streams and swamps of the He-Ho plain, which lies a few miles to the south-west at an altitude about 800 feet higher. Further, we obtained good series of fossil and subfossil shells from several deposits both in this plain and in the Hsing-Dawng valley some five miles north-east of the lake.

So far as I am aware, no molluscs have been recorded from the Inlé Lake, but several of the species common to it and neighbouring waters have been described by Theobald,[1] by Nevill,[2] by von Martens,[3] by Kobelt[4] or by Pilsbry,[5] from the Northern Shan States and Upper Burma. The species described by Theobald have been admirably figured in Theobald and Hanley's *Conchologia Indica* (1876). I have found the references to literature in Mr. H. B. Preston's volume on the freshwater Mollusca (1915) in the *Fauna of British India* series of great value, though they are far from complete. I have to thank my friends Mr. E. Vredenburg of the Geological Survey of India and Mr. Stanley Kemp of my own department for going through certain parts of the proofs of this paper and making valuable suggestions.

## Part I.—SYSTEMATIC.

### Gastropoda.

### Order **PULMONATA.**

### Family SUCCINEIDAE.

#### Genus **Succinea,** Draparnaud.

It is only by some stretching of terms that a species of *Succinea* can be dealt with in a paper exclusively on aquatic molluscs, for there

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[1] *Journ. As. Soc. Bengal* (2), XXXIV, pp. 273-279 (1865).
[2] *Journ. As. Soc. Bengal* (2), XLVI, pp. 14-41 (1877).
[3] *Wiegm. Arch. Naturg.*, LXV (1), pp. 30-48 (1899).
[4] *Paludinen* in Martini and Chemnitz's *Conch. Cab.* (ed. Küster), (1909).
[5] *Proc. Ac. Nat. Sci. Philadelphia*, pp. 188-190 (1901).

is no reason to think that this species differs from its congeners in habits. It lives at the edge of water and can doubtless swim attached shell-downwards to the surface film, but does not lead a true aquatic life. My reason for referring to it here is the remarkable resemblance between its shell and that of a *Limnaea* to be discussed later (p. 109).

### **Succinea indica,** Pfeiffer.

Plate x, figs. 10, 11 ; plate xi, figs. 5, 6.

1876. *Succinea indica*, Hanley and Theobald, *Conch. Ind.*, pl. lxvii, figs. 1 & 4.
1914. *Succinea indica*, Gude, *Faun. Brit. Ind.*, *Moll.* II, p. 447.

Living specimens were found at the edge of the Inlé Lake at Thalé-u on the eastern shore and in the swamp at the northern end. Subfossil shells occur in considerable numbers in the superficial deposits on the He-Ho river just above its gorge.

Shells from the Inlé Lake (fig. 10, pl. x) agree as regards outline and general appearance with Theobald and Hanley's figures, but are rather smaller (14 mm. long) and of a darker colour. The animal is that of a normal *Succinea*. I figure the jaw and a central and a lateral tooth from the radula (pl. xi, figs. 5, 6). Subfossil shells from the He-Ho river (pl. x, fig. 11) are thicker and have the growth-lines so coarse that the surface approaches that of *S. plicata*, Blanford, in sculpture. They do not differ otherwise from living shells.

The species is essentially a Himalayan one, hitherto known from Kumaon and Kashmir. Gude (*op. cit.*, 1914) doubts the identity of Egyptian shells assigned to it by Jickeli.

## Family LIMNAEIDAE.

### Genus **Limnaea,**[1] Lamarck.

The genus is cosmopolitan and capable of living in conditions generally unfavourable to molluscs, for example at great altitudes and in great depths. Its shell is remarkably plastic and varies in size, shape, thickness and colour with changes in the environment. This character of plasticity is admirably illustrated by the forms found living and fossil in the Inlé and He-Ho basins. I have been able to recognize only three species among the living forms, but one of these has several fossil and subfossil phases. I have also to refer briefly to a fourth (fossil) species represented in our collection by two imperfect shells.

The three living species fall into two well marked groups and in one of these a remarkable series of shells can be arranged, linking together two living species unlike in shell-characters by means of several apparently extinct phases. The third living species has two distinct phases, each of which lives in a different kind of habitat.

[1] I take this opportunity to state that the species from Japan described by Preston (*Ann. Mag. Nat. Hist.*, (8) XVII, p. 160, pl. ix, fig. 6, 1916) under the name *Lithotis japonica* is not related to the Indian species of *Lithotis* and does not belong to the Succineidae. The radula is that of a *Limnaea*. The shell is like that of *L. brevispira*, von Martens.

A noteworthy feature of the Shan *Limnaeae* is their small size. We saw no shell more than 12 mm. long.

### **Limnaea andersoniana,** Nevill.

Plate x, figs. 1, 2.

1877. *Limnaea andersoniana*, Nevill, *Journ. As. Soc. Bengal*, (2) XLVI, p. 26.
1881. *Limnaea andersoniana, id., ibid.*, L (2), p. 142, pl. v, fig. 9.

"Shell small, horny brown, imperforate, globose, spire short; whorls four to five, last whorl large, ovate; columella remarkably thick and reflected, straight, without any twist; aperture subovate, anteriorly rather wide.

This small species, well characterized by its remarkable columella, is unlike any Indian species; the figure that it most resembles in 'Kuster's Monog.' is var. of *L. peregra*, pl. 3, figs. 17, 18; there is no shell like it figured in the 'Conch. Iconica'; probably *L. andersoniana* will prove to be a common species throughout S. China." (*Nevill*).

The species was originally described from Yunnan. It was also recorded by its author from the Shan States, but there is no reference to it in Preston's volume in the official *Fauna of British India* (1915). The shell, as Nevill notes, resembles that of *L. pervia*, von Martens, a common Chinese and Japanese species, but differs in its very coarse columellar callus; his statement that the columella is absolutely straight is not substantiated by either his figure or his type-specimen. The animal has a peculiar leaden grey colour, which extends almost uniformly over all the exposed parts except the sole of the foot, this being pale. The jaw and radula are of normal type. The lateral teeth are bicuspid and one of the cusps is very long and slender.

Both in the Chinese collection obtained by the late Dr. J. Anderson and examined by Nevill and in our own, shells of two forms are present. I have no information about the habitat of the Chinese molluscs except that they were taken at an altitude of about 4,000 feet. In the Inlé basin, however, the two forms of shell represent two distinct phases of the species, each associated with a definite type of habitat. In one phase (pl. x, fig. 1) the shell is relatively broad and, though by no means large, is considerably larger than in the other, attaining a length of 12 mm. Nevill selected a shell of this phase as the type of the species and figured it in 1881. Shells of the other, narrower phase (pl. x, fig. 2) do not exceed 9 mm. in length. They are duller and greener in colour and perhaps a little thicker. The larger, broader form of shell is found in ponds and marshes amidst dense aquatic vegetation; we took a single dead shell floating on the surface of the water at the edge of the Inlé Lake. The smaller form was observed in considerable abundance in a small slow-moving stream with a muddy bottom and devoid of vegetation at Fort Stedman (*ca.* 3,000 feet). We also collected a few shells in small streams at Thamakan (Hsamönghkam) about 1000 feet higher.

### [**Limnaea bowelli,** Preston.]

Plate x, fig. 4.

1909. *Limnaea bowelli*, Preston, *Rec. Ind. Mus.* III, p. 115, figs. 1, 2.

This species is known only from very high altitudes (13,000 to 14,000 feet) in Tibet, where it lives in small streams.

Preston describes the shell as follows :—

"Shell rimate, acuminately ovate, rather solid, polished, shining, pale yellowish horn colour; whorls 4, shouldered above, marked with rather coarse lines of growth: sutures deeply impressed; columella obliquely and diffused above into a thick callus which joins the upper margin of the peristome; peristome simple; aperture ovately, inversely auriform."

He also refers, on the authority of the Rev. E. W. Bowell, to the peculiar form of the upper jaw, the central part of which is produced into a blunt beak-like projection, and to the *Planorbis*-like appearance of the radula. Mr. Bowell even suggested the erection of a new genus on account of the former character.

I mention *L. bowelli* here because we found in the Inlé and He-Ho basins a series of fossil and recent shells that differed considerably in different deposits and zones but formed a very regular gradation between a shell that resembled that of *L. bowelli* in certain characters but differed from it considerably in others, and one that had little outward resemblance to it. The only living phase in this series, moreover, though far removed from the Tibetan form in shell-characters, proved on comparison to be identical with it in buccal armature. *L. bowelli* is probably itself a modified form, living as it does at an almost unique altitude, but it is, to say the least, highly probable that still further links might be found between it and the various phases I have here grouped together under the name *L. shanensis.*

### **Limnaea shanensis,** sp. nov.

Plate x, figs. 5, 8; plate xi, figs. 2, 3.

The shell in all the phases of this species is much narrower than in *L. bowelli*, the aperture is less patent, the peristome projects less, the spire consists of two instead of three whorls, the whorls are not at all flattened above and the suture is more sinuous and more oblique. These characters become intensified with the gradual evolution of what appears to be a true lacustrine deep-water type, but certain features are always retained, *viz.*, the complete aperture, the imperforate but rimate condition of the shell, the short, rather blunt spire, impressed suture, ovate form, coarsely developed growth-lines and small size. More important than any of these is the structure of the jaw and radula in the only living phase. Each phase, of which I can distinguish four, is or was associated with a definite type of environment. I will refer to them alphabetically and describe them *seriatim.* The complete gradation is better shown on plate x than can be described in words.

*Type-specimen* (phase A). No. M. 11059/2, Zoological Survey of India (*Ind. Mus.*).

#### **Phase A.**

In this phase the shell is nearer that of *L. bowelli* than any other, but there are distinct and constant features in the much narrower form, more oblique suture, longer and narrower aperture, etc. The shell is fairly thick and its growth-lines are very coarse. It is of approximately

the same size as the type of *L. bowelli*. The following are the measurements of a specimen :—

| | mm. |
|---|---|
| Length ... ... ... ... ... ... | 9 |
| Greatest breadth ... ... ... ... ... | 6·5 |
| Length of aperture ... ... ... ... ... | 6·25 |
| Greatest breadth of aperture ... ... ... ... | 3·75 |

The shell occurs abundantly in the friable clay of the He-Ho lake-deposit at an altitude of about 3,600 feet. The specimens are well preserved so far as form is concerned, but difficult to extract in a perfect condition owing to their fragility. They have evidently sunk to the bottom of an open lake and there been buried in very fine mud. This phase is, therefore, the most ancient with which we are acquainted as well as the nearest to the Tibetan species. It is very constant.

**Phase B.**

The shell is still narrower than in phase A and the aperture, which is of about the same length, is constricted posteriorly. The suture is still more oblique and the apical whorl is reduced in size. The shell is rather thick and has still coarser growth-lines. There is no great divergence in size from the former phase. The measurements of shells are as follows :—

| | mm. | mm. | mm. |
|---|---|---|---|
| Length ... ... ... ... | 10 | 9 | 8·5 |
| Greatest breadth ... ... ... | 6 | 5·75 | 5 |
| Length of aperture ... ... ... | 6·5 | 6 | 5·75 |
| Greatest breadth of aperture ... ... | 3·75 | 3·5 | 3 |

Shells are abundant in the superficial deposit on the banks of the He-Ho river just before it plunges down towards the Inlé plain, about a mile to a mile and a half east of the point where the types of phase A were discovered and at a slightly lower altitude. It is probable that the deposits represent the debris at the edge of a marsh or lake. The shells are sometimes slightly waterworn and as a rule more or less broken. I class them as subfossil. They also are constant.

**Phase C.**

This is the only phase I have seen in a living condition. The shell is thin and fragile but of a rather dark brown colour. It is a little narrower and more acuminate than that of phase B and has the apical whorl still smaller, but the suture is not quite so sinuous and the aperture is not so contracted posteriorly. The growth-lines are conspicuous but not so coarse. The rimation, though quite distinct, is less strong. The shell is rather larger ; the following are measurements of two specimens :—

| | mm. | mm. |
|---|---|---|
| Length ... ... ... ... ... | 10·25 | 8 |
| Greatest breadth ... ... ... ... | 6 | 4·25 |
| Length of aperture ... ... ... ... | 7 | 5 |
| Greatest breadth of aperture ... ... ... | 4 | 2·25 |

We found a small but constant series of living specimens near the shore-line of the marginal zone of the Inlé Lake at Fort Stedman. They were living amidst much decaying vegetation matter in conditions which favoured the formation of peat.

**Phase D.**

The shell is thicker than that of phase C and has coarser growth-lines. The sutures are sinuous but not very oblique and the whorls of the spire swollen. The apical whorl is very small and almost globular. The body-whorl is contracted and the whole shell is narrow. The aperture is also narrow but less contracted posteriorly than in phase B. The columellar callus is less well developed than in the other phases. The size is much reduced, as the following measurements will show :—

| | mm. |
|---|---|
| Length ... ... ... ... ... ... | 6·5 |
| Greatest breadth ... ... ... ... ... | 2·75 |
| Length of aperture ... ... ... ... | 4·5 |
| Greatest breadth of aperture ... ... ... ... | 2 |

I only know this phase from two dead shells dredged from the bottom in about 7 feet of water in the central region of the Inlé Lake. There is no doubt that the animal lived approximately in the place where the shells were found, for one of the specimens has been perforated (see figure) and must have sunk at once into the bottom of the lake. The phase is of great interest in that, while clearly a member of the same series as the other phases, it leads on towards the next species, which I have called, for other reasons, *L. mimetica.*

Considering all these phases together we may be sure of the following facts :—

(*i*) They may be regarded conventionally as the links in a chain of evolution in which the tendency is towards a narrowing of the shell and of its aperture and a reduction of the spire.

(*ii*) Evolution has affected the buccal armature less than it has affected the shell and though there is a distinct break in shell-form between phase C and the Tibetan species with which I have associated the phases, the radula and jaw are practically identical.

I will discuss the significance of these facts when dealing with variation among the shells of the Inlé and He-Ho basins (*v.* p. 151).

### **Limnaea mimetica,** sp. nov.

Plate x, figs. 9, 9*a* ; plate xi, fig. 4.

The shell is very small and delicate, transparent, colourless or tinged with yellow, imperforate, rimate, narrow, subcylindrical. It has the lines of growth well marked but not coarse. The spire, which is set on the body-whorl at a slight angle, is blunt and short, but so obliquely spiral that it appears twice as long in the dorsal as it does in the

ventral aspect ; in the latter it occupies only one tenth of the length of the shell. It consists of two whorls, which are neither shouldered nor markedly tumid. The suture is not or hardly impressed. The body-whorl is ovate, elongate and narrow ; its lateral outlines do not project far beyond those of the base of the spire ; its anterior internal margin is broadly rounded, its anterior outer margin angulate and a little produced. The aperture is almost straight, narrow, elongate and practically lanceolate in outline. Posteriorly it tapers gradually to a fine point and in front it is angulate externally. The peristome is simple, the rimate margin of the orifice distinct but delicate. The columella is almost concealed ; it is nearly straight and slopes forwards and outwards. Its callus is feebly developed.

The animal is that of a typical *Limnaea*. The foot is very extensible but can be retracted well within the shell. The tentacles are short. The whole external surface is white or greyish, with black eyes and an effusion of black pigment on the dorsal surface of the body and on the mantle. The specimens examined are sexually mature. A figure of the genital system, dissected out and drawn for me by Dr. Baini Prashad of the Bengal Fishery Department, is reproduced on p. 175 of this paper. It seems quite normal, but all the parts are slender as compared with those of European and American species. The spermathecal duct is long and the penis-sheath stout.

The jaw resembles that of *L. bowelli*, but is much less produced. The radula (pl. xi, fig. 4) is also similar, but the cusps of the lateral teeth are more nearly equal and equidistant and the marginal teeth (except at the extreme edge) have four instead of three cusps.

| | mm. |
|---|---|
| Length of shell ... ... ... ... ... | 6 |
| Greatest breadth of shell ... ... ... ... | 2·5 |
| Length of aperture ... ... ... ... | 4·25 |
| Greatest breadth of aperture ... ... ... ... | 2 |

*Type-specimen.* No. M. 11271/2, Zoological Survey of India (*Ind. Mus.*).

The species is probably but the final stage in a line of evolution similar to that of the phases of *L. shanensis* (pl. x, figs. 4–8). It may be no more than an extremely degenerate phase of *L. acuminata*,[1] Linn.

*L. mimetica* lives amidst dense growing vegetation both in the intermediate zone and the central region of the Inlé Lake, but probably avoids the extreme edge. It is not uncommon but nowhere abundant. Individuals from the intermediate zone have both shell and soft-parts darker than those from the open lake.

In general appearance the shell bears a very striking resemblance to that of *Succinea indica*, a mollusc not uncommon at the edge of the Inlé Lake, but one that does not live submerged. The shell of this semi-terrestrial species differs from that of the *Limnaea* in its much

[1] The upper jaw of *L. acuminata* is not produced in front, but the radula is very like that of *L. mimetica*. I am not convinced that the shape of the jaw is constant. Moreover, the radular teeth are subject to minor variations in shape.

arge size, darker colour, less extreme fragility, non-rimate character and non-angulate anterior margin. How close the resemblance is in other respects is shown clearly by figs. 9–11 on plate x.

It is difficult to see how this resemblance can be anything but fortuitous. It can be of no protective value to animals that never meet, have entirely different habits and probably different enemies. It cannot be due to convergence, to use the term in its technical sense, because of the difference in habits. It is well that attention should be called to apparently fortuitous resemblances of the kind, for they are apt to be ignored by students of mimicry—a series of phenomena as to the meaning and causation of which I must confess myself, after nearly twenty years' experience of tropical nature, in an agnostic frame of mind.

### **Limnaea** ? prox. **ovalis,** Gray.

Plate x, fig. 3.

I am unable to assign two fossil specimens from the old lake-deposit in the He-Ho plain to any described species but think it probable that they represent one allied to *L. ovalis* (pl. x, fig. 3). They are not unlike some dwarfed shells of *L. ovalis* from pools of brackish water in Orissa, but differ in the almost complete bilateral symmetry of the body-whorl and in the very long aperture. With such imperfect material it is best not to give the form a name.

## Genus **Planorbis,** Geoffroy.

Living specimens of five species of this genus were found in the Inlé Lake, while the shells of a sixth are not uncommon in the superficial deposits of the He-Ho plain. These six species fall into three of the subgenera or groups into which the genus has been divided, *viz.*, *Planorbis*, *s.s.* ; *Gyraulus*, and *Segmentina*. They may be distributed into these groups as follows :—*Planorbis exustus* to *Planorbis s.s.*, *P. saigonensis* (subfossil), *P. velifer*, sp. nov. and possibly *P. trochoideus*, which lacks the characteristic internal partitions of the shell of *Segmentina*, to *Gyraulus* ; *P. calathus* and *P. caenosus* to *Segmentina*.

### **Planorbis exustus,** Desh.

Plate xi, figs. 1, 1*a*.

1834. *Planorbis exustus*, Deshayes, *Belang. Voy. Ind. Orient., Zool.*, p. 417, pl. i, figs. 11-13.
1836. *Planorbis Indicus*, Benson, *Journ. As. Soc. Bengal*, V, p. 743.

The shell of this species seems to differ from *P. coromandelicus*, of which I have examined specimens from Bangalore, in its less inflated whorls, darker and duller colour and in the fact that the angle at the lower end of the mouth is less produced. Shells from the Kashmir lakes, from a small pond of slightly brackish water on Barkuda Island in the Chilka Lake, from the marginal zone of the Inlé Lake and from ponds and swamps at Yawnghwe and on the He-Ho plain are closely similar ; except that the Kashmir examples are a little smaller. Speci-

mens from the Talé Sap in Peninsular Siam differ very little. The species, therefore, seems to be a remarkably constant one, neither plastic nor variable. It is common in the more swampy parts, close inshore, of the marginal zone of the Inlé Lake and in all ponds, etc., in the district. It is found in similar situations in Bengal and Siam and it does not appear to be anywhere a true lacustrine mollusc.

I figure the shell of a very young individual, which puzzled me greatly until I had seen a series.

### **Planorbis saigonensis (?),** Crosse & Fischer.

Plate xi, fig. 12.

1909. *Planorbis saigonensis*, Germain, *Rec. Ind. Mus.*, III p. 117.
1915. *Planorbis* (*Gyraulus*) *compressus*, Preston, *Faun. Brit. Ind., Freshw. Moll.* p. 118.

Germain has discussed the synonymy of this species in the paper cited. I assign to it with some doubt a number of subfossil shells from the banks of the He-Ho stream. They seem to be intermediate between *P. saigonensis* and *P. convexiusculus*, which is perhaps no more than a variety, but in none of them is the aperture definitely lunate. In some a faint peripheral ridge can be detected, while in others there is no trace thereof. The largest shell is only 5 mm. in greatest diameter.

The species is widely distributed in Mesopotamia, Afghanistan, India, Indo-China, China, Japan and the Malay Region.

### **Planorbis velifer,** sp. nov.

Plate xi, figs. 7—11.

Shell minute, delicate, transparent, colourless or faintly tinted with yellow, with very fine close-set regular transverse striae, with 3½ whorls, slightly depressed above in the centre, with the upper surface very slightly convex and the suture impressed, with the periphery angulate and as a rule faintly carinate, with the centre of the lower surface moderately depressed and with this surface otherwise almost flat ; aperture large, broad, moderately oblique, its lower margin slightly concave, its upper margin moderately convex ; the edge of the lip sharply defined without thickening ; no internal callus. Maximum diameter 4 mm., minimum diameter 3·5 mm., height 1·75 mm.

*Type-specimen.* M. 11288/2 Zoological Survey of India (*Ind. Mus.*).

var. **ciliata,** nov.

This variety only differs from the typical form in having a variable number (usually five or six) of spiral ridges on both surfaces. These ridges are formed entirely of very minute epidermal cilia closely pressed together. They are often obsolete.

The two forms of shell fade gradually one into the other. Both exhibit considerable variation in the size and obliquity of the aperture

and in the degree of depression of the whole shell. In both there is usually a curious protruding veil-like structure running along the peripheral carination or angle. This "velum" is rarely altogether absent, but I believe it to be of parasitic origin. The presence of a similar structure on the shells of *P. saigonensis* is perhaps indicated in Clessin's[1] figure of the upper surface of the shell of *P. compressus*. In well-preserved specimens it has a gelatinous appearance and is full of bacteria.

The species (both varieties) is common in all parts of the Inlé Lake among dense masses of living weed.

Possibly *P. velifer* should be regarded simply as a lacustrine phase of *P. saigonensis*. Its shell closely resembles subfossil specimens from He-Ho, except that it is considerably smaller, has the sculpture finer and more regular and appears to be thinner. The subfossil shells are naturally more opaque than living ones.

### **Planorbis trochoideus,** Benson.

1836. *Planorbis trochoideus*, Benson, *op. cit.*, p. 742.
1876. *Planorbis trochoideus*, Hanley and Theobald, *Conch. Ind.*, pl. xxix, figs. 4-6.

This species occurs commonly with *P. velifer* in both the central region and the marginal zone of the Inlé Lake. It is also found in the fossil lake-deposit of the He-Ho plain. Shells from the lake agree well with Hanley and Theobald's figures. The largest are about 3 mm. in maximum diameter. They are diaphanous but tinted with yellow. I can find no trace of internal partitions such as exist in *P. calathus* and *P. caenosus*.

The species has hitherto been found only in the neighbourhood of Calcutta.

### **Planorbis calathus,** Benson.

1850. *Planorbis Calathus*, Benson, *Ann. Mag. Nat. Hist.*, (2) V, p. 348.
1876. *Planorbis calathus*, Hanley and Theobald, *op. cit.*, pl. xxix, figs. 1-3.

*P. calathus* is common in the Inlé Lake with the two preceding species. The specimens are very small, not exceeding 3 mm. in maximum diameter. Some are colourless, while others are distinctly brownish, but all are transparent.

The species has a wide distribution in northern India (mainly in the Himalayas) and Ceylon; it is also recorded from Siam.

### **Planorbis caenosus,** Benson.

1850. *Planorbis caenosus*, Benson, *op. cit.*, p. 349.
1876. *Planorbis caenosus*, Hanley and Theobald, *op. cit.*, pl. xxix, figs. 7-9.

We found two very small specimens, only 2 mm. in maximum diameter, in the marginal zone of the Inlé Lake off Fort Stedman. They are fully adult, as one of them contains eggs in the ovary. In spite of their small size the shells agree well with Hanley and Theobald's

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[1] Clessin, "Limnaeiden" in Martini and Chemnitz's *Conch. Cab.* (*ed.* Küster), p. 191, pl. xvii, fig. 10 (1886).

figures. They are transparent and of a faint yellowish colour. Possibly they represent a dwarfed race of the species.

*P. caenosus* has been found in Ceylon as well as in Northern India.

## Order **PECTINIBRANCHIATA.**

### Suborder **Taenioglossa.**

### Family MELANIIDAE.

### Genus **Melania,** Lamarck.

1915. *Tiara*, Preston, *op. cit.*, p. 10.

The species found living in the Inlé Lake and its basin belong to two groups or subgenera, *Striatella*, Brot and *Melanoides*, H. and A. Adams. The former is represented by the widely distributed and plastic *M. tuberculata*, while we have of the latter *M. terebra* and a race of *M. baccata*. A single shell of a form of *M. variabilis*, which also belongs to this group, was found in a cave-deposit at Hsin-Dawng. The only one of all these species that lives in the lake is M. *tuberculata*.

### **Melania tuberculata** (Müller).

Plate xii, figs. 1, 2.

1874. *Melania tuberculata*, Brot, *Melaniaceen* in Martini and Chemnitz's *Conch. Cab.* (ed. Küster), p. 247, pl. xxvi, figs. 11-11*h*.

This is the most widely distributed species in the genus, ranging as it does from the southern and eastern shores of the Mediterranean, through Africa and Asia to China and North Australia. The shell is very plastic in certain characters, notably in size, but also to a lesser degree in shape and sculpture. I have before me a large series from many localities in India and the neighbouring countries and also from Mesopotamia, Palestine and China. Numerous varieties have been described, but our collection seems to prove that as a rule the differences are directly due to differences in environment rather than to locality. The tubercles on specimens from southern Asia are, however, often less strongly developed than in those from Palestine. I will discuss certain aspects of the plasticity of this mollusc in dealing with the variation and evolution of the Inlé shells. Here it will be sufficient to say that the shells, both living and subfossil, from the Inlé and He-Ho basins fall into three phases :—(1) normal living shells of rather dark colouration, of moderate size, not exceeding 25 mm. in length ; (2) subfossil shells which were apparently also of dark colour, but are much larger (reaching at least 35 mm. in length) and rather broader in the basal whorl ; and (3) subfossil shells of very small size with the suture much impressed. These do not exceed 16 mm. in length.

The first group still lives both in the central region of the Inlé Lake and in the middle of the Yawnghwe river, while shells of the other two occur at different points in the superficial calcareous and peaty

deposits on the He-Ho plain. Each of these phases was constant in the locality or precise deposit in which it was found.

### **Melania terebra,** Benson.

Plate xii, fig. 9.

1836. *Melania Terebra*, Benson, *op. cit.*, p. 747.
1876. *Melania terebra*, Hanley and Theobald, *op. cit.*, pl. lxxi, figs. 8, 9.

A few living shells were found in the Yawnghwe river with *M. tuberculata*. They agree well with Hanley and Theobald's figures. The species is known from Sylhet and north-eastern Assam.

### **Melania baccata** (Gould).

Plate xii, figs. 3, 3*a*, 4—7.

1915. *Tiara* (*Melanoides*) *baccata*, Preston, *op. cit.*, p. 26.

*Melania baccata* is a species, or possibly a group of species, that seems to have become differentiated on the Shan Plateau and in Upper Burma into a large number of well-defined races. To what extent all these races are constant we do not yet know, but the only one found living or subfossil in the Inlé and He-Ho basins, though it varies somewhat in sculpture and is plastic in size, is, nevertheless, remarkably constant in the shape of the shell, in which it differs from any form as yet described. I have thought it best, in view of our ignorance of the anatomy and our scanty knowledge of the distribution of the various "varieties," to call this form a subspecies, by which I mean a local race.

subsp. **elongata,** nov.

In shape the shell is long, narrow and tapering. When complete it has 11 or 12 whorls, but the first two are usually eroded. The aperture is very narrow and nearly oval; the lip is considerably produced forwards and the columella is less bent than in most forms of the species. The sculpture is always well developed; on the last three whorls there are usually three spiral rows of tubercles joined together by ridges in such a way as to form a very regular reticulation. On the body-whorl the uppermost row of tubercles is situated close to the upper edge. There are three well-developed simple or superficially somewhat undulated ridges beneath the lowest row. Sometimes, however, there are only two rows of tubercles on this and the preceding whorl. The shell is thin; the epidermis is dark-brown or dull olivaceous-green; internally the surface is white and somewhat opalescent, as a rule with several deep-brown spiral bands.

At least two phases of this race can be distinguished:—(*a*) With a very large shell, when complete nearly 80 mm. long and 26 mm. in greatest breadth, and (*b*) with a much smaller shell not exceeding 50 mm. in length and 17 mm. in breadth. Of the first phase we found only a few specimens, all living in a swamp on the He-Ho plain. The second phase is abundant in the Yawnghwe river in a living condition and is also common subfossil in peaty and calcareous deposits on the He-Ho plain.

The type-specimen of the race (belonging to the large form) is No. M. 11155/2 in the collection of the Zoological Survey of India.

### Genus **Paludomus**, Swainson.

This genus is represented in our collection by two small shells only. They were found near the town of Yawnghwe. The genus, though occasionally found in still water, is usually an inhabitant of small streams and never lacustrine.

### **Paludomus ornata**, Benson.

1856. *Paludomus ornata*, Benson, *Ann. Mag. Nat. Hist.*, (2) XVII, p. 496.
1876. *Paludomus ornata*, Hanley and Theobald, *op. cit.*, pl. cviii, fig. 8.

The two shells of this species in our collection are very small, the larger being only 15 mm. in length. They are covered with a thin but somewhat dense layer of calcareous matter, which partly conceals the parallel grooves running round the top of the whorls, and gives the shell a dull appearance. When this calcareous matter is removed, however, the natural colouration and sculpture of the surface appear uninjured.

The shells were found living on a muddy bottom in a small runnel of clear water by the roadside some two miles east of Yawnghwe.

The species was described from Upper Burma, but occurs also in Pegu and in the valley of the Brahmaputra.

## Family HYDROBIIDAE.

1915. Paludestrinidae, Preston,[1] *op. cit.*, p. 67.

A large proportion of the members of this family are lacustrine and it is therefore not surprising that several species are common in the Inlé Lake. In Indo-China and China a number of peculiar genera have been evolved, but most of these seem to be peculiar to swift-running water, a type of environment of which we had little experience in the Shan States. None of the Indo-Chinese genera, perhaps for this reason, were found in the Inlé basin. With one exception, the six species of the family that we found belong to the peculiar genus *Hydrobioides*, Nevill. This genus was erected, as a subgenus of *Bithynia*, to include two species, one of which (*H. turrita*, Blanford) we found in a subfossil condition on the He-Ho plain, while the other, the position of which is still doubtful and which has not yet received a name, was from Kach. The named form was described from the Irrawaddi system and is still only known from empty shells, but four other species were found living in the Inlé basin and it has been possible to give a description of the operculum, the radula and the external anatomy of three.

The only other species of the family is assigned provisionally to the genus *Amnicola*, from the typical forms of which, however, it differs in its calcareous operculum.

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[1] Preston's removal of *Bithinella* (*op. cit.*, p. 66) from the family and its inclusion as a subgenus in *Cremnoconchus* (fam. Littorinidae) is not explained.

## Genus **Hydrobioides**, Nevill.

1884. *Hydrobioides* (subgenus of *Bithynia*), Nevill, *Hand List Moll. Ind. Mus.* II, p. 42.

The shell is thick, of moderately small or minute size, imperforate, of somewhat variable shape but not definitely neritiform. The aperture is large, ovoid or subtriangular. There is a very stout columellar callus, which is in continuation at both ends with a thickening of the outer lip. The lip is often fortified also by a strong ridge or varix that runs across the outer surface of the shell a short distance from the margin.

The operculum is calcified and thick but often surrounded by a membranous margin. The nucleus is almost central and surrounded by numerous well-defined concentric striae.

The soft-parts, externally at any rate, closely resemble those of *Bithynia*, the penis in particular being bifid. Both of its branches are well-developed. There is a deep but narrow transverse groove on the sole of the foot parallel to and close behind the anterior margin.

The radula is like that of *Bithynia*.

*Type-species.* *Bithynia* (?) *turrita*, Blanford.

The genus is closely allied to *Bithynia*, of which it might, but for the inconvenience of multiplying subgeneric names, rank as a subgenus. Of the five species assigned to it, one approaches the stouter and shorter forms of *Bithynia* such as *B. orcula*, one is elongate, while the other three agree in general appearance with more normal species of *Bithynia* such as *B. tentaculata*. The most characteristic feature is the peculiar armature of the mouth of the shell.

The shells may be distinguished as follows :—

I. Shell more or less elongate, with the spire in the same axis as the body-whorl.
  A. A ridge or varix running across the outer aspect of the body-whorl ... ... ... *H. nassa.*
  B. No varix.
    1. Shell at least 6 mm. long.
      (*a*) Shell twice as long as broad ... *H. turrita.*
      (*b*) Shell much less than twice as long as broad ... ... ... *H. avarix.*
    2. Shell not more than 3 mm. long ... *H. nana.*
II. Shell globose, with the spire short, directed backwards and outwards ... ... ... ... *H. physcus.*

### **Hydrobioides turrita** (Blanford).

1869. *Fairbankia ?* (an *Bithynia ?*) *turrita*, Blanford, *Proc. Zool. Soc. London*, p. 446.
1881. *Bithinea* (*?*) *turrita*, Nevill, *Journ. As. Soc. Bengal*, L (2), p. 157, pl. vi, fig. 15.
1884. *Bithinea* (*Hydrobioides*) *turrita*, Nevill, *op. cit.*, II, p. 42.

Blanford describes the shell as follows :—

"Testa subperforata, turrita, solidula, fulva, glabra, nitidula. Spira elongata-conica, sutura impressa. Anfr. 7, convexi, ultimus antice subascendens, subtus rotundatus. Apertura ovata, postice vix angulata, varice externo mediocri instructa; peristoma undique expansiusculum, marginibus callo junctis, externo leviter arcuato, columellari obliquo, antic cum basali subangulatum juncto. Operc. ? Long. 6¼ diam. 3 mm.; aperturae long. 2½, lat. 1¾ mm."

Nothing is known of the operculum or of the soft parts, but the shell is so like that of the species here described as *Hydrobioides avarix* that they must be congeneric.

The species was described from Kyoukpong on the Irrawaddi. Several subfossil shells were found on the banks of the He-Ho stream.

### **Hydrobioides nassa** (Theobald).

Plate xiii, figs. 1—7 ; plate xiv, figs. 4, 4*a*.

1865. *Bithinia nassa*, Theobald, *Journ. As. Soc. Bengal*, XXXIV (2), p. 275.
1870. *Bithinia nassa*, *id.*, *ibid.*, XXXIX (2), p. 402, pl. xviii, fig. 8.
1876. *Bithynia nassa*, Hanley and Theobald, *op. cit.*, pl. xxxvii, figs. 8, 9.

Theobald describes the shell as follows :—

"Testâ elongatâ, turbinatâ, politâ, diaphanâ, soliduscula. Labio expansiusculo, plicâ callosâ externâ munitâ. Anfractibus quinque. 0·45 0·25."

I figure the radular teeth and external male organ on pl. xiv. Both branches of the latter are well-developed and, from the point at which the organ bifurcates to their tips, are about equal in length. The inner branch is somewhat expanded distally, but flattened at the apex. The outer branch tapers gradually to a point. The whole organ is practically smooth. A band of dark pigment runs along the middle of the upper surface of the outer branch and of the basal undivided part.

The expanded foot is tongue-shaped and truncate in front, with the anterior angles slightly produced. The proboscis is moderately stout ; not distinctly notched in front ; it extends beyond the anterior margin of the foot. The antennae are filiform and when fully expanded longer than the shell. They are, however, highly contractile and one is often (temporarily) more extended than the other. The foot, the base of the tentacles and the edge of the mantle are dull yellow ; the proboscis is black with gold specks, becoming paler distally ; the tentacles (except at the base, where they are pale) are greenish and speckled.

The operculum is narrowly ovoid, pointed and a little produced posteriorly ; the marginal membraneous part is narrow ; there is a well-marked depression in the centre of the external surface : although the striae are concentric on the peripheral part of the surface, there is a distinct spiral in this depressed region ; a low but broad ridge runs along the internal margin. The whole operculum is whitish and transparent.

The shell, though not markedly variable in any one habitat, exhibits considerable plasticity and it is possible to recognize at least four races or phases among the living and fossil specimens we obtained.

Theobald's types, of which there are several in the collection of the Indian Museum, came from a locality situated at a considerable distance north-east of the Inlé basin. The form common in ponds in that basin does not, however, differ in any important character from these specimens. All that can be said is that the shells are as a rule a little smaller and a little more conoidal. I think it best, therefore, not to distinguish this form by name and will refer to it as the *forma typica*. The most interesting feature in which the four races

differ from one another is the structure and position of the ridge that runs, nearer or further from the aperture, across the outer aspect of the body-whorl.

**forma typica.**

The shell exhibits some variation, and possibly some local plasticity in size and shape. The spire is, however, in all cases sharply pointed, unless eroded, and the colour dull. The condition of the ridges at or near the mouth is fairly constant, the varix being separated from the lip, to which it runs nearly parallel, by a broad groove. This groove is, however, somewhat variable in breadth. There is no trace of an intermediate ridge.

Individuals of this type are abundant in ponds round Yawnghwe, always living amongst dense weeds. They are also to be found, with the race *lacustris*, at the edge of the Inlé Lake, but never in the central region.

*Type-specimen.* M. 2237/2, Zoological Survey of India (*Ind. Mus.*) (Theobald Coll.).

subspecies **lacustris,** nov.

This race differs from the *forma typica* in its narrower, more pointed and more brightly coloured shell and in the structure of the varix and lip. It also attains a larger size and the microscopic sculpture of the surface of the shell is usually more strongly developed. In both these latter characters, however, it is somewhat variable. Well-developed shells are as much as 10·5 mm. long by 6·5 mm. broad. Microscopic longitudinal striae run, close together, along all the whorls and the shell is sometimes minutely decussated; obscure spiral ridges are also sometimes to be detected, while opaque, almost flat longitudinal ribs can be seen on the body-whorl of some individuals. In fully developed shells the edge of the aperture is always widely separated from the varix, which does not run parallel to it but rather across the arc it forms. The distance apart of the two ridges is variable. The intermediate space, moreover, is not a groove but distinctly convex; strong transverse striae and often one or more incompletely developed transverse ridges occur on it.

The largest and most brightly coloured shells of this race are found in the least congested part of the intermediate zone of the lake. They are of a pale amber-yellow colour. In the central region shells do not as a rule exceed 9·5 mm. in length and, when free from minute algae, are of a pale cream tint. These shells also tend to have the spire narrower and more sharply pointed. In all parts of the lake this mollusc is found amongst dense growing weeds.

*Type-specimen.* M. 11135/2, Zoological Survey of India (*Ind. Mus.*).

subspecies **rivulicola,** nov.

The shells of this form are much thinner than those of the others assigned to the species. They are of a dull green colour and have the longitudinal striae well-developed. The spire tapers less regularly than in the *forma typica*, the whorls are more swollen individually and

the suture more impressed. The varix is very low and the thickening of the margin of the aperture comparatively slight ; the relation between the varix and the edge of the shell is similar to that noticed in the *forma typica*.

We found a few specimens of this race among weeds in the backwaters of small streams at Thamakan, which lies some 1000—1200 feet higher than the Inlé Lake.

*Type-specimen.* M. 11139/2, Zoological Survey of India (*Ind. Mus.*).

subspecies **distoma,** nov.

The shell is small and compact, not exceeding 8 mm. in length and 5 mm. in greatest breadth. The longitudinal striae are often well-developed, but the surface has a smooth appearance. The varix, which is prominent, is situated very close to the edge of the shell.

Shells of this race are abundant in a fossil and subfossil condition on the He-Ho plain in all the deposits that we examined. It must be regarded as the most primitive in the series of forms to be included under the name *Hydrobioides nassa*.

*Type-specimen.* M. 11140/2, Zoological Survey of India (*Ind. Mus.*).

**Hydrobioides avarix,** sp. nov.

Plate xiv, figs. 1, 2, 2*a*, 2*b*, 2*c*.

In this species the shell, though the peristome is thickened, entirely lacks a varix on the body-whorl. I can find no trace of a ridge. Otherwise the shell closely resembles that of *H. nassa distoma*. It is small (not longer than 7 mm. and broader than 3·5 mm.), moderately thick, with longitudinal striae, of a dark olivaceous colour. I have examined the animals of several individuals. The females agree precisely with those of the typical form of *H. nassa* in external anatomy. I have found only one male. Its external male organ only differs from that of *H. nassa typica* in that the internal branch is much shorter. This, however, may be due to immaturity or contraction. The radula closely resembles that of *H. nassa* (see figures), except that the outer lateral tooth is slightly broader and the marginal tooth a little shorter.

*Measurements of shells.*

| | mm. | mm. | mm. |
|---|---|---|---|
| Length of shell ... ... ... | 7 | 6·5 | 6·25 |
| Greatest breadth ... ... ... | 4 | 4·75 | 4 |
| Length of aperture ... ... ... | 3·5 | 3 | 2·5 |
| Greatest breadth of aperture ... ... | 2·5 | 2·25 | 2 |

The operculum is a little broader than that of *H. nassa* and less clearly spiral in the centre ; it lacks the membranous margin.

Most of our specimens have the tip of the shell eroded.

This species was found in great abundance among weeds (*Hydrilla*) in a stream of slightly warm water flowing out of a spring about a mile from the edge of the Inlé Lake near Fort Stedman. I have discovered in the collection of the Indian Museum some shells from Moulmein in

Tenasserim which belong to the same species. They are labelled "*Bithynia subnassa*, Nevill." This is apparently a *nomen nudum.* They only differ from the Shan types in being slightly larger, the largest being about 9 mm. long.

*Type-specimens.* M. 11127-9/2, Zoological Survey of India (*Ind. Mus.*). From near Fort Stedman.

### **Hydrobioides nana,** sp. nov.

Plate xiv, fig. 3.

Shell conoidal, moderately elongate, thick, transparent, brownish, with the spire darker than the body-whorl, smooth and polished on the surface, narrowly umbilicate, with the spire straight, blunt; with 4 whorls; whorls swollen, suture somewhat impressed; aperture large, ovate, oblique, bluntly pointed posteriorly; peristome thickened, continuous; no varix on the body-whorl.

*Measurements of specimen.*

| | mm. |
|---|---|
| Length of shell ... ... ... ... ... | 2·75 |
| Breadth of shell ... ... ... ... ... | 1·75 |
| Length of aperture ... ... ... ... | 1·25 |

The operculum is ovoid, thick, whitish, translucent, with the central area marked off by a distinct external ovoid ridge in the adult, with very numerous fine concentric striae.

From young shells of *H. nassa* those of this species can be recognized by their more swollen whorls, less pointed aperture and umbilicate condition, and especially by the structure of the operculum, which in young *nassa* is distinctly spiral.

We found about half a dozen specimens of this species at the edge of the Inlé Lake at Fort Stedman and in a small pool in the marsh at the northern end of the lake. I have been unable to examine the anatomy.

*Type-specimen.* M. 11289/2, Zoological Survey of India (*Ind. Mus.*).

### **Hydrobioides physcus,** sp. nov.

Plate xiii, figs. 8, 8*a*, 9; plate xiv, figs. 5, 5*a*.

Shell thick, translucent, white or pale yellow, globose, subneritiform, sub-umbilicate, with the spire short, pointed, directed obliquely backwards; suture not strongly impressed; $4\frac{1}{2}$ whorls, the body-whorl relatively very large and swollen. Aperture patent, oblique, almost as broad as long, with the outer lip slightly produced outwards, not much thickened, as a rule brownish; columellar callus very broad, longitudinally striate, strongly convex. The first $3\frac{1}{2}$ whorls rounded; basal whorl with a strong but blunt ridge running round its dorsal aspect a short distance below the suture and as a rule broken up more or less distinctly by longitudinal grooves; other almost obsolete spiral ridges sometimes to be detected running parallel to it on the central

part of the whorl. The whole shell ornamented with coarse, more or less sinuous longitudinal striae. The varix, which is not well-defined, running a short distance above the lip, but not precisely parallel to it, on the central part of the whorl.

*Measurements of shells.*

| | mm. | mm. | mm. |
|---|---|---|---|
| Total length ... ... ... ... | 6·5 | 7 | 6·5 |
| Greatest breadth ... ... ... | 6·25 | 6·25 | 6·25 |
| Length of aperture ... ... ... | 3·25 | 4 | 3·75 |
| Greatest breadth of aperture ... ... | 2·5 | 3 | 3 |

The radular teeth and external male organ are figured on pl. XIV. The latter differs considerably from that of *P. nassa.* The inner branch is much longer, distinctly annulated and not at all expanded at the tip; the outer branch is irregularly annulated and narrowed abruptly a short distance before its apex, which is blunt.

The foot is quadrangular, expanded in front, truncated behind, with a slight median posterior notch. The outline of the posterior extremity is, however, subject to considerable variation. The outline of the anterior margin is sinuous. The proboscis is stout and short and notched in front, it does not extend quite so far forward as the anterior margin of the foot. The tentacles are slender and tapering, not quite as long as the shell when fully extended. All the soft parts extruded from the shell are bright olivaceous, speckled with golden green.

The operculum is broadly ovoid, bluntly pointed posteriorly; the central part is thick and almost porcelainous, but translucent; the membranous marginal border is rather broader externally than internally. The outer surface is flat with a small depression round the nucleus, which is less clearly spiral than in *H. nassa.* There is a strong semi-circular ridge running round the outer margin of the thickened region on the inner surface.

*Type-specimen.* M. 11113/2, Zoological Survey of India (*Ind. Mus.*).

This species is extremely abundant in all parts of the Inlé Lake and also in swamps at He-Ho. It is found in much smaller numbers in ponds near Yawnghwe. I can discern no constant difference between shells from different localities or types of habitat, except that those from He-Ho are slightly smaller than those from the Inlé Lake.

Genus **Amnicola,** Gould & Haldeman.

I assign provisionally to this genus a species which apparently differs from the American forms in having a testaceous operculum.

**Amnicola alticola,** sp. nov.

Plate xiv, figs. 6, 6*a*.

Shell ovately fusiform, moderately elongate, minute, thin, transparent, chestnut-brown, sculptured with very minute longitudinal striae set close together, otherwise smooth, strongly opalescent internally,

with the whorls swollen in both planes and the suture impressed, narrowly umbilicate; aperture large, broadly sub-oval, rounded both in front and behind, strongly rimate and projecting; lip thin, sharp; columella arched.

*Measurements of specimen.*

| | mm. |
|---|---|
| Length of shell ... ... ... ... ... | 3 |
| Breadth of shell ... ... ... ... ... | 2 |
| Length of aperture ... ... ... ... | 1·5 |
| Greatest breadth of aperture ... ... ... ... | 1 |

The operculum is ovoid, pointed posteriorly, broadly rounded or sub-truncate anteriorly; it is thick but hyaline; 4 whorls can be distinguished on it; the outer surface is nearly flat; numerous spiral striae run round its periphery; the inner surface, which has a peripheral ridge, is strongly convex. Towards the periphery the suture becomes merely a ridge on the inner surface.

*Type-specimen.* No. M. 11110/2, Zoological Survey of India (*Ind. Mus.*).

The species is probably allied to *A. cincta*, Gould, from Tenasserim, but differs in that the body-whorl of the shell is not subcarinate. From *A. parvula* (Hutton) the shell may be at once distinguished by the broader whorls of its spire. Moreover, *A. parvula* is stated to have a horny operculum.

This species is not uncommon in the Inlé Lake, in which it occurs both in the central region and the marginal zone, always among living weeds. We found several subfossil shells on the banks of the He-Ho stream. They did not differ from fresh specimens.

## Family VIVIPARIDAE.

### Genus **Vivipara**, Lamarck.

It is a remarkable fact that only a single specimen that can be assigned to any normal species of this almost universally distributed genus was found in the course of our tour in the Southern Shan States.

### **Vivipara lecythis** (Benson).

1836. *Paludina Lecythis*, Benson, *op. cit.*, p. 745.
1876. *Paludina lecythis*, Hanley and Theobald, *op. cit.*, pl. lxxvi, fig. 6.
1909. *Vivipara lecythis*, Kobelt, *Paludinen* in Martin and Chemnitz, *Conch. Cab.*, p. 148, pl. 30, figs. 1, 2.

Specimens of this species from different localities differ considerably, but as we obtained only a single broken shell in the Inlé Lake, it is impossible to describe the local race it probably represents.

The shell was found floating on the surface of the water in the marginal zone close to the western shore of the lake.

### Genus **Taia**, gen. nov.

I have thought it necessary to give a new generic name to a group of Viviparidae that seems to be peculiar to the Shan Plateau and Upper

Burma. The shells of these remarkable species exhibit affinities both with *Vivipara* (*s.s.*) and with *Margarya*, Nevill; they also have some resemblance to those of *Tulotoma*, Haldeman.

The genus may be defined concisely as follows :—

Shell conical-ovate, conoidal or conical, varying greatly in thickness but never excessively thick and often quite thin, with coarse longitudinal striae and strong spiral ridges usually of a granular, nodular or squamous structure; at least three such ridges present on the basal whorl; whorls 7 to 8; spire well-developed, often produced but never cylindrical; aperture of shell sub-triangular, often contracted above; *columellar callus very broad and thick, extending over the umbilicus in the form of a convex ridge or flat plate;* operculum nearly as large as aperture of shell, horny, pyriform, concave on the external surface, and with a strong ridge along the inner margin, with the muscular scar relatively large but not very thick, with at any rate the outer margin membranous. Radular teeth elongate, with the terminal denticulation strong, with a well-developed lamellar process on the tip of the central and lateral teeth. Anatomy of the soft parts as in *Vivipara.*

Type-species: *Vivipara naticoides.* Theobald.

I assign to this new genus eleven species from the Shan Plateau; also *Vivipara noetlingi*, Kobelt, from the Lower Chindwin district of Upper Burma and an undescribed species from Ava on the Irrawaddi which I only know from a single broken shell. Of the Shan species six are extinct.

In describing a new genus and so many species I have followed the course that seemed most convenient. In the first draft of this paper I adopted a trinomial or rather quadrinomial system, but not only did I find myself constantly tripping over the names, but in several instances could not be quite sure to which species to assign a subspecies. Moreover, between the different sets of specimens that I had proposed to regard as representing distinct races or varieties I found constant differences in the form of operculum and in the proportions of the radular teeth, in all instances in which it was possible to examine these structures.

The development of the columellar callus, which sometimes extends from the aperture across the whole of the lower surface of the inner part of the body-whorl, is the most constant feature of the genus, and distinguishes it from *Margarya* and also from *Tulotoma.* This constitutes a resemblance to the Chinese genus *Rivularia*, Heude, but in other respects the structure and form are very different. From *Tulotoma*, *Taia* is also differentiated by the structure of the prominences on the chief spiral ridge of the body-whorl. My friend Mr. G. H. Tipper of the Geological Survey of India has been kind enough to cut sections of shells of *Margarya melanioides*, *Tulotoma magnifica*[1] and *Taia lacustris* for me. In transverse sections of the *Tulotoma* shell, the prominences on the chief ridge of the body-whorl appear to be com-

[1] For figures of this shell, which is apparently somewhat variable, see Küster's Monograph of Paludina, etc., in *Chemnitz's Conch. Cab.*, p. 23, pl. v, figs. 3-6 (1852), *T. magnifica* lives on stones in the Alabama river. It is the only known living species of its genus.

posed of convex, concentric layers of shell-substance. The layers are often oblique, but not so oblique that the layer is directed outwards or forwards on the shell. In similar sections of the shell of *Margarya* and *Taia* the layers of shell-substance are nearly straight, and project outwards and forwards in the form of well-defined lamellae. In a longitudinal section the appearance of the layers would be hardly different in *Tulotoma*, but in the other two shells they would be convex and more or less concentric. This is evident from the fact that the prominences in the American shell are arched both longitudinally and transversely, whereas in the Asiatic shells their convexity is longitudinal; horizontally they project almost flat.

### *Key to the Shan Species of* Taia.

A. Shell somewhat globosely conoidal.
  1. Shell almost subumbilicate, with the spiral ridges always present but never strongly developed and never regularly tubercular or squamous ... *T. theobaldi.*
  2. Shell entirely non-umbilicate, with some or all of the ridges distinctly tubercular if at all well defined, sometimes almost absent.
    (*a*) Shell obese, thick, with the microscopic sculpture on the apical whorls resembling a web of fine cloth, with the spiral sculpture granular or tubercular ... ... *T. obesa.*
    (*b*) The microscopic sculpture of the apical whorls less well developed; shell as a rule longer and less obese.
      (i) Spiral sculpture extremely variable; a regular series of subspiniform scales never present on body-whorl ... *T. naticoides.*
      (ii) Spiral sculpture much more constant, granular or tubercular, sometimes with a regular series of subspiniform scales on the body-whorl ... ... *T. intermedia.*

B. Shell elongate-conoidal.
  1. Elongation of shell moderate; shell thin; a regular series of subspiniform scales present on the body-whorl ... ... ... ... *T. shanensis.*
  2. Elongation of shell considerable, suture extremely oblique above body-whorl; scale-like projections on body-whorl, if developed, never spiniform.
    (i) Shell large (length 45-60 mm.), extremely elongate ... ... ... *T. cylindrica.*
    (ii) Shell smaller (length 35-37 mm.), less elongate ... ... ... ... *T. lacustris.*

C. Shell conical.
  1. A regular series of subspiniform or spiniform scales never produced on the shell ... ... *T. analoga.*
  2. A more or less regular series of spiniform or subspiniform scales present on the body-whorl.
    (i) Scales on body-whorl spiniform, regular; shell not exceeding 32 mm. in length, narrowly conical, constant ... ... *T. intha.*
    (ii) Scales on body-whorl subspiniform, less regular; shell at least 35 mm. in length, less narrowly conical, variable in size, shape and sculpture.
      (*a*) Scales on body-whorl irregular; shell at least 45 mm. in length, thick ... *T. conica.*
      (*b*) Scales on body-whorl more prominent and less irregular; shell as a rule less than 40 mm. long, thinner ... *T. clitoralis.*

**Taia theobaldi** (Kobelt).

Plate xv, fig. 18; plate xvi, fig. 1;
plate xviii, fig. 15-17.

1909. *Vivipara* (*naticoides* var. ? ) *theobaldi*, Kobelt, *Paludinen* in Martin and Chemnitz's *Conch. Cab.* (ed. Küster), p. 151, pl. xxx, figs. 10, 11.

Kobelt describes this species as follows :—

"Testa exumbilicata, ovato-conica, tenuis, haud nitens, unicolor fusco-olivacea vel sub-nigricans subtiliter striatula, plerumque limo ferrugineo adhaerente induta, apice nigricante. Spira conica, apice acuto, sutura parum impressa. Anfractus 7, superi convexi, inferi supra planati et angulati, carinis spiralibus plus minusve distinctis 3 cincti, ultimus acute carinatus, carina versus aperturam distinctiore et subtuberculata, utrinque convexus, carinulis tribus superioribus, prima et secunda magis approximatis, duabus inferis minoribus cinctus, antice descendens, basi irregulariter costato-sulcatus, spirae altitudinem superans. Apertura parum obliqua, basi recendens, ovata, supra acutiuscula, faucibus coerulescentibus, vix fasciatis; peristoma callo anguste nigro-marginato continuum, margine externo vix incrassato, extus ad carinam angulato, columellari calloso, distincte duplici sed parum incrassato, albo, nigro-marginato.
Alt. 31·5, diam. 24, alt. apert. obl. 17, diam. 12 mm."

I figure the radular teeth and operculum on pl. XVIII, figs. 16, 17. The former are of a dark brown colour.

The species on the whole is a constant one, but somewhat variable in colour—partly owing to the fact that there is often a deposit of some kind on the surface, and partly because the dark spiral bands may be either present or absent. It is as a general rule smaller than *T. naticoides*. The whorls are more separate and more swollen. The spiral sculpture is never very prominent, and never includes well-defined nodules, granules or scales. Two of the spiral ridges of the body-whorl are usually more prominent than the others. An interesting feature of the shell is that the columellar callus is not so well-developed as in the other species of the genus, and the shell in consequence is almost subumbilicate. The callus, however, has exactly the same general structure as in *T. naticoides* and its allies.

We found *T. theobaldi* living in abundance in small streams devoid of vegetation both in the Inlé plain and near Kalaw, 2,000 feet higher. It is also common at the latter locality in a subfossil state in the soil, and we obtained single specimens both from the superficial deposits of the He-Ho plain and from the caves at Hsin-Dwang.

**Taia naticoides** (Theobald).

Plate xv, figs. 16, 17; plate xvi, figs. 3-6;
plate xviii, figs. 1-3.

1865. *Paludina naticordes*, Theobald, *op. cit.*, p. 274, pl. ix, figs. 1-3.
1876. *Vivipara Shanensis*, *id.*, *Cat. Land Fresh W. Shells, Brit. Ind. Moll.*, p. 14.
1876. *Paludina naticoides*, Hanley and Theobald, *op. cit.*, pl. lxxvi, figs. 1, & 4.
1884. *Paludina naticoides*, Nevill, *op. cit.*, p. 25.
1899. *Vivipara naticoides* (with var. *obsolescens*[1]), von Martens, *Wiegm. Arch. Naturg.* LXV(1), p. 35, pl. iv, figs. 4, 5.
1909. *Vivipara naticoides*, Kobelt, *op. cit.*, p. 149, pl. xxx, figs. 4-9.
1915. *Vivipara naticoides*, Preston, *op. cit.*, p. 85.

Kobelt gives the following Latin diagnosis of the species :—

Testa exumbilicata, ovato-acuta, solida, crassa, parum nitida, undique oblique costellato-striata, costellis confertis, regularibus, sculptura spirali obsoletissima, olivaceo

[1] Founded on an immature shell.

viridis, fasciis latis castaneis 2 in anfractibus superis, 3 in ultimo ornata. Spira conica apice acuto, nigrofusco ; sutura distincta pallidius marginata, interdum subirregulariter impressa. Anfractus 7 regulariter accrescentes, supri convexi, laeves, inferi ad suturam planati et cingulis spiralibus parum prominentibus distantibus varie cingulati, ultimus interdum subrotundatus, interdum distincte angulatus, postice spirae altitudinem superans, antice vix descendens. Apertura obliqua, irregulariter ovata, faucibus fuscescentibus fasciis translucentibus ; peristoma callo crasso fuscescente continuum, margine externo recto vel (? in spec. adultioribus) leviter expanso, columellari usque ultra basin valde calloso, incrassato, dilatato, interdum saturate fusco, appresso, umbilicum omnino claudente.

Alt. 32, diam. max, 21·5, alt. apert obl. 18, diam. cum perist. 16 mm.

The operculum and radular teeth are figured on pl. XVIII, figs. 1, 2. The teeth are rather paler in colour than those of *T. theobaldi.*

All authors who have referred to and figured the shell have recognized its variability. Theobald in his original description named two varieties (*fasciata* and *carinata*), while Nevill gave the typical form the name var. *concolor.* These varieties, however, as their authors recognized, have no constant character and are linked together by intermediate phases. They represent no more than individual variation, and shells belonging to all of them, and to intermediate phases, occur together under identical conditions. The species also exhibits a certain racial variation correlated with environment. Theobald's specimens, of which some are preserved in the Indian Museum, were from the Upper Salween in the eastern part of the Shan States. Unfortunately we have no information as to the type of environment in which they were found. They are of relatively small size, and of somewhat elongate form, though the body-whorl is usually globose or sub-globose. We found in small sluggish streams on the He-Ho plain a very similar race, exhibiting almost the same variation in shell-characters, but including individuals of somewhat larger size. In ponds and swamps in the Inlé basin there lives a slightly different race, with the shell of somewhat smaller size, a little more globose and never with the sculpture so well-developed as in the var. *carinata.* The differences in both races are beyond the range of exact statistics or of mensuration, depending as they do mainly on differences in outline and details of the prominences on the shell and of colouration. I will, however, discuss them as precisely as possible later (p. 160).

The form that I have described in this paper as *Taia intermedia* (p. 128) is hardly more than a standardized type of *T. naticoides* var. *carinata,* but the fact that it is standardized is of great interest and seems to warrant its reception of a differential name. I have already alluded to the awkwardness inherent in a trinomial nomenclature when large numbers of allied forms have to be considered, and here the difficulty is increased because *intermedia* is to all appearance a fairly constant form derived from and but little differentiated from a most variable species. To adopt for it Theobald's name *carinata* might be legitimate on purely technical grounds, but this would conceal its true relation to *T. naticoides.* Moreover, its identity with the var. *carinata* of that species, though closely approximate, is not absolute (see figs. 3-6, pl. xvi).

The only locality records for *T. naticoides,* apart from Theobald's, are Kobelt's :—Meungyaw in Upper Burma and Lashio in the Northern Shan States.

**Taia intermedia,** sp. nov.

Plate xv, fig. 13 ; plate xvi, figs. 7-9.

I describe this form, as I have already explained, as a distinct species purely as a matter of convenience in nomenclature, for it certainly does not appear to be more than a fixed race of the inconstant species *T. naticoides*. It will be sufficient, therefore, to note the differences that distinguish it.

The shell is always a little more conical than that of *T. naticoides* and has the sculpture of the spiral ridges definitely nodular, but the nodules are small. The main ridge of the body-whorl is not as a rule strongly developed, but in some shells has a scaly character. Occasionally definite squamous projections are present on this ridge, but they are never spiniform and rarely arranged in a regular series. The first four whorls of the spire are smooth, but there are at least two nodular ridges on the fifth whorl. The aperture of the shell, though somewhat variable, is relatively small and narrow.

*Measurements.*

| | mm. | mm. | mm. | mm. |
|---|---|---|---|---|
| Total length ... ... ... | 37 | 34 | 33 | 32 |
| Greatest breadth ... ... | 23 | 22 | 25 | 20 |
| Length of spire (on dorsal surface) ... | 17 | 14 | 14 | 15 |
| Length of aperture ... ... | 15 | 13 | 15 | 14 |
| Greatest breadth of aperture ... | 12 | 10 | 11 | 10 |

*Type-specimen.* M. 11030/2, Zoological Survey of India (*Ind. Mus.*).

Shells are common in a subfossil condition in all the superficial deposits of the He-Ho plain, but the species appears to be extinct.

**Taia obesa** sp. nov.

Plate xv, fig. 19 ; plate xvi, fig. 2.

This species is distinguished from *T. naticoides* mainly by its very thick shell and more globose form. The two basal whorls are considerably swollen, and the outline of the whole shell is less broken. The ventral surface of the basal whorl is considerably swollen. The aperture is very broadly ovoid, sub-angulate posteriorly and rounded anteriorly. The columellar callus is broad, rather flat and very irregularly grooved in a longitudinal direction.

Microscopic transverse striae are abundant and well-developed on the protoconch, forming with the longitudinal striae a well-defined pattern like that of the web of fine cloth. The first five whorls are otherwise smooth. There are either two or three well-defined low spiral ridges on the sixth whorl, on which the microscopic pattern is continued. The ridges are undulate on the surface. On the upper part of the body-whorl there are two ridges that have a marked granular character. The third ridge is more prominent and occasionally exhibits a certain squamosity. Below it there are three lower undulate

ridges. The longitudinal striae are coarser and more irregular on this whorl and have sometimes almost the character of low ridges.

*Measurements of shells.*

| | mm. | mm. |
|---|---|---|
| Total length ... ... ... ... | 40 | 35 |
| Greatest breadth ... ... ... ... | 30 | 26 |
| Length of spire (on dorsal surface) ... ... | 17 | 15 |
| Length of aperture ... ... ... ... | 20 | 18 |
| Breadth of aperture ... ... ... ... | 14 | 13 |

*Type-specimen.* M. 11037/2, Zoological Survey of India (*Ind. Mus.*). A cotype in the collection of the Geological Survey of India.

Four shells of this species, two of which are immature, were found in the cave-deposits of the Hsin-Dawng valley in red soil.

### **Taia shanensis** (Kobelt).

Plate xv, figs. 14, 15; plate xvi, fig. 10; plate xviii, figs. 4-6.

1909. *Vivipara shanensis*, Kobelt (*nec* Theobald), *op. cit.*, p. 411, pl. lxxvii, figs. 4, 5.
1915. *Vivipara shanensis*, Preston, *op. cit.*, p. 93.

There has been some confusion about the specific name *shanensis*. It was first introduced into literature by Theobald in his "Catalogue" (1876) as an absolute synonym of *naticoides*, a name which he had himself used in 1865 for the species here called *Taia naticoides*. He proposed the change of name under the impression that *naticoides* was preoccupied in *Paludina*.[1] Kobelt, however, in 1909, under a misapprehension, revived the name *shanensis*, which had been dropped by Nevill and other Indian authors, but applied it to a different species. He did this, apparently, because he found in Moellendorff's collection specimens of this species labelled "*shanensis*" and stated to have come from the "Gebiet der Shan in Hinterindien," and because he was unaware that the types of *Paludina naticoides*, which was described as from the "Upper Salween," also came from the Shan States. He therefore concluded that the form *shanensis* was at least a "sehr gute Lokalform."

His Latin diagnosis is as follows:—

"Testa exumbilicata, ovato-conica, solida, crassa, oblique striata, in aufractibus inferis spiraliter et peculiariter costata, costis nodosis, nitida, virescenti-fusca, subunicolor vel subnigro trifasciata. Spira elata, apice acuto, nigro; sutura distincta, inter anfractus inferos subirregularis, impressa. Anfractus 7, superi 3 lentissime accrescentes laeves, conulum regularem formentes, superi subscalati, liris spiralibus rudibus tribus primum laevibus, dein tuberculatis, sculpti; ultimus postice fere 3 5 altitudinis aequans, liris tuberculiferis vel sereibus tuberculorum obliquis 4-5 majoribus nonnullisque minoribus cinctus, serie quarta peripherica peculiariter squamosa, aperturam versus supra sub-declivis, subangulatus, ad angulum productus, vix descendens. Apertura irregulariter ovalis, supra accuminata, basi valde recendens, intus concolor vel fasciata; peristoma callo anguste nigro-marginato continuum, margine externo tenui, acuto, ad

[1] Strictly speaking he was correct in this view, for Férussac's *Paludina naticoides*, now placed in the Hydrobiidae, has long priority.

peripheriam subangulato, margine columellari calloso; dilatato fusco, nigromarginato, processum semilunarem, umbilicum omnino occludentem emittente.

Alt. 30, lat. max. 24, alt. apert. obl. 18, diam. 14-15 mm."

The teeth, figured on plate XVIII, fig. 6, are almost black.

The species is a fairly constant one, exhibiting considerable individual variation in shell-colour in respect to the presence or absence of dark spiral bands, but not in sculpture or, except sexually, in form of shell. The shell figured by Kobelt is that of a female; those figured on pl. XV of this paper belong to both sexes. The species seems to be closely related to *T. lacustris*, but the shell is larger, thinner and less produced and its sculpture more regular.

*T. shanensis* lives in great abundance in the marginal zone of the Inlé Lake, especially towards the shore, where the formation of floating islands and of peat is proceeding with the greatest vigour. The food consists largely of a somewhat massive alga of the family Rivulariaceae that contains a considerable proportion of calcareous matter. It is perhaps in correlation with this fact that the radular teeth are thicker and darker than those of the other species examined.

### **Taia cylindrica,** sp. nov.

Plate xv, fig. 9; plate xvii, fig. 2.

The shell is thick, of large size, elongate, with the first five whorls sharply conical, and the two basal whorls subcylindrical, there being 7 whorls in all. The basal whorl is remarkably oblique. The first four whorls form a regular, moderately broad cone. The fifth whorl is considerably broader than the fourth, but its outlines are hardly convex. It is nearly as long on the dorsal surface as the third and fourth whorls together. The sixth whorl is again considerably broader than the fifth, and about twice as long; its outlines are a little more convex. In dorsal view the body-whorl is not much broader than the sixth, but more than twice as long. This is owing largely to the abrupt change in the spiral of the suture. In the first four whorls, which may be taken to represent the protoconch, the suture is very regular and not at all impressed; the fifth whorl is, however, shouldered. Above the sixth whorl the suture becomes impressed, and the upper surface of the whorl is sub-angular. Above the seventh it is also impressed, but considerably more so on the outer part of the shell than on the inner part of the ventral surface. The body-whorl is not shouldered above, and is no broader above than the sixth whorl. The ventral surface of the sixth whorl is considerably swollen. The aperture is broadly ovoid, hardly angulate posteriorly, broadly rounded anteriorly and very oblique both transversely and in its longitudinal plane. The outer lip is slightly produced outwards and downwards. The callus is broad, not so prominent as in some species, irregularly grooved longitudinally.

The first five whorls are almost smooth to the naked eye, but bear numerous longitudinal and spiral microscopic striae. On the fifth whorl traces of a double ridge can be detected in well-preserved specimens. The sixth whorl bears four spiral ridges, one of which is situated at

the lower edge of the whorl. All the ridges are more or less granular. This is the case to a greater extent in the two median ridges. The microscopic sculpture is much as in the upper whorls. There are three irregular ridges on the upper part of the body-whorl, often tending to split up transversely and always irregularly nodular. The longitudinal striae on this part of the shell are much coarser and more irregular, and the transverse striae much less apparent. The fourth spiral ridge on the body-whorl consist mainly of a row of low squamous projections, which are not at all spiniform. Below it there are three or four irregular ridges, nodular, sub-nodular or undulate on the surface.

*Measurements of shells.*

| | mm. | mm. |
|---|---|---|
| Total length ... ... ... ... | 50 | 45 |
| Greatest breadth (without projections) ... ... | 27 | 28 |
| Length of spire (on dorsal surface) ... ... | 25 | 25 |
| Length of aperture ... ... ... ... | 22 | 21 |
| Breadth of aperture ... ... ... ... | 16 | 16 |

I have given the measurements of the two most perfect adult shells we obtained, the first of which I have selected as the type-specimen; but most of our specimens are broken, and some must have attained a considerably larger size.

*Type-specimen.* M. 11028/2, Zoological Survey of India (*Ind. Mus.*).

We obtained over twenty more or less complete specimens in the cave-deposits in which the type of *Taia obesa* was also found, in the Hsin-Dawng valley a few miles east of the town of Yawnghwe.

**Taia lacustris,** sp. nov.

Plate xv, figs. 10, 11; plate xvii, fig. 1;
plate xviii, figs. 7-9.

The shell of this species resembles that of *T. cylindrica* but is considerably smaller, less elongate and less oblique in the body-whorl. Its sculpture is more prominent, and at the same time less definitely nodular. There are two obtuse spiral ridges on the fourth whorl and four on the fifth. The projections on the chief ridge of the body-whorl are irregular and have a less definitely squamous character. The aperture is relatively smaller and less oblique in its longitudinal and transverse axes. The columellar callus is even broader and distinctly more prominent. It retains a fine oily lustre even in the fossil shell.

*Measurements of shells.*

| | mm. | mm. |
|---|---|---|
| Total length ... ... ... ... | 37 | 35 |
| Greatest breadth (without projections) ... ... | 24 | 23 |
| Length of spire (on dorsal surface) ... ... | 20 | 20 |
| Length of aperture ... ... ... ... | 14 | 14 |
| Breadth of aperture ... ... ... ... | 10 | 11 |

The shell sometimes retains a trace of colour. It does not seem to have been banded.

*Type-specimen.* M. 11029/2, Zoological Survey of India (*Ind. Mus.*).

We found a large series of well-preserved shells of this species in a lacustrine deposit at the eastern end of the He-Ho plain. It occurs in the superficial deposits of the same plain, but is there scarce.

Our specimens are fairly uniform in structure and shape, though the details of the sculpture vary slightly. The change in the direction of the suture above the body-whorl is not so marked in all specimens as in the one figured, which is perhaps the best preserved in the series.

The lacustrine deposit in which the shells were found is at least 20 feet deep, and is divided horizontally a few feet above its apparent base by a layer of peat only a few inches thick. The shells were found both above and below this layer, in very fine friable grey clay.

### **Taia analoga,** sp. nov.

Plate xv, figs. 6, 7, 12 ; plate xvii, figs. 3, 4.

The shell is rather narrowly conical, sharply pointed at the apex, moderately thick, entirely non-umbilicate. It has seven complete whorls in addition to a minute vestigial apical whorl or half whorl. The protoconch closely resembles that of *T. intha* but is perhaps a little broader at the base. Indeed, the whole shell is very similar, differences being its greater thickness, rather broader base, larger size, broader columellar callus, broader aperture ; its less regular sculpture and greater variability in size and shape. In this variability it exactly resembles *T. conica* and *T. elitoralis*, to which I regard it as the He-Ho analogue. The main difference between it and the shells of *T. conica*, *T. elitoralis* and *T. intha* lies, however, in the fact that the third (or fourth) spiral ridge of the body-whorl never has a regular series of spiniform projections. This ridge, indeed, is sometimes but little more developed than the two immediately above it. It is more or less squamous and sometimes bears irregular projections of a half scaly, half nodular character. In one of the specimens figured on plate XVII, the spire is not in the same straight line as the body-whorl, but this is evidently no more than an individual abnormality.

*Measurements of shells.*

| | mm. | mm. | mm. |
|---|---|---|---|
| Total length ... ... ... ... | 43 | 37 | 35 |
| Greatest breadth ... ... ... | 27 | 24 | 19 |
| Length of spire (on dorsal surface) ... | 20 | 18 | 18 |
| Length of aperture ... ... ... | 16 | 15 | 14 |
| Breadth of aperture ... ... ... | 12 | 12 | 10 |

*Type-specimen.* M. 11069/2, Zoological Survey of India (*Ind. Mus.*).

We found four shells of this species on the He-Ho plain in superficial deposits. They are all filled with peaty substance. I class the form as subfossil, but it may have considerable antiquity. As it occurred in much smaller numbers than the other forms associated with it, it may not have lived in precisely the same habitat as *T. intermedia.*

**Taia conica,** sp. nov.

Plate xv, fig. 8; plate xvii, fig. 8.

The shell is thick, of moderate size, conical in outline, sharply pointed apically. There are seven complete whorls and a rudiment of an eighth. The protoconch (apart from the rudimentary apical whorl) consists of four whorls, of which the first three have together a pyramidical outline. They are all very small. The fourth whorl is considerably broader, but not very much deeper than the third, and the four together are only a little longer than the fifth, while the five are not much longer than the sixth, and the six a little shorter than the seventh or body-whorl. The suture is not deeply depressed; on the spire it runs almost transversely across the shell, but above the body-whorl assumes a marked outward and downward obliquity. None of the whorls are swollen. The spire as a whole is conical, the body-whorl, as seen from below, truncate-ovoid, the broader and rounded end being situated anteriorly. The aperture is oblique, broad and patent, subtriangular but with all the angles rounded. The lip is a little expanded outwards and forwards and joins the columellar callus at the posterior end of the aperture. The callus is very broad and almost smooth.

The whorls of the protochonch are somewhat worn, though not at all eroded, in my specimens. Traces can still be seen under the microscope of a pair of spiral ridges. These ridges grow stronger on the fourth whorl and gradually assume a coarsely granular structure. On the fifth whorl they are still stronger, and a third ridge begins to arise below them round the base of the whorl. On the sixth whorl they remain much as on the fifth, but the new ridge becomes stronger and more tubercular, while a fourth, which has from its commencement an irregularly tubercular structure, appears at the base of the whorl and soon grows stronger than any of the others; on the ventral surface of the shell its projections assume a distinctly squamous appearance. It is this ridge that becomes the chief ridge of the body-whorl, on which the upper of the two primitive ridges grows obsolete and disappears. On the chief ridge of the body-whorl a series of strong but not exactly spinous scale-like projections appear. They are truncate apically and strongly concave outwardly. Below the chief ridge two others and finally traces of a third make their appearance. These three ridges are undulate or irregularly serrate on the surface.

As the shell is only known as a fossil, nothing can be said about its natural colouration. It is actually yellowish white, stained with red. It retains a certain degree of translucency.

*Measurements of type-specimen.*

| | mm. |
|---|---|
| Total length ... ... ... ... ... | 46 |
| Greatest breadth (without projections) ... ... ... | 27 |
| Length of spire (on dorsal surface) ... ... ... | 18 |
| Length of aperture ... ... ... ... | 21 |
| Breadth of aperture ... ... ... ... | 16 |

*Type-specimen.* M. 11018/2, Zoological Survey of India (*Ind. Mus.*) : a co-type in the collection of the Geological Survey of India.

I have examined 9 specimens. They were found in cave-deposits on the eastern slope of the Hsin-Dawng valley. Some of the specimens, including the one selected as type and figured on plate XV, are in a very perfect condition.

**Taia elitoralis,** sp. nov.

Plate xv, figs. 4, 5 ; plate xvii, figs. 5, 6 ;
plate xviii, figs. 13, 14.

In this living species the shell is considerably thinner and as a rule smaller than in *T. conica*, apparently more variable in shape and more regular in sculpture. At any rate in the male shell the spire is relatively narrower and more elongate, but there is considerable individual and sexual variation in this respect. The suture is a little more impressed and not so oblique above the body-whorl. The whorls of the protoconch are still smaller but relatively broader. The ornamentation has essentially the same pattern but the squamous processes on the body-whorl are more numerous, more prominent and more spiniform.

*Measurements of shells.*

| | mm. | mm. | mm. | mm. |
|---|---|---|---|---|
| Total length ... ... ... | 39 | 46 | 35 | 36 |
| Greatest breadth (without projections) | 24 | 24 | 22 | 23 |
| Length of spire (on dorsal surface) ... | 19 | 25 | 17 | 18 |
| Length of aperture ... ... | 16 | 20 | 18 | 17 |
| Breadth of aperture ... ... | 11 | 16 | 14 | 13 |

The epidermis is thin. When not stained by the growth of minute algae it is brown on the three last whorls, and practically colourless on the protoconch. It becomes gradually darker towards the anterior end of the shell. The shell-substance is white and translucent, except in the protoconch, in which it is bluish-grey and opaque. There are no dark spiral bands. The interior of the shell is lustrous and has a strong white opalescence.

The operculum is dark brown, broadly ovoid, somewhat sinuous on the outer margin, and a little produced posteriorly, though the apex is blunt. The inner margin is strongly convex. The external surface is concave, the false nucleus excentric and situated near the outer margin ; the lines of growth are strongly marked. The internal surface is convex, its muscular scar relatively large, and of a broadly ovoid shape, approaching the outer surface of the operculum for a considerable distance. The inner margin is membranous.

The external soft parts are precisely like those of *Vivipara*. The radular teeth are elongate, those of the marginal and outer lateral rows particularly so, and all have a rather pale brown colour. The central teeth are short and broad, truncate and very slightly emarginate above, with the sides slightly sinuous; the lamellar projection of the edge is broad, shallow and nearly symmetrical; it has five small denticulations on either side. The lateral teeth are stout, considerably longer than the central teeth and produced vertically into a fine process at the inner basal angle. Their lamellar process is broad, and has three or four stout denticulations on either side of it. The teeth of the two outer rows are sub-equal and much longer than those of the inner lateral row. The inner marginal teeth are narrow and produced triangularly at the base; the lamellar projection points slightly inward but is submedian; it is small and the denticulations are rather feeble. The outer marginal teeth are similar in form but slightly broader. Their denticulations are slender and rather long in the middle of the edge, becoming gradually shorter on either side.

*Type-specimen.* M. 11012/2, Zoological Survey of India (*Ind. Mus.*).

*Habitat.* This species lives in the Inlé Lake. It is not found in the middle of the lake, though it avoids water fouled with decaying vegetation, but inhabits the outer edge of the marginal zone (*i.e.*, the intermediate zone of the lake), concealing itself amongst dense vegetation. Individuals occasionally stray through the ring of floating islands that surround the lake. We found a few shells in a pool in the swamp at the northern end, and even in the canal at Yawnghwe. The species is much less abundant than either *T. intha* or *T. shanensis*. We obtained only 12 specimens.

### **Taia intha,** sp. nov.

Plate xv, figs. 1-3; plate xvii, fig. 7;
plate xviii, figs. 10-12.

The shell is fairly thin, of relatively small size, narrowly and regularly conical, with the spire produced and tapering and the apex sharply pointed; it is not at all umbilicate. When complete it has eight whorls, but the apical whorl is minute and often disappears in adult shells. It is, therefore, best ignored in reference to them. I will describe the embryonic shell presently. In that of the adult the first two whorls (apart from the vestigial apical whorl) are minute, rounded and smooth; the third whorl, though still very small, is as long as the first and second together; the fourth is twice as broad as the third and as long as the second and third together. These four whorls in a sense represent the protoconch, though they do not represent the complete embryonic shell. Below the fourth there is a slight change in the direction of the spiral often accompanied by a constriction of the shell. The upper part of the fifth whorl is very little broader than the base of the fourth, and it does not increase much in breadth towards its own base. The sixth whorl is much broader and deeper, and increases gradually on to the seventh or

body-whorl, which is obliquely transverse and usually shorter than the spire. Except the smaller whorls of the protoconch none of the whorls are swollen or shouldered. The suture is not impressed except above the fifth and seventh whorls and there only slightly. The aperture is broadly ovoid, oblique, of moderate size, hardly angulate posteriorly, broadly rounded anteriorly. The columella is strongly arched, the columellar callus broad, smooth, and polished. The outer lip is thin.

The spiral sculpture commences on the third complete whorl, on the dorsal surface of which a faint groove appears. As this groove curves round the shell its margin becomes gradually raised until it assumes the appearance of a pair of smooth highly convex ridges. The double ridge thus formed proceeds on to the fourth whorl, becoming gradually stronger and assuming a granular structure. On the sixth whorl it becomes regularly tubercular and a single ridge appears below it at the base of the whorl near the inner edge of the dorsal surface. Almost from its point of origin this new ridge has a squamous appearance, and bears small, not at all granular projections. On the body-whorl the primitive paired ridge persists, but its tubercles become irregular and more or less confluent. The ridge that appeared on the sixth whorl also persists and grows stronger, its projections taking the form of short spiniform processes, blunt at the tip and concave outwards and forwards. Below this ridge there are two and a half or three others, all of which are rather feebly developed and undulate rather than tubercular.

*Measurements of shells (in millimetres).*

| | | | | |
|---|---|---|---|---|
| Total length ... ... ... | 31 | 31 | 32 | 31 |
| Greatest breadth (without projections) | 20 | 18 | 20 | 20 |
| Length of spire (on dorsal surface) ... | 16 | 17 | 15 | 15 |
| Length of aperture ... ... | 15 | 12 | 15 | 14 |
| Breadth of aperture ... ... | 10 | 9 | 11 | 10 |

The colour of the external surface of the shell is very pale olivaceous green tinged with ferruginous brown. The protoconch is brownish or colourless ; the fifth and sixth whorls are paler than the body-whorl but the colour is shaded gradually. The spiral ridges are a little darker than the rest of the surface, but there are no definite dark spiral bands. The shell substance is whitish and translucent, except in the protoconch, in which it is bluish-grey. The inner surface is whitish, tinged with brown, but with opaque white bands corresponding in position with the spiral ridges. This surface is lustrous and has a milky opalescence. The columellar callus is brown externally and white internally, very highly polished.

The embryonic shell, removed from the parent at full time, consists of six whorls, but the apical whorl, which often disappears in the adult shell, is minute. The external colour is very pale green with several light brown spiral bands. The shape is sub-conical, but the main axis is oblique and the part surrounding the aperture somewhat produced. The first five whorls have a different character from the sixth, in which there is an abrupt change of direction in the spiral. The minute apical whorl is smooth ; on the second whorl a rather

obscure, broad spiral ridge appears; on the third this grows stronger while on the fourth it becomes double; on the fifth whorl there are three ridges of this kind, and on the sixth, which represents the upper part of the fifth whorl in the adult shell, there are five. On this whorl the two upper ridges become definitely nodular.

The operculum of *T. intha* closely resembles that of *T. elitoralis*, but is thinner and less produced posteriorly. The radular teeth are of a bright golden colour. They differ from those of *T. elitoralis* mainly in proportions; a characteristic feature that both have in common is the coarseness of the lateral denticulation of the central tooth. The differences are that the upper margin of the central teeth is convex, the teeth of the inner lateral row are rather larger, only a little longer than the central teeth, and distinctly shorter than the marginal teeth.

*Type-specimen.* M. 11004/2, Zoological Survey of India (*Ind. Mus.*).

*Habitat, etc.*—This species only lives in the central region of the Inlé Lake, where it is extremely abundant. It crawls slowly on the bottom, on weeds and on posts, but is very sluggish, and often remains for days without moving. Its food consists of minute algae of a very soft consistency.

As I have examined many hundreds of specimens of this remarkable species I am able to speak with confidence of its constancy. There is very little sexual variation in the shell and I did not always find it possible to distinguish males from females by the shell alone. The only characters in which individual variation was found were the development of the spiniform processes, the number of spiral ridges, the degree of attenuation of the spire, and changes in the direction of the spiral. In all these points, moreover, the shells that exhibited variation were what a lepidopterologist would call aberrations. Shells occur occasionally, but very rarely, in which the spiniform processes are developed on the basal ridge of the penultimate whorl as well as on the body-whorl. A shell of this kind is figured on pl. XV, fig. 2. Shells in which there are three instead of two tubercular ridges above the main ridge of the body-whorl are less rare, and others in which the spire is considerably more attenuated than usual are still more common, while shells in which there is an abrupt change in the spiral at more than one point are not uncommon. In no case, however, is the abnormality at all extreme. Towards the edge of the lake shells are a little larger than those out in the middle, but the average difference in length is not more than 2 mm. The larger shells, moreover, sometimes have the sculpture slightly less regular and the body-whorl broader. There is, however, no transition to *T. elitoralis*.

## Family AMPULLARIIDAE.

1915. *Pilidae*, Preston, *op. cit.*, p. 96.

### Genus **Ampullaria**, Lamarck.

1911. *Pachylabra*, Kobelt, in Martini and Chemnitz's *Conch. Cab.* (ed. Küster), I, pt. II *Ampullaria*, p. 44.
1915. *Pila*, Preston, *op. cit.*, p. 96.

Kobelt has shown that the American species to which the name *Ampullaria* belongs in a restricted sense differ from those of Africa and

Asia in having a horny operculum. He, therefore, calls the latter *Pachylabra*, Swainson. Preston calls them *Pila*, Bolten. I am not convinced, however, that the generic division is necessary, and in the case of generic names I am not in favour of disinterring those which have long been buried and forgotten, even if this be done with due rites and in accordance with law.

Only a single species of *Ampullaria* was found in the Inlé basin and none were obtained, either recent or fossil, on the He-Ho plain.

### **Ampullaria winkleyi,** Pilsbry.

Plate xii, fig. 10.

1901. *Ampullaria Winkleyi*, Pilsbry, *Proc. Ac. Nat. Sci., Philadelphia*, LIII p. 189, pl. v, figs. 2, 3.
1915. *Pila winkleyi*, Preston, *op. cit.*, p. 103.

This species is somewhat plastic. In specimens from streams running out of hot springs on the western side of the lake, the shells are not longer than 45 mm. and have the mouth narrow, while those from flooded rice-fields in the same district reach 65 mm. and have the mouth somewhat broader, though a little narrower than in Pilsbry's figure. The latter specimens are also paler in colour. Specimens from the edge of the Inlé Lake and from the Yawnghwe river are intermediate. Probably the most characteristic and the most constant feature of the species is the concentric sculpture of the columellar side of the scar of the operculum. This is constant in a large series and differentiates the operculum from those of *A. conica*, Gray and *A. compacta*, Reeve, in both of which the sculpture is irregular and without definite pattern.

As in many other species, the resting-stages in growth are often marked by distinct ridges on the shell, and in some specimens from two to four distinct regions can be distinguished on the body-whorl in this way. In the specimen figured on pl. X there are four regions of the kind and the last one is much paler in colour than the remainder of the shell.

The species was described from Henzada, Pegu. According to Pilsbry it is somewhat allied to *A. begini*, Morlet, a species distributed through the whole of Cambodia and on the lower Mekong.

## Pelecypoda.

### Order **TETRABRANCHIA.**

### Family UNIONIDAE.

### Genus **Physunio,** Simpson.

1900. *Physunio*, Simpson, *Proc. U. S. Nat. Mus.*, 22, p. 830.

Two species from the Inlé basin that represent this genus both belong to the section *Physunio, s.s.*

**Physunio micropteroides,** sp. nov.

Plate xix, figs. 1-3.

Shell inequilateral, suboval, elongate, thin, with a broad low blunt wing on the dorsal margin, rounded anteriorly, subtruncate and often a little produced posteriorly, with a pair of low diverging ridges (obsolete in old shells) proceeding backwards and downwards from the umbo, with coarse irregular transverse striae on the surface, slightly inflated; the umbo rounded, not at all prominent; epidermis dark brown, with obscure concentric transverse dark or black lines; nacre rather dull, of a livid bluish tint; lateral tooth long, thin, nearly straight, on right valve trifid almost from its point of origin, on left valve simple, its hinge-margin obscurely corrugated; pseudo-cardinal teeth on both the valves very short, curved, prominent, rounded ventrally, the left tooth with the edge produced triangularly and somewhat retroverted; edge smooth on both teeth.

*Measurements of shells (in millimetres).*

| | Type. | | |
|---|---|---|---|
| Length of shell ... ... ... | 58 | 55 | 55 |
| Greatest depth of shell ... ... ... | 37 | 36 | 37 |
| Thickness of shell ... ... ... | 15 | 16 | 15 |

*Type-specimen.* M. 11048/2, Zoological Survey of India (*Ind. Mus.*).

*Habitat.*—Sluggish streams on the Yawnghwe plain, in dense mud in about 3 feet of water.

This species is very closely allied to *Physunio micropterus* (Morelet), with shells of which from Cambodia I have compared my specimens. It differs, however, in the form of the hinge, in its even less produced wing, in its less prominent umbo and darker colouration.

I hope that Dr. Ekendranath Ghosh will shortly publish a general account of the anatomy of this and the succeeding species.[1] Mr. Baini Prashad has given me a paper for this volume on the glochidia and marsupium of both.

The glochidium is parasitic on the fins of the small loaches *Nemachilus brevis*, Boulenger and *N. brunneanus*, mihi.

**Physunio ferrugineus,** sp. nov.

Plate xix, figs. 4-9.

This species is allied to the last one, but larger, with a thinner shell, with the wing better developed, with the diverging longitudinal ridges stronger, with the striae on the external surface finer and more regular, with the epidermis of a rich iron-brown (sometimes with darker concentric lines), with the nacre paler, with the lateral teeth more prominent and the pseudo-cardinal teeth of a different shape (see figures). In general appearance the young shell resembles *P. semialatus*.[2]

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[1] In *Rec. Ind. Mus.*, XV (1918). The paper is now in press.

[2] Deshayes and Jullien, *Nouvelles Archives du Museum*, X, p. 123, pl. vi, fig. 1, 2, *Bulletin*, 1874.


Figs. 1-3.—Hinges of shells of *Physunio.*

Fig. 1. *Physunio microptervoides.* Type-specimen from the Yawnghwe river. *a*=pseudocardinal teeth enlarged.
Fig. 2. *Physunio microptérus.* Shell from Cambodia for comparison.
Fig. 3. *Physunio ferrugineus.* Type-specimen from the Inlé Lake. *a*=pseudocardinal teeth of same specimen enlarged; *b*=same teeth of another specimen also enlarged.

The shape is variable (see figures). I figure on pl. XIX a series showing different growth-stages as well as variation in old shells.

*Measurements of shells (in millimetres).*

| | Type. | | |
|---|---|---|---|
| Length of shell ... ... ... | 71 | 73 | 70 |
| Greatest depth of shell ... ... ... | 47 | 49 | 50 |
| Thickness of shell ... ... ... | 18 | 18 | 20 |

*Type-specimen.* M. 11290/2, Zoological Survey of India (*Ind. Mus.*).

*Habitat.*—This mollusc is very abundant in the semi-liquid mud at the bottom of the central region of the Inlé Lake in water from 7 to 12 feet deep. Its position of rest in the mud is with the longer axis vertically upright and the valves buried nearly as far as the posterior end of the wing. It progresses through the mud by thrusting out the foot downwards and forwards. This forces the whole animal in the opposite direction and at the same time presses the dorsal edge of the valves downwards. The foot is then withdrawn and the shell regains its vertical attitude a little in advance of its former position. The foot is thrust out again and the movement repeated. The result is that the mollusc progresses with a see-saw motion, dorsal edge in front, the wing assisting greatly in overcoming friction by acting as a kind of ploughshare. The posterior end of the valves is often covered with a massive brown alga of the family Rivulariaceae.

The glochidium is parasitic on the fins of *Barilius auropurpureus, mihi.*

## Suborder **Conchacea.**

## Family CYRENIDAE.

### Genus **Corbicula,** Mergerle.

### **Corbicula noetlingi,** v. Martens.

Plate xix, fig. 12.

1899. *Corbicula Noetlingi,* von Martens, op. cit., p. 47, pl. iv, figs. 7-9.

Shells from the Inlé and He-Ho basins differ from those figured by von Martens in being somewhat longer. There is, however, some individual variation in this respect, and probably greater plasticity. Shells from Thamakan (alt. 4,000 feet) approach the typical form in shape more nearly than do those from the Inlé basin.

*Measurements of shells (in millimetres).*

Specimen A is from Thamakan, specimen B from the Yawnghwe river, while specimen C was found subfossil in the superficial deposits of the He-Ho plain; specimens D and E, an adult and a young shell, are recent and from the same locality as C.

| | A. | B. | C. | D. | E. |
|---|---|---|---|---|---|
| Length of shell ... ... | 21·75 | 21 | 22·25 | 29·5 | 14·5 |
| Height of shell ... ... | 18·25 | 18·5 | 20·5 | 26·25 | 11·25 |
| Transverse diameter ... | 11·75 | 11·5 | 14 | 16·5 | 8·25 |

No species of *Corbicula* was found in the Inlé Lake, but C. *noetlingi* is abundant in ponds, marshes and slow streams in its basin and also in similar situations at He-Ho and Thamakan. Even the thinnest-shelled forms of the genus would sink in the semi-liquid mud of the lake.

The species was described from the Northern Shan States.

### **Pisidium casertanum** (Poli).

Plate xix, figs. 13, 14.

? 1878. *Pisidium hydaspicola*, Theobald, *Journ. As. Soc. Bengal*, XLVII, p. 147.
1900. *Pisidium* (*Fluminina*) *dubium*, Lindholm in Korotneff's *Wiss. Ergebn. Zool. Exp. Baikal-See*, IV (Moll.), p. 85, pl. ii, figs. 45, 46.
1913. *Pisidium casertanum*, Woodward, *Cat. Brit. Pis.*, p. 31, pls. i, figs. 3-6, iii, fig. 3, xiii-xviii.
? 1915. *Pisidium hydaspicola*, Preston, *op. cit.*, p. 225, fig. 27.
1916. *Pisidium casertanum*, Annandale, *Mem. As. Soc. Bengal*, VI, pl. i, p. 53, pl. iii, fig. 14.

Specimens from the Inlé Lake and the He-Ho plain are so like those from Japan, examined by Woodward, in structure and appearance that they must be assigned to the same species. Their shells differ from those from Lake Biwa in being as a rule still smaller, in being subtruncate posteriorly and in having the umbo more prominent. In outline they closely resemble Lindholm's figure of his *P. dubium* from Lake Baikal, but the shell is smaller, evidently thinner and more transparent and the external striae closer, finer and more regular. A specimen from the He-Ho stream is more globose than those from the Inlé Lake and a little broader.

The following measurements (in millimetres) are those (A) of the He-Ho shell, (B) and (C) of shells from the lake.

| | A. | B. | C. |
|---|---|---|---|
| Length ... ... ... ... | 3·75 | 3·5 | 2·75 |
| Height ... ... ... ... | 3·0 | 3·0 | 2·25 |
| Transverse diameter ... ... ... | 2·25 | 1·75 | 1·05 |
| Height to length ... ... ... | 1 : 1·18 | 1 : 1·16 | 1 : 1·22 |
| Transverse diameter to height ... ... | 1 : 1·33 | 1 : 1·7 | 1 : 1·8 |
| Transverse diameter to length ... ... | 1 : 1·66 | 1 : 2·0 | 1 : 2·2 |

The specimen from the He-Ho was found in a crevice in the bark of a tree-trunk submerged at the edge of the stream in a kind of small backwater. In the soft mud of the central region of the Inlé Lake the species is not uncommon. In shells from this mud the posterior extremity is coated with a reddish substance precisely as in Japanese deep-water specimens. There is no deposit of the kind on the He-Ho shell.

*P. casertanum* is widely distributed in Europe. In Asia it has been reported only from Lake Baikal in Siberia (2-3 fathoms) and from deep water (17-30 fathoms) in Lake Biwa in Japan. It seems to me by no means improbable that *P. atkinsonianum*, Theob., which is not uncommon in small pools in streamlets in the Eastern Himalayas at altitudes between 5,000 and 10,000 feet, is merely a dwarfed form of the species, and I am very doubtful whether *P. hydaspicola*, Theob., from Kashmir is specifically distinct.

## PART II.—PALAEONTOLOGICAL.

The deposits in the Inlé and He-Ho basins from which fossil and subfossil shells were obtained are of three classes: (1) cave-deposits, (2) lake-deposits and (3) superficial deposits on the banks of streams and in dried-up marshes.

### CAVE-DEPOSITS.

The cave-deposits were discovered in two small limestone caves on the eastern slope of the valley of the Hsin-Dawng stream some three miles east of the town of Yawnghwe. They are at a height of three to five hundred feet above the level of the Inlé Lake and in what was probably the basin of a small but deep subsidiary lake that dried up at a period long before the He-Ho lake disappeared. Unfortunately there are no precise data for fixing the age of the deposits, but it seems legitimate at any rate to class the animal remains as fossil. These remains were in or upon the surface of banks of red soil, the depth of which was not ascertained. They consisted (apart from teeth of the Thamin, *Cervus eldi*—probably those of a single individual) of shells of *Taia* and *Melania*, those of the former genus being abundant but the latter represented by a single specimen. In other words, the smaller molluscs such as the Limnaeidae and Hydrobiidae that are likely to have existed in the fauna are entirely absent, while the larger shells of more expanded form are well represented. This is probably due to the fact that shells of *Taia* when dry and full of air or gas float readily on the surface of water,[1] while those of molluscs of smaller size or more contracted shape such as *Planorbis* or *Hydrobioides* as a rule sink. If this theory be correct the shells must have floated on the surface of a lake or pool until they were stranded at the base of limestone rocks and there been buried. Their unworn condition proves that they have not been carried by running water.

The remains from these cave deposits represent the following species:—

| Mammalia. | Mollusca. |
|---|---|
| *Cervus eldi.* | *Melania variabilis.* |
| | *Taia obesa.* |
| | *Taia cylindrica.* |
| | *Taia conica.* |

These remains must have been contemporaneous, but it is by no means improbable that the molluscs lived in different types of environment and were brought together in the manner indicated. The deer and the *Melania* survive, the species of *Taia* are all extinct.

### LAKE-DEPOSIT.

At the north-east corner of the He-Ho basin there is, between two limestone spurs, a small plain through which the He-Ho river has cut for itself a narrow but rather deep bed. On the north side of this bed

[1] This was observed both in the Inlé Lake and in the He-Ho streams.

a deposit of about 20 feet deep is exposed. It consists for the most part of grey clay of great friability and composed of very minute particles mixed with fragments of vegetable origin. This clay seems to be precisely similar to that now being deposited in the open parts of the Inlé Lake and we may take it that the deposit is of true lacustrine origin. There is evidence, however, that conditions did not remain uniform throughout the period of its deposition, for there exists, about 5 feet above the base of the exposure, a layer of black peaty substance not more than six inches deep. This layer must have been formed in conditions different to those in which the friable clay was laid down and points to a brief interruption in the formation of the deposit. The whole exposure, nevertheless, is full of shells and no difference can be detected between those above and those below the peaty layer. The shells found in this deposit were :—

*Limnaea*, sp. ? nov.
*Limnaea shanensis.*
*Planorbis trochoideus.*
*Hydrobioides nassa distoma.*
*Taia lacustris.*

The most abundant form was the *Taia*. Though in a rather brittle condition and often broken, none of the shells were at all waterworn. No other animal remains were observed. I think that the shells should be regarded as fossil. The *Hydrobioides*, the *Taia* and possibly one of the *Limnaeae* are extinct.

## Superficial Deposits.

The superficial deposits of the He-Ho basin are of two kinds. Firstly we have masses of exposed and usually broken shells lying on the banks of the He-Ho river in sheltered places. The largest of these is on the northern bank just above the point at which the stream plunges downwards through a narrow gorge into the Inlé plain. This deposit is situated a mile to a mile and a half east of the lacustrine deposit exposure already described and lies at an altitude of about 3,600 feet, *i.e.*, about 600 feet higher than the Inlé Lake. To judge from the molluscs represented in it, it is mainly a marginal deposit formed at the edge of the old He-Ho lake. This is indicated in particular by the abundance of shells of *Succinea*. Some of the shells are, however, slightly waterworn.

The species are :—

*Succinea indica.*
*Limnaea shanensis.*
*Planorbis saigonensis.*
*Melania baccata elongata.*
*Hydrobioides turrita.*
*Hydrobioides nassa distoma.*
*Amnicola alticola.*
*Taia theobaldi.*
*Taia intermedia.*
*Taia lacustris.*
*Corbicula noetlingi.*

No other animal remains were found, except a few land shells, which may have been quite recent. They include a *Plectopylis* still living in the He-Ho gorge. Probably all the shells should be regarded as subfossil. They include only two apparently extinct species, namely *Taia lacustris* and *T. intermedia*. The race *distoma* of *Hydrobioides nassa* is also extinct.

The other kind of superficial deposit in the He-Ho basin is of a peaty or calcareous nature, the calcareous parts taking the form of narrow ridges of tufa in the masses of peat. No difference could be detected between the species from the tufa and those from the peat, but there is evidence that the shells had in some instances been carried about for short distances by the streams whose beds are represented by calcareous ridges,[1] and it is probable that all are not precisely of the same age. Specimens of *Melania baccata* and of *Planorbis exustus* in some cases retain their epidermis, which has entirely disappeared from the other shells. The fresher specimens were as a rule found embedded in tufa. The species are :—

*Planorbis exustus.*
*Melania tuberculata.*
*Melania baccata elongata.*
*Hydrobioides nassa distoma.*
*Taia intermedia.*
*Taia lacustris.*
*Taia analoga.*
*Corbicula noetlingi.*

These species and races, with the exception of *Taia intermedia*, *T. lacustris* and *T. analoga*, still survive. The shells are probably not all contemporaneous but the deposits as a whole evidently represent the last stages of the old He-Ho lake, when it had already become a mere swamp and parts of its bed were practically dry, with small streams winding through them. I class the shells as subfossil.

In this section of the paper mention should also be made of the extinct phase of *Limnaea shanensis* dredged from the bottom of the Inlé Lake. It was the only fossil or subfossil shell found in this position.

## PART III.—GEOGRAPHICAL.

### I. LIVING MOLLUSCA.

In considering the geographical relationships of the fauna of the Inlé Lake it is necessary to consider also those of the non-lacustrine aquatic fauna of connected waters. In the following list I have included the names of all the species and races of Mollusca found in streams, pools and marshes in both the Inlé and the He-Ho basins, as well as those of the species and races that live in the lake. The fossil and subfossil forms of the district I will consider separately.

#### *Gastropoda.*

*Succinea indica.*
*Limnaea andersoniana.*
*Limnaea shanensis.*
*Limnaea mimetica.*
*Planorbis exustus.*
*Planorbis velifer.*
*Planorbis trochoideus.*
*Planorbis calathus.*
*Planorbis caenosus.*
*Melania tuberculata.*
*Melania terebra.*
*Melania baccata elongata.*
*Paludomus ornata.*
*Hydrobioides nassa.*
*Hydrobioides nassa lacustris.*
*Hydrobioides physcus.*
*Hydrobioides avarix.*
*Hydrobioides nana.*
*Amnicola alticola.*
*Vivipara lecythis.*
*Taia naticoides.*
*Taia theobaldi.*
*Taia shanensis.*
*Taia elitoralis.*
*Taia intha.*
*Ampullaria winkleyi.*

[1] See the Introduction to this volume, p. 5.

*Pelecypoda.*

| | |
|---|---|
| *Physunio micropteroides.* | *Corbicula noetlingi.* |
| *Physunio ferrugineus.* | *Pisidium casertanum.* |

In this list of 30 species and races we have the names of 13 genera. Of these, 10 are of wide distribution, one distinctly Indo-Chinese, and 2 peculiar to Burma.

The widely distributed genera have, as genera, little geographical interest. The characteristic Indo-Chinese genus (*Physunio*) is, however, interesting because it represents a real element in the fauna of the Shan Plateau. This genus, of which one species (*P. velaris*, Sow.) has penetrated as far west as Assam, and another to Sumatra, is found mainly in Cambodia, Cochin China and Siam. The Inlé species belong to a Siamese-Cambodian section of the genus, while the Assamese form represents a section of wider range.

The endemic Burmese genus *Hydrobioides* bears in some respects the same relation to the widely distributed *Bithynia* as *Taia* does to the still more widely distributed *Vivipara*. Both genera have probably originated on the Shan Plateau, but have spread sparsely beyond its borders.

Of the 30 names on the list 28 are those of the *formae typicae* of their species, while 2 are those of races or subspecies. Of the 28, 16 (more than half) are those of species endemic or practically endemic on the Shan Plateau, while 7 (one quarter) are those of species only known from the Inlé basin. It is clear, therefore, that a well-marked endemic Shan element is present among the aquatic Mollusca of the district. It is represented by 17 out of 30 species and races, *i.e.*, by over 50 per cent. of the whole.

No other geographical element is so conspicuous. One Western Chinese species (*Limnaea andersoniana*) has been found, while only two (*Paludomus ornatus* and *Ampullaria winkleyi*) apart from endemic Shan forms are exclusively Burmese or Burmese and Assamese, and one (*Vivipara lecythis*) Assamese, Burmese and Western Chinese. These four species (a little less than one-seventh of the species represented in the fauna) may be considered to compose together a Far Eastern element.

Two species (*Melania tuberculata* and *Planorbis exustus*) are widely distributed in the Oriental region and *M. tuberculata* ranges far beyond the limits even of that region. It is probable that three other species (*Planorbis calathus*, *P. caenosus* and *P. trochoideus*) have also a wide Oriental distribution, but their minute size has caused them to escape the notice of collectors, and the records of their occurrence are few and scattered.

Evidence of the existence of a Palaearctic element, though not very definite, is not altogether lacking. *Pisidium casertanum* has hitherto been found only in the Palaearctic Region, and the form that lives in the Inlé Lake closely resembles those only known hitherto from the eastern part of the Region, from Lake Baikal and Japan. The existence of a species allied to the Tibetan *Limnaea bowelli* on the Shan Plateau points in the same direction.

No exclusively Indian species is on the list, but *Melania terebra* has been known hitherto only from Assam, and *Succinea indica* from the Himalayas.

The living molluscan fauna of the Inlé and He-Ho basins is, therefore, to a considerable extent endemic, so far as species are concerned. A Far Eastern element, represented by one genus and by about one-seventh of the species, is also apparent. A certain proportion of the species, as well as the great majority of the genera, are of wide geographical range, while two of the species are Palaearctic or have strong Palaearctic affinities. Most of the characteristic genera of Indo-China (*e.g.*, *Lacunopsis*, *Julliena*, etc.) are, however, absent and the Palaearctic forms are both Eastern. It seems by no means improbable, therefore, that the Far Eastern element has immigrated on to the plateau from the north-west, but the importance of the absence of such genera as *Lacunopsis* and *Julliena* is somewhat decreased by the fact that they are mainly fluviatile, whereas the fauna with which we are dealing is predominantly lacustrine. The Palaearctic forms, moreover, may have been introduced by migratory water-birds such as ducks, and have been able to survive owing to the comparatively low temperature of the plateau. We know that one of them has been established in the neighbourhood for a considerable period.

## 2. Fossil and Subfossil Mollusca.

I have already discussed the different deposits in the Inlé and the He-Ho basins from which shells of aquatic Mollusca have been obtained. Here it is only necessary to consider the shells in two categories, those of fossil and of subfossil forms. The distinction is of course conventional.

The fossil forms were found in two beds, in cave-deposits near Yawnghwe in a basin probably at one time subsidiary to the Inlé basin, and in an old lake-deposit in the He-Ho plain. In these two beds the following species and subspecies occur :—

*Limnaea*, ? sp. nov.
*Limnaea shanensis.*
*Planorbis trochoideus.*
*Melania variabilis.*
*Hydrobioides nassa distoma.*
*Taia theobaldi.*
*Taia obesa.*
*Taia conica.*
*Taia cylindrica.*
*Taia lacustris.*

Of these 10 forms, 6 (5 species and 1 subspecies) are apparently extinct and have not been found elsewhere. Moreover, of the four surviving species only *Planorbis conoideus* and *Taia theobaldi* survive in identical form, the shells of *Limnaea shanensis* and the *Melania* (which we did not find living in either basin) being slightly different from those of living individuals.

The subfossil shells were taken in superficial deposits on the He-Ho plain. The following is a list of the species and subspecies :—

*Succinea indica.*
*Limnaea shanensis.*
*Planorbis exustus.*
*Planorbis saigonensis.*
*Planorbis trochoideus.*
*Melania tuberculata.*
*Melania baccata elongata.*
*Hydrobioides turrita.*
*Hydrobioides nassa distoma.*
*Amnicola alticola.*
*Taia intermedia.*
*Taia theobaldi.*
*Taia analoga.*
*Corbicula noetlingi.*

Most of these shells are specifically identical with those now found living in the Inlé basin and only two species (*T. analoga* and *T. intermedia*) are apparently extinct. *Hydrobioides turrita*, originally described from the Irrawaddi, was not found living in the district, while the race of *Planorbis saigonensis* that survives in the Inlé Lake has changed so considerably that it has to be described as a new species. The shells of *Succinea*, *Limnaea* and *Hydrobioides* from these deposits also differ, but in a less degree, from those of the living forms.

The extinct forms have not been found elsewhere. Among the living forms there is less apparent trace of the Far Eastern element noted among the living mollusca of the district, but the endemic element is as clearly marked, represented by the same genera (*Hydrobioides* and *Taia*) and by 7 species and subspecies out of 14. We have, however, in these fossil and subfossil forms a much less complete record of the fauna than in the case of the living Mollusca.

### 3. Conclusions.

The geographical conclusions to be drawn from a study of the living and extinct aquatic mollusca of the district, so far as the latter are known, are as follows :—

The fauna of the Inlé basin has been isolated for a considerable period from that of districts outside the limits of the Shan plateau, but not sufficiently long for the evolution of highly specialized genera. Some of the living molluscs may possibly be descended from forms more peculiar than themselves that inhabited large lakes now no longer existing, but the ancestors of the majority probably came from the east of the Shan States, *i.e.*, the country now watered by the Mekong and the Upper Salween. We know very little about the aquatic molluscs of other parts of the Shan Plateau or of the Upper Salween, but, except in so far as purely lacustrine species are concerned, there is no reason to think that there is any great divergence in different parts of the plateau. The small Palaearctic element may have been introduced by the agency of water-birds, which migrate annually from higher latitudes.

## Part IV.—PLASTICITY AND EVOLUTION.

We have now considered the molluscan fauna, living and extinct, of the Inlé Lake and the neighbouring waters from a geographical, a palaeontological and a taxonomic point of view ; there remains to discuss it in reference to its variability, plasticity and evolution. To do this it will be necessary to recapitulate the information available as to each genus and species, searching out parallel instances where possible, and then to summarize the whole.

### Pulmonata.

The genus *Limnaea* provides us with interesting evidence as to the course evolution has taken, and is taking, on the Shan Plateau so far as

the shell-form of aquatic Gastropods is concerned. The three species now living in the Inlé Basin belong to two groups, that of *L. pervia* and that of *L. bowelli*. These groups are separated not only by the form and structure of the shell but also by those of the buccal armature. To the first group belongs *L. andersoniana*, while the group of *L. bowelli* is represented by *L. shanensis* and *L. mimetica*.

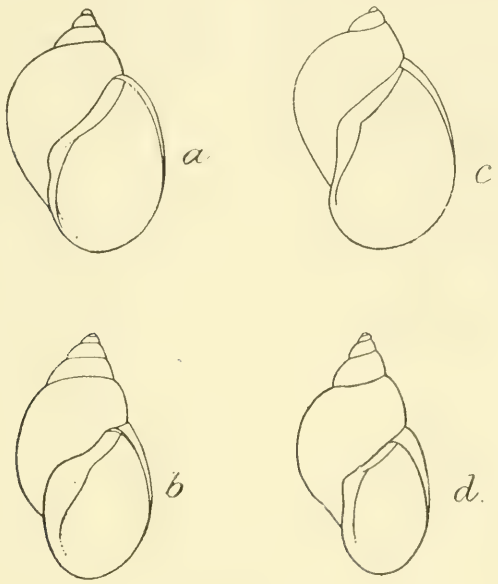


FIG. 4.—Shells of *Limnaea* illustrating differences between pond and stream forms.
*a.* Pond form of *L. andersoniana* from a pond near Yawnghwe.
*b.* Stream form of the same species from a small stream at Fort Stedman.
*c.* *L. ovata* from Germany.
*d.* *L. peregra* from Germany.
The figures are not drawn to scale. Figs. C and D are after Thiele.

Two phases of *L. andersoniana* are found both in the Inlé basin and in Yunnan. In the Shan States at any rate, one of these phases lives in ponds, while the other has been found only in a small stream. Moreover, the differences between the shells of the two phases are precisely comparable to those between the European *L. ovata* and *L. peregra*, forms still accepted by German conchologists[1] as distinct species, although it has been shown that it is possible to transform the direct offspring of one into the other by transferring the eggs of *L. ovata* into running water, or those of *L. peregra* into still water.[2] In both cases

[1] Thiele states that both forms are found in still and slow-running water, but it is not improbable that the form of the shell becomes fixed at an early age and that a later transference would not alter it. See Thiele, "Mollusca" in Brauer's *Süsswasserfauna Deutschlands*, XIX, pp. 6, 7 (1909).

[2] See Cooke in the volume (III) on Mollusca, etc. in the *Cambridge Natural History*, p. 93 (1895). I have not been able to refer to Hazay's work on the subject.

the chief differences between the shells are that that of the still-water form is considerably broader and has a more patent aperture and a shorter spire than that of the running-water form.

The other two Inlé species of *Limnaea* (*L. shanensis* and *L. mimetica*) are proved to be related to *L. bowelli* rather by the structure of their jaws and radulae than by any very close resemblance in the shell. The peculiarities of the buccal armature of *L. bowelli* are so great that it has been proposed to erect a new genus for its reception. The similarity in this respect between *L. bowelli* and the only living phase of *L. shanensis* is so close as to amount to a practical identity. We know of four phases of *L. shanensis*, three of which are fossil or subfossil, while one survives in the lake. Information is available as to the habitat in which each phase lives or lived. The shell in the four phases represents a gradual and almost even series from a form of normal shape, not very far removed from that of *L. bowelli*, but narrower and with a smaller spire. This phase lived in an open but rather shallow lake at an altitude of about 3,800 feet. The next phase, which is distinctly narrower and has the spire rather more reduced, lived in the same neighbourhood and at the same altitude, but in conditions that were rather paludine than lacustrine. The third phase, which still lives in the Inlé Lake at an altitude 800 feet lower, inhabits the marginal zone amidst decaying vegetation. While going further in the direction of narrowness and reduction of the spire, the shell differs from all the other phases in its thinness. The fourth phase lived in the open part of the Inlé Lake, possibly at a time when the water was very much deeper than it is now. The shell is in all respects, except that it is rather thick,[1] that of a typical deep-water form of the genus, and is by no means remote, so far as shape is concerned, from *L. mimetica*, the only species that now lives in the central region of the Inlé Lake.

In every particular, including thinness and paleness of shell and lack of pigment in the soft parts, *L. mimetica* is a typical deep-water form, although it survives in water that is nowhere more than 12 feet deep. Its actual descent from the extinct deep-water phase of *L. shanensis* is negatived by the divergence in the structure of the radula and columella ; the differences are greater than those between that phase and *L. bowelli*. *L. mimetica* and the extinct Inlé form have, however, at any rate followed a similar course in the line of descent. The shells in both cases are greatly reduced in size ; the spire is relatively small ; the whole shell is narrow, and the aperture, though by no means expanded, is relatively of great size. The differences between the shell of these two forms on the one hand and that of the Tibetan *L. bowelli* on the other are strictly comparable to those between *L. abyssicola* and *L. foreli* of the deeper parts of the Swiss Lakes and the common European

[1] It has struck me as not improbable that dead shells in strongly calcareous water may grow thicker by the equal deposition on their surface of salts of lime. Geologists whom I have consulted on the subject are not agreed as to the possibility of this but one distinguished member of the Geological Survey of India tells me that he believes that it frequently occurs.

The position of the shells of phase D on or near the surface of the mud is difficult to account for if they lived at a period previous to the filling in of the lake. There is no evidence that the water-level has sunk to any great extent.

shallow-water *L. auricularia*, from which, according to Forel,[1] the deep-water "species" are derived.

The cases of *L. shanensis* and *L. mimetica* are not altogether parallel to that of *L. andersoniana*, for we have not here a difference induced in the shell by a change from still to running or running to still water, but rather, at any rate in *L. shanensis*, an apparently gradual evolution, the physical changes in environment connected with which are complex and therefore obscure. I have already pointed out that phase D of *L. shanensis* and also *L. mimetica* have a considerable resemblance in shell-form to the deep-water Swiss species or varieties *L. foreli* and *L. abyssicola*. Swiss conchologists agree with Forel that these deep-water Limnaeae are derived from the common shallow-water *L. auricularia*, a species of which the geographical range extends as far south and east as the great plateau just north of the Himalayas and even into Kashmir. There is in the collection of the Indian Museum a fine series of shells of this species from various localities on the Pamirs. I have found among these shells numerous specimens of a phase that is abundant in small streams at high altitudes in Central Asia. Like the typical form of the species, it has an expanded mouth to the shell, but this feature is not nearly so pronounced as in the *forma typica*. The shell is small compared with that of the *forma typica*, although somewhat larger than that of *L. bowelli*, with which I propose to compare it as being also a running-water form from high altitudes on an Asiatic plateau. *L. auricularia* is a very plastic species and a large number of varieties have received names; I select one (var. *andersoni*, Clessin [2]) which seems to bear much the same superficial relationship to the Pamir form as phase A of *L. shanensis* does to *L. bowelli*. It was found in the Gulf of Bothnia in salt or brackish water and differs from the Pamir phase in that the shell is considerably narrower and its mouth less patent. I have arranged outline figures of the Pamir race, of the variety *andersoni* and of *L. foreli* side by side with those of *L. bowelli* and phases A and D of *L. shanensis*. It is easy to see how closely parallel the differences and resemblances are. In all cases the lowest figure is much more highly magnified than the other two.

*L. mimetica*, so far at any rate as the shell is concerned, seems to bear much the same relationship to the *forma typica* of the common Indian *L. acuminata*, Lamarck, an extremely plastic species, as phase D does to *L. bowelli*, and among the varieties of *L. acuminata* it would be possible to select at least as complete a series of intermediate forms as in the case of *L. auricularia* and *L. foreli*. Extreme types of shell in

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[1] *Le Léman*, III, p. 102 (1906). See also Clessin, *Malakoz. Blatt.* XXIV, pp. 171-177. pl. iii, figs. 1-4, 8-9. More recently Roszkowski (*Zool. Anz.* XL, p. 375) has demonstrated that the genitalia of *L. foreli* agree with those of *L. ovata* rather than those of *L. auricularia*. The bearing of this fact on the present inquiry is rendered less evident by the existence of many phases intermediate between *L. ovata* and *L. auricularia* so far as their shells are concerned. Indeed, Bollinger apparently claims to have found a complete series of shells linking the two together. It may be, therefore, that the true specific distinctions are anatomical and not conchological. In any case the facts as represented by Roszkowski—I have been unable to consult Bollinger's work—have a distinct bearing on my remarks in the next paragraph.

[2] Clessin, *Malakoz. Blatt.* XXV, p. 73, pl. iii, fig. 8 (1878).

*L. acuminata*[1] appear to bear the same relationship to one another as do *L. peregra* and *L. ovata*, but in this species the differences are not correlated with life in still or running water. I have recently examined

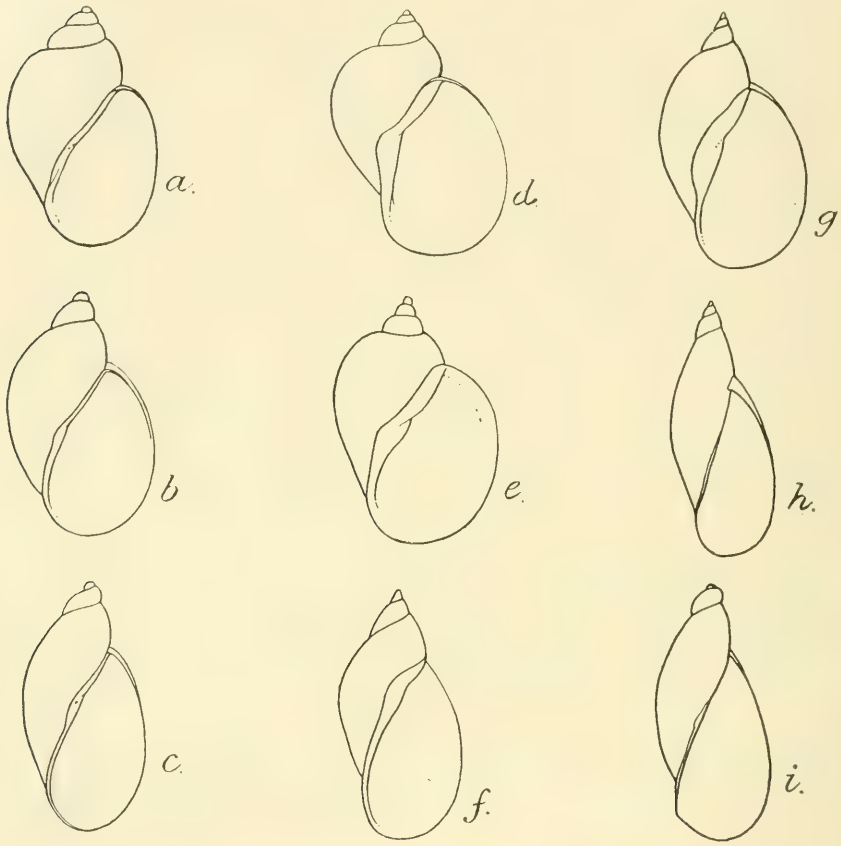


Fig. 5.—Shells of *Limnaea* illustrating the evolution of deep-water forms.

*a.* Type-specimen of *L. bowelli* from Tibet.
*b.* Living form (phase C of *L. shanensis*) from the Inlé Lake.
*c.* Fossil form (phase D of the same species) from the bottom of the Inlé Lake.
*d.* *L. auricularia.* Form from small streams on the Pamirs.
*e.* *L. auricularia* var. *andersoni* from the Gulf of Bothnia.
*f.* *L. foreli* from the depths of the Lake of Geneva.
*g.* *L. acuminata.* Typical form from Calcutta.
*h.* Narrow form (?) of the same species from near Khulna in the Gangetic Delta.
*i.* Type-specimen of *L. mimetica* from the Inlé Lake.

The figures are not drawn to scale. Figs. E and F are after Clessin.

shells of the narrowest type known to me—narrower even than the var. *gracilior*, Marts.—both from the river Ganges and from the

[1] Dr. N. N. Marshall has recently sent me specimens of a small form of *L. acuminata* from Rangoon. For good figures of the varieties of this species see von Martens, *Mitth. Conch.* I, p. 75, pl. xiv (1886).

tank in the Museum compound in Calcutta. The form may, indeed, represent a distinct species, but it is in any case closely allied. The different phases of *L. shanensis* probably resemble those of *L. acuminata*, assuming the narrow form to be specifically identical, in this respect, and there is no more reason to be certain that one is directly descended from the other, than there would be reason to claim that the Baltic race of *L. auricularia* was directly descended from the Pamir race, or the deep-water Swiss forms from the Baltic race. It is convenient to arrange the shells in a regular series, but it is not improbable that they represent divergent lines from a common type, rather than a single line of descent undergoing progressive modification. They may, therefore, be called links in a chain of evolution only in quite a general sense. Details of these instances of plasticity in *Limnaea* are different in the different cases, but they have one important point in common. They provide little evidence of individual variation. The individuals of each species found in the same environment as a rule resemble one another closely, but those from different environments differ.

These facts, observed under natural conditions, receive considerable additional interest from the experiments made by Semper,[1] by de Varigny,[2] by Whitfield[3] and by Roszkowski[4] in aquaria. The investigations of Semper and deVarigny were carried out independently and mainly with the object of discovering the results of confinement on *Limnaea*. Both experimentors agree that if individuals of this genus are kept in small masses of water, the shells of their young, bred in captivity, are dwarfed and more or less altered in shape. They found, moreover, that the effect was cumulative from generation to generation. The chief point in which they differed was that of the agency that produced these changes, but it seems not improbable that the most important factor in all cases was the products of metabolism, which contaminated the water and did not diffuse equally through the whole of an aquarium even when the individuals on which the experiment was being made were confined merely by means of a piece of muslin covering the end of an open tube. This factor was, therefore, essentially a chemical change in the water. For our purpose it is not necessary to follow these interesting experiments further. An excellent summary is given by Vernon in his "*Variation in Animals and Plants*" (London : 1903).

Whitfield, apparently by accident, obtained additional evidence of the dwarfing and distorting of the shells of *Limnaea* through succeeding generations in captivity. He discovered that confinement in an aquarium resulted, after three generations, "in the production of a monoecious animal from a dioecious one of the most perfect kind. Also in changing the specific characters, as far as the form of the shell can be considered, to such an extent that when shown to a good working conchologist (Dr. James Lewis) he gave it as his opinion that they could have no specific relations to each other."

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[1] *Arb. a. d. Zool. Inst. in Wurzburg*, I, p. 137 (1874).
[2] *Journ. de l'Anat. et de la Physiol.*, p. 147 (1894).
[3] *Bull. Amer. Mus. Nat. Hist.*, I, p. 29 (1882).
[4] *Zool. Anz.* XL, p. 375 (1912).

Roszkowski reared in captivity eggs of *L. profunda*, which he regards as synonymous with *L. foreli*, from deep water. He found that after nine months the shells of the young molluscs showed an extraordinary resemblance to those of the shallow-water form *L. palustris*, Müller.

The only other genus of true aquatic pulmonates represented in the Inlé basin is *Planorbis*, the shell of which is apparently less plastic than that of *Limnaea*. Possibly the flattened spiral form offers less opportunity for variation. Be that as it may, the species of the genus that occurs in the Inlé Lake fall into two categories. We have on the one hand the widely distributed, comparatively large and thick-shelled species *P. exustus* (belonging to the group or subgenus *Planorbis, s.s.*) the geographical range of which is very great and the variation and plasticity small. On the other hand we have a number of minute thin-shelled forms of the groups or sub-genera *Gyraulus* and *Segmentina*, most of which have also a wide distribution, while their variation, though by no means extreme, is in some respects less restricted. *P. exustus* need not concern us further in this connection as it is in no sense a variable form. The smaller species (*P. calathus*, *P. caenosus*, *P. velifer*, and *P. trochoideus*) are not, however, altogether devoid of interest. With the exception of *P. velifer*, which is only known as yet from the Inlé Lake, all these species have in the lake even smaller and thinner shells than they do in other localities. Their shells, moreover, are almost or completely devoid of colouring matter, while the pigmentation of their soft parts is also reduced. We have a few specimens of *P. trochoideus* from a lacustrine deposit in the He-Ho plain ; so far as can be ascertained, they did not differ when living from living individuals in the existing lake.

*P. velifer* is interesting for two reasons. In the first place it is little more than a highly specialized, dwarfed race of a widely distributed form (*P. convexiusculus*), which in its turn is possibly no more than a variety of *P. compressus* or *saigonensis*, a species of still wider distribution. Shells intermediate between *P. convexiusculus* and *P. saigonensis* occur in the superficial deposits of the He-Ho plain and only differ from the typical Indian form of the latter species in being rather smaller and in having the peculiar structure of the aperture that distinguish the form from *P. saigonensis*, a little less strongly developed. From these shells those of living individuals of *P. velifer* differ in their smaller size, still less developed aperture, thinness and transparency. Individuals from the middle of the lake are absolutely colourless, while those from the margin have a faint yellowish tint.

There is very little variation in the shape of these living shells, but their ornamentation is by no means constant. In some examples there are a number of curious spiral ridges on both surfaces of the shell. Examined under a fairly high power of the microscope these ridges are seen to be entirely epidermal, and to consist of closely adpressed cilia or minute horny processes. The rows of these processes vary in number and degree of development ; sometimes they are quite absent, though at least traces can usually be detected by careful examination. Variation in this respect is entirely individual and occurs both among the colourless shells from the centre of the lake and among the tinted shells

from the marginal zone. Its explanation can hardly be the same as that which would apply to the gradual change in the shape of the shell illustrated by the various phases of *Limnaea shanensis*. In the one case we are dealing with mere individual variability, on the other with true plasticity.

## PROSOBRANCHIATA.

Of the Pectinibranchiate genera that are found in the Inlé basin there is nothing particular to be said about *Amnicola*, the single species of which seems to be very constant, while in *Vivipara* and *Ampullaria* the material available so far as the Shan States are concerned does not suffice for serious study. I shall have to notice a peculiarity of certain shells of *Ampullaria*, but will do so in discussing those of *Hydrobioides* in the final part of this section of my paper. In *Hydrobioides*, however, in *Melania*, and above all in *Taia* the variation observed is of a very remarkable character.

The only species of *Melania* found in the Inlé Lake is *M. tuberculata*. The shell of this species, which has an extremely wide range in Africa and Asia, is very plastic as regards its size and sculpture, though variation in shape is less common or at any rate less marked. In the Inlé Lake and also in the Yawnghwe river the shells (fig. 6*a*) are of a rather small size, not exceeding 25 mm. in length. They are of dark colour and have the tubercular sculpture characteristic of the species well-marked. In a ridge of recent tufa on the He-Ho plain we found a number of shells of much larger size, from 38 mm. to 40 mm. long (fig. 6*b*). They retain remains of the epidermis, which appears to have been dark, and their sculpture is less strongly developed. On another ridge on the same plain, however, we found shells (fig. 6*c*) not more than 16 mm. long with the sculpture very strongly developed and with the suture more impressed than usual. Unfortunately we have no information as to the differences in environment correlated with this difference in size and form of shell.

At first sight it is remarkable that in this species shells from the central region of the lake, where the water is extremely clear and where vegetation is rather abundant, differ in no respect from those taken in the muddy streams that traverse the Yawnghwe plain, but in both types of environment the animal lives almost buried in very soft mud. Moreover, there is evidence that the factor or factors which most strongly influence plasticity in this species are not always those that are most conspicuous or most readily ascertained. For the sake of clarity in discussing the facts known to me I will confine my statement on this species to forms that I have been able to investigate in the field myself. I have collected specimens chiefly in four districts, *viz.*, the lake of Tiberias in Palestine, the Gangetic Delta, the shores of the Chilka Lake on the east coast of India, and Yawnghwe State. The normal form of the species, that is to say, the one that approximately strikes the mean between extremes, chances also to be the *forma typica*, which was described from the coast of Madras. In this form (fig. 6*a*) the size is moderate, the length being from 25 to 30 mm., the spire tapers gradually, the colour is brown or dull green with more

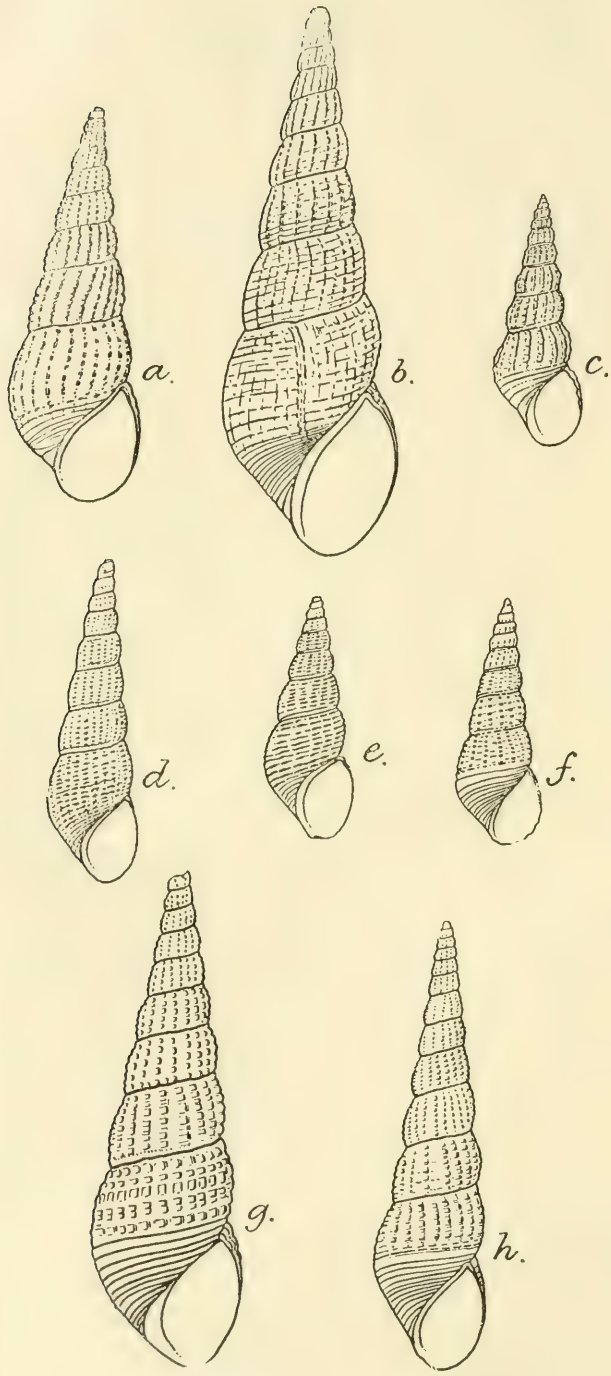


Fig. 6.—Shells of *Melania tuberculata* from different localities and types of environment.

*a.* Typical form from Inlé Lake. × 2.
*b.* Large form from a superficial deposit on the He-Ho plain.
*c.* Small form from another superficial deposit on the same plain.
*d.* Slightly dwarfed form from a pond in the Museum garden in Calcutta.
*e.* Dwarfed form from a small basin in a fern-house in the same garden.
*f.* Dwarfed form from a pool of brackish water at Port Canning in the Gangetic Delta.
*g.* and *h.* Large varieties from the Lake of Tiberias in Palestine.

or less evident reddish markings, and the sculpture consists of by no means prominent granules or tubercles arranged more or less definitely in longitudinal and spiral lines. Shells from some ponds in Calcutta agree well with those of the *forma typica*. In the pond, however, in the Museum compound—it is about 150 yards square and from 12 to 20 feet deep in the middle and has a fairly, but not a very abundant vegetation of entirely sub-aquatic plants—a distinct dwarfing is noticeable, shells (fig. 6*d*) rarely, if ever, exceeding 23 mm. in length ; the sculpture is also as a rule somewhat obliterated and the shell rather narrow. The only reason I can give for the dwarfing of the shells from this pond—a feature which is also noticeable in *M. variabilis* and in *Vivipara bengalensis*—is extreme overcrowding. Individuals of these three species abound to such an extent that we find it impossible to grow any kind of water-lily, because the snails congregate in such large numbers on the stems of young leaves shooting up from the bottom that they bear them down and prevent them reaching the surface of the water. In the same compound there is a small fern-house, thatched with an open layer of straw on wire-netting, but not enclosed with glass. In this fern-house there is an oval concrete basin 5 feet long by 4 feet broad by 1 ft. 4 inches deep. It is supplied with filtered water by a tap and is never entirely stagnant for long, as it overflows in wet weather and the gardeners are apt, contrary to municipal regulations, to leave the tap running. There is, moreover, in it a fairly dense growth of *Vallisnieria spiralis*. Some years ago one or two plants of the water hyacinth were introduced into the basin, and apparently brought with them, probably from a pond in Calcutta, the eggs or young of *M. tuberculata*. The molluscs (fig. 6*e*) have flourished so far as numbers are concerned, and must have gone through several generations. None of the shells are longer than 17 mm., and the shape is broader and shorter than that of individuals from ponds. Similar peculiarities are to be noted in shells from pools and canals of brackish water in both the Gangetic Delta and Orissa, except that the shell (fig. 6*f*) is a little more elongate.

Individual variability is not usually characteristic of *Melania tuberculata*, but in the Lake of Tiberias, and apparently also in other parts of Palestine, two varieties (fig. 6*g*, *h*) occur. Both have the sculpture well developed and both are of relatively large size. In one, however, the shell is rather smaller and distinctly narrower than in the other. (There is some doubt as to the proper name to be applied to the narrower form.) The interesting points, however, about these two forms from Palestine are (1) that they are found together under identical conditions and (2) that even though they live in water of very abnormal chemical composition they are not dwarfed, but rather above the average size.

All these facts about *M. tuberculata* are illustrated in the outlines of shells reproduced in text-figure 6.

Two other species of the genus *Melania* are found in the Yawnghwe river, *viz.*, *M. terebra* and *M. baccata*. There is very little difference between the shells of the former species from this stream and specimens from Cachar, the original locality. Our series is not a large one and does not exhibit any marked individual variation.

*M. baccata* is a species or a group of species that raises great difficulties in nomenclature owing to the variability and plastic character of the shell. It is found chiefly in the Shan Plateau, but in different parts thereof a number of local races seem to have become differentiated. All the shells, both recent and fossil, that we obtained in the two basins belong in a sense to a single race for which it has been necessary to find a new name. In reference to the elongation of the shell I have called it "subspecies *elongata*." But this race has at least two, if not three, phases, and shells from the same environment exhibit considerable individual variation in sculpture. The shells of the different phases do not differ in shape, but those from streams both in the Inlé and the He-Ho plains are very considerably smaller than those from a swamp in the latter. Subfossil shells from both peaty and calcareous deposits on the He-Ho plain seem to have the sculpture rather more sharply developed than those from streams, with which they agree in size. In a large series of living specimens from the Yawnghwe river the majority have three well-developed spiral ridges with series of tubercles on the last two whorls, but in a small proportion of specimens there are only two ridges of the kind. No actually intermediate individuals were found, but in one or two shells the uppermost of the simple ridges below the series of tubercles on the body-whorl has a slightly tubercular character. The same variation occurs among subfossil shells. Further information is necessary before we can discuss in detail the meaning of the differences in this species. I figure in outline a specimen of a shell from the Northern Shan States side by side with one of the smaller phase of the sub-species *elongata* for comparison.

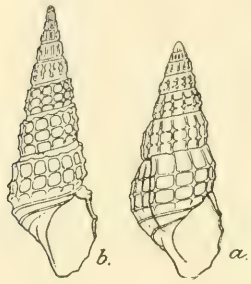


FIG. 7.—Shells of *Melania baccata* ($\times \frac{2}{3}$).
*a.* Shell from Hsipaw in the Northern Shan States.
*b.* Shell of small phase of var. *elongata* from the Yawnghwe river.

I have recognized the genus *Hydrobioides* as consisting of five species, one of which is very unlike the others in appearance. This species (*H. physcus*) departs widely in form of the shell from the type usual in *Bithynia*, the genus from which *Hydrobioides* is derived, and is not plastic. Specimens from a swamp near He-Ho hardly differ from those taken in the central region of the Inlé Lake except in being a little smaller. This species is only known from the two basins. Three other species of more normal shape are also, so far as we know, neither variable nor plastic.

It is otherwise, however, with the remaining species of the genus—*H. nassa*, which has a wide range in the Shan States and departs much less far from *Bithynia* than does *H. physcus*, but further than *H. avarix*, the species to which it is most closely related. *H. nassa* was originally described from a locality that lies some considerable distance east or north-east of the Inlé Lake, but is common all over Yawnghwe and the neighbouring states. There are cotypes of the species in the collection of the Indian Museum. They differ very slightly from the

form that now lives in ponds and swamps both in the Inlé and the He-Ho basins, but have the spire constantly a little more elongate and slender. Unfortunately we have no information as to the type of habitat in which they were found. Both in them and in the Inlé pond-form the most important of the specific characters is well marked. The character is—not only is the whole margin of the aperture thickened but on the outer part of the shell there is also a thick ridge or varix running almost parallel to the thickened margin across the body-whorl. In the type-specimens and in those of the Inlé pond-form the ridge lies very near, but distinctly separated from the rim of the aperture. In the Inlé Lake another race is predominant. The shell attains a larger size, is usually of a brighter and yellower colour, is invariably narrower and more elongate, and has the varix separated from the lip by a considerably greater though very variable space. When the shell is fully developed the ridge no longer lies parallel to the rim of the aperture but has a much less marked downward convexity. To this form I have given the name *lacustris*, regarding it as a race or subspecies of *H. nassa*. I cannot find any anatomical difference between it and the latter. A third race is found in fair abundance in small streams at Thamakan some distance west of He-Ho. This locality lies about 400 feet higher than He-Ho, and 1200 feet higher than the Inlé Lake. For the Thamakan race I have proposed the subspecific name *rivulicola*. The shell agrees with the typical form in its general structure, but is distinctly thinner and more conoidal ; in size it slightly exceeds it. Yet a fourth race (subspecies *distoma*) occurs, or rather occurred, in the Inlé district. It is found both fossil and subfossil in the different deposits of the He-Ho plain. The shell is small, thick, and moderately elongate, but its chief character lies in the very close proximity of the varix to the rim of the aperture. So close, indeed, do they lie that the two thickenings form together little more than a single ridge divided transversely by a narrow groove.

In this species, therefore, and in its ally *H. avarix* we have a most interesting series illustrating the gradual accentuating of a generic character. In *H. avarix* the actual rim of the mouth of the shell is thickened, but there is no varix. In the fossil and subfossil race of *H. nassa* the varix is beginning to be differentiated from the thickened rim of the aperture, in the Thamakan race the process has been carried further, in the typical form of the species further still, while in the lacustrine form the two ridges have little connection.

In the Inlé Lake the local phase of the typical form of the species and the lacustrine race occur together in the marginal zone, in which conditions are not very different from those to be found in a large pond full of vegetation such as the former usually effects, but in the open central region only the lacustrine race occurs. This race grows to a larger size in the intermediate zone of the lake than it does in the centre of the central region or in the marginal zone, but I have not been able to find any other difference in shells from different parts of the lake, except that examples from clear water are usually more transparent than those from places where it is at all turbid or discoloured. It is difficult, moreover, to be sure that the latter peculiarity is not

due to the absence or presence of minute algae on the surface of the shell.

In the genera we have as yet considered it has been possible, at any rate in the more conspicuous cases, to trace some one line of evolution, but we have now to consider a genus in which matters are more complicated, namely the genus *Taia*. In some respects *Taia* is comparable to *Hydrobioides*, having originated, probably on the Shan Plateau, from a genus with a simple, almost smooth shell, but possessing itself a shell with pronounced and peculiar sculpture. The genus from which it is derived is the almost universally distributed *Vivipara*. As we shall see presently, this genus has undergone a very similar but quite independent course of evolution in other parts of the world also. I have thought it most convenient to recognize no less than eleven species of *Taia* among the living and extinct forms of the Inlé, He-Ho and Hsin-Dawng basins, but some of them are closely allied and might doubtless be regarded from a purely taxonomic point of view as races (subspecies) or varieties, rather than distinct species. These forms, whatever we may call them, do not follow a single line of evolution but diverge from one ancestral type in different directions. The ancestral type is represented by a species (*T. theobaldi*) that still survives but is known also in a fossil state. The relationship of the other ten forms to this species and to one another is shown in a diagrammatic fashion in the figure on the opposite page. Two other species, one of which is still unnamed and very imperfectly known, are found in different parts of the Irrawaddi system. The possible place of one of these (*T. noetlingi*) is shown in the diagram, but it may have been derived from an unknown form analogous to *T. intermedia*, or direct from *T. naticoides*.

*T. theobaldi*, if it stood alone, might be accepted as a somewhat abnormal type of the genus *Vivipara* comparable to *V. quadrata* (Benson) from China, but it is distinguished from all the species of that genus *sensu stricto* by the structure of the columellar callus, and from most of the species by the spiral ridges on its shell. These are the two chief generic characters of *Taia ;* they are less strongly developed in *T. theobaldi* than in other forms. *T. theobaldi* has a wide range in the Southern Shan States, and was originally described from "Burma." It is an inhabitant of small streams, and single shells have been found both in the cave deposits of the Hsin-Dawng valley and in the superficial deposits of the He-Ho basin.

From a geographical and biological point of view the species of *Taia* that occur on the Shan Plateau fall into four groups. Firstly we have two non-lacustrine species, *T. theobaldi* and *T. naticoides*, that have a wide or fairly wide range on the plateau, if not beyond its limits. Then we have three little groups of lacustrine species each of which is, or was, peculiar to a single lake—one to the old He-Ho lake, one to the smaller but probably still older Hsin-Dawng lake, and a third to the existing Inlé Lake. All these lakes must have in a sense belonged to the same lake-system, but probably intermigration of the fauna had many obstacles.

The two surviving widely distributed, non-lacustrine species are certainly among the most primitive in the genus ; to one of them (*T.*

*theobaldi*) I have already referred as representing the ancestral type. I have also referred to the fact that in it the generic characters are less

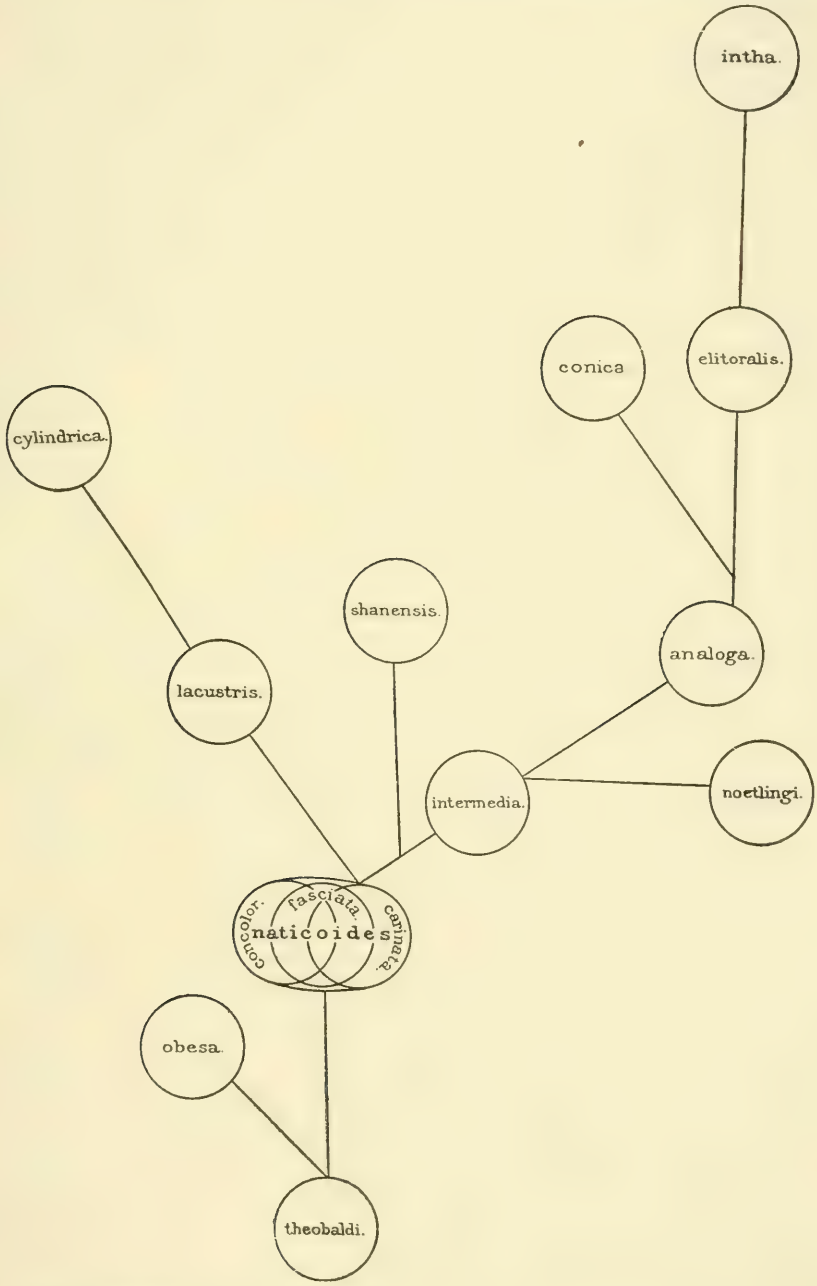


Fig. 8. Diagram showing the relations of the different described species of *Taia*.

marked than in the other species, the spiral ridges on its shell being less strongly developed and its columellar callus less expanded.

*T. theobaldi* is a fairly constant form. Shells from 3,000 feet do not differ, except in such accidental characters as being more free from a coating of calcareous deposit, from shells from 5,000 feet, nor do those from ancient deposits differ from those found with the animal alive. The fact that shells from Kalaw are coated in the manner indicated while those from Yawnghwe are nearly clean proves in itself that the two lots were living under different conditions ; that they closely resemble one another proves that the shell of the species is not plastic. In some at any rate of the streams in which it occurs *T. theobaldi* is subjected to the influence of frost. It is not always easy to distinguish single shells of *T. theobaldi* from selected shells of the other non-lacustrine species (*T. naticoides*), though their radular teeth differ considerably in proportions ; but *T. naticoides*, which lives in swamps, pools and the back-waters of larger streams, never so far as we know at very high altitudes, is an extraordinarily variable species in respect not only to shell-sculpture, but also to colouration and to shell-form. Theobald in his original description recognized three " varieties," which he named " the typical form," var. *fasciata* and var. *carinata*, but he acknowledged that it was not possible to draw an exact line between them. The shell of his typical form (afterwards named var. *concolor* by Nevill) was almost smooth, while those of the varieties *fasciata* and *carinata* had spiral ridges developed in different degrees. So far as these characters are concerned, Theobald's observations are fully borne out by my own, but a large series of specimens does not support his assumption that differences in colouration and shape of shell are always correlated with differences in shell-sculpture. The more highly ornamented shells are often more conical than others, but beyond this I cannot go. The differences that do exist are entirely individual and in a single handful of shells from a single pool one may find specimens that are nearly smooth, specimens in which the sculpture is highly developed, and all intermediate phases. As I will show presently the proportionate number of individuals that can be assigned approximately to one variety or another differs in different localities.

In describing the three varieties Theobald, probably with a limited number of shells before him, gave due attention to colouration, shape and sculpture. His specimens were apparently all from the Upper Salween, several hundred miles from the localities in which we collected. I have taken at random one hundred shells from a series collected in a sluggish stream on the He-Ho plain. Of these nine have no definite spiral ridges, but none are absolutely smooth (see figs. 3, 4, pl. xvi). All these shells without spiral ridges are distinctly banded in colouration. I found fifteen shells that could be definitely assigned to the var. *carinata* so far as shape and sculpture were concerned, but unbanded, while the remaining seventy-six shells formed an unbroken series between *carinata* and *fasciata* in shell-form and sculpture, but were all banded. The nine banded, comparatively smooth shells were all of a somewhat globose type, on an average distinctly less conical than the carinate examples, but no difference of a kind that could be measured or accurately estimated in any other way was observed. The average size of fully adult shells in this series (length 35-38 mm.) is greater than was probably the case

among the shells included in Theobald's series, but it is evident from his description and figures that he did not examine adult shells only.

We may legitimately conclude from this statement that Theobald and I are dealing with the same species, but that races from different localities differ considerably in details of variation. I have not been able to find a single specimen from He-Ho in which the shell is absolutely smooth, or in which even approximate smoothness is correlated with absence of spiral bands. But Nevill called the typical smooth form from Theobald's series "var. *concolor*."

There is, therefore, evidence that details of variation differ in different localities. This is further proved by an examination of a series from Yawnghwe, 800 feet below the He-Ho plain. This series was taken in a large pond and a canal. In fifty specimens, twenty-nine are unbanded and carinate, fifteen banded and carinate, two smooth and banded, two smooth and unbanded. These results may be expressed in a table of percentages.

| Locality. | Smooth and unbanded. | Smooth and banded. | Carinate and unbanded. | Carinate and banded. |
|---|---|---|---|---|
| He-Ho . . . . . | *None* | 9 | 15 | 76 |
| Yawnghwe . . . . . | 8 | 4 | 58 | 30 |

In addition to this difference in individual variation between the shells from the two localities (and also from two types of environment) there is a distinct racial difference in structure. The shells of the Yawnghwe race are all thinner than those of the He-Ho race. They are smaller, fully adult shells being from 30 mm. to 32 mm. long. When bands are present they are rarely so dark, and it is often difficult to say whether they are present or absent, so faint may the bands be. Moreover, the shells are constantly a little more globose (*cf.* figs. 17, 16, pl. xv, and figs. 3, 4, pl. xvii), the smooth examples are smoother, and the carinate ones never quite so nodular. Finally the chief ridge of the body-whorl is often more distinctly squamous than it ever is in the He-Ho race, thus affording some approach to *T. shanensis*. The radulae of the two races are very similar, but the teeth of the Yawnghwe race are paler in colour and probably less stout than those of the He-Ho race.

We have no evidence of the existence of this variable and plastic species in a fossil state, but to it all except one of the lacustrine forms of the three basins can be traced directly. The exception is *T. obesa*, with which I shall deal when discussing the Hsing-Dawng group, but the He-Ho species must be discussed first because they are less highly specialized than those of the other two lakes. It is with the more highly specialized individuals of *T. naticoides* that all the lacustrine species must be associated. Indeed, it is not always easy to distinguish between the more strongly carinate shells of the former and the typical shells of *T. intermedia*, the simplest of the He-Ho forms.

In *T. intermedia* the shell, however, is constantly more tubercular and a little more globose than *T. naticoides*, and no even approximately smooth specimens are found. There is considerable variation both in

the details of shell-sculpture and in shell-form, while in a few individuals a distinct series of squamous projections occur on the body-whorl ; but the variability is small as compared with that of *T. naticoides.* The species is, therefore, no more than an extension in one direction of the carinate type of *T. naticoides.* It apparently lived in a swampy marginal zone which gradually encroached upon the open water of the old lake.

Two other species, both more remote from *T. naticoides*, also lived in this lake. They belonged respectively to the conical and the elongate-conoidal types that we shall find also in the other two lakes. The conical type is represented by a somewhat variable species of which only a few shells were obtained. They were found in the same deposits as *T. intermedia*, but need not necessarily have lived in precisely the same conditions. On account of their resemblance in shell-form to species that live or lived in the Inlé and Hsin-Dawng Lakes I have called them *T. analoga.* The corresponding Inlé species lives in the outer parts of the central region. The shell of *T. analoga* has the spiral ridges well developed, and the chief ridge of the body-whorl sometimes bears a series of definite projections, but these projections are not spiniform, and are not arranged in a regular series. The shell is very like that of *T. noetlingi* (Kobelt) from the Lower Chindwin, but we have no particulars as to the habitat of that species. The third He-Ho species is distinctly conoidal though elongate. We know that it lived in the open parts of the lake, and persisted without change for a considerable period. It is chiefly interesting on account of its relationship to one of the Hsin-Dawng species, *T. cylindrica.* It was constant in shell-form and not very variable in sculpture.

All the He-Ho shells are thicker than those from the Inlé Lake, but thinner than those from Hsin-Dawng. In the Hsin-Dawng valley we found, in cave deposits, the shells of four quite distinct species of the genus. One of these, represented by a single shell, is *T. theobaldi ;* the other three belong to the same three types as those from the He-Ho deposits, *viz.*, the conoidal, the elongate-conoidal and the conical, but all are more highly specialized, larger and considerably thicker. The representative of the conoidal type is *T. obesa*, a shell that seems to come from the common stock of *T. theobaldi* and *T. naticoides* but has the spiral sculpture better developed than that of the former and is more globose than either. I have been able to examine only four specimens of this species, but it does not seem to be variable. The elongate-conoidal shell (*T. cylindrica*) is a very remarkable one, allied to *T. lacustris* from the He-Ho deposits, but both more elongate and with the chief spiral ridge of the body-whorl distinctly squamous though without spiniform projections. We collected a good series, which is constant. The conical shell (*T. conica*) from this basin differs from *T. analoga*, apart from its greater size and thickness, mainly in the more elaborate nature of its spiral sculpture and especially in the possession of a regular series of subspiniform projections on the body-whorl. Our series is not a large one but the specimens in it are uniform.

More information is available about the three species of *Taia* that still live in the Inlé Lake than about those that formerly lived at He-Ho

and Hsin-Dawng, because it has been possible to examine them in a living condition. The three species are *T. intha*, *T. elitoralis* and *T. shanensis*. The first two of these have a conical shell, while that of *T. shanensis* is elongate-conoidal, but not so elongate as those of *T. lacustris* and *T. cylindrica*. All the shells are thin or moderately thin and all have a regular series of well-developed spiniform or subspiniform squamous processes on the chief spiral ridge of the body-whorl. *T. intha* and *T. shanensis* are constant species, while *T. elitoralis* is a variable one.

*T. intha* lives only in those parts of the lake in which the water is clear and transparent. It has the most elaborately sculptured shell of any of the species in the genus, and it varies as little as any. Shells from the less congested parts of the outer edge of the marginal zone are slightly larger on an average, a little broader than and not quite so constant or so regular in sculpture and in shape as those of individuals that live in the middle of the lake. Even the former, however, show no real approximation to the shell of *T. elitoralis*. This species, which is found living only in the intermediate zone of the lake amidst dense aquatic vegetation, is much scarcer than *T. intha*. It is also very much more variable both in shape and size, and has the sculpture decidedly less regular. Some shells are much more elongate than others. On the whole the species is nearest to the fossil *T. conica* from Hsin-Dawng, but it is nearer to *T. intha* than it is to *T. shanensis*.

*T. shanensis* does not reach so large a size as *T. elitoralis*, but is more constant both in this respect and also in shell-form. It is indeed a fairly constant species, although it lives in conditions very different from those in which *T. intha* is found. It inhabits the comparatively foul water of the marginal zone among floating islands, where circumstances are favourable for the formation of peat. It is at least as closely related to *T. naticoides* as to any other species.

We have thus three species of *Taia* from each of the three lakes, for there is every reason to suspect that the few shells of *T. theobaldi* that have been found at He-Ho and Hsin-Dawng are adventitious so far as their position is concerned. From the He-Ho lake we have *T. intermedia*, *T. lacustris* and *T. analoga*; from Hsin-Dawng *T. obesa*, *T. cylindrica* and *T. conica*; from the Inlé Lake *T. elitoralis*, *T. intha* and *T. shanensis*. Each of the nine species is either conical, globosely conoidal or elongate-conoidal in shell-form. To the first group belong *T. analoga*, *T. conica*, *T. elitoralis* and *T. intha*; to the second *T. lacustris*, *T. cylindrica* and, less definitely, *T. shanensis*, while in the third *T. obesa* and *T. intermedia* find a place. In the Inlé Lake at any rate, the conical type of shell is definitely associated with true lacustrine conditions, and this was probably the case also in the other two lakes; whereas the globosely conoidal type is or was to be found rather in the swampy marginal zone. The elongate-conoidal forms seem to have been strictly lacustrine, but *T. shanensis*, which is intermediate between the globosely conoidal and the elongate-conoidal, is practically paludine in habits. The non-lacustrine species (*T. theobaldi* and *T. naticoides*) may be classified among the globosely conoidal forms. As all the conical shells are also elongate, elongation of the shell in *Taia*, therefore,

seems, in this district at any rate, to be associated with life in an open lake.

In order to avoid confusion I have confined the foregoing statement about *Taia* to species from the Shan Plateau, with a passing reference to those found in other parts of Burma. Before proceeding, however, to consider variation in the bivalve shells of the lake and its vicinity it will be convenient to discuss briefly certain cases from other countries parallel at any rate to some extent to that of the Shan *Taiae*. The most important cases are those of *Margarya* in Yunnan and of a remarkable series of *Vivipara* described from Tertiary deposits in Austria.

*Margarya* is a genus of Viviparidae known only from Western China. All the forms as yet discovered have been assigned by conchologists to a single species, *M. melanioides*, Nevill ; but eight or nine varieties have been described. Some of these are apparently constant and at least as distinct from the typical form as *T. theobaldi* or *T. shanensis* is from *T. obesa*. The shells resemble those of the species of *Taia* in sculpture, but are much thicker and larger and have not the expanded columeller callus characteristic of my genus. I have examined a large series of fresh and subfossil specimens from Tali-Fu in Yunnan, the type-locality. They include representatives of three of the varieties (*carinata*, Neumayr, *rotundata*, Neumayr, and *francheti*, Mabille) as well as of the typical form, of which we have the type-specimens. Individuals intermediate between the typical form and *carinata* are common, but I can find none between the latter and *rotundata* or between *rotundata* and *francheti*, which I am inclined to regard as distinct species. I have not seen the forms called var. *Monodi*, var. *Mansuyi*, and var. *obsoleta* by Dautzenberg and Fischer,[1] but they also seem likely to be specifically distinct. Among the eight or nine forms there are two groups, in one of which the spire is moderately elongate and more or less conical, while in the other it is greatly produced and almost cylindrical. In both groups we find a transition from almost smooth shells to shells ornamented much as in *T. elitoralis*. We find none, however, that have the sculpture so regular as in *T. intha*, and none in which the shell is so globose as in *T. obesa* or even *T. naticoides*.

Unfortunately we know very little about the types of environment in which these forms live or lived. Dautzenberg and Fischer[1] say :—

"La forme typique du *Margarya melanioides* et les variétés *Delavayi* et *Monodi* sont représentées dans les récoltes de *M. Mansuy* par des exemplaires provenant du gisement quaternaire du déversoir du lac de Yunnan-Sen, á Koui-An.

La var. *Mansuy* est plus abondante que les autres formes : M. Mansuy en a récolté des spécimens actuels (fig. 2) dans les lacs de la Chaussée, à Mong-Tsé ; il l'a trouvée également dans les gisements quaternaires de Tong-Hai (fig. 3), jusqu'à 50 mèters d'altitude au-dessus du niveau du lac actuel, et dans le quaternaire de Mong-Tsé, près le ville (fig. 4)

La var. *obsoleta* n'a été recueillie que dans les gisements quaternaires des lacs de la Chaussée, plaine de Mong-Tsé (fig. 5) et de Tong-Hai.

Les var. *Francheti*, Mab. et *tropidophora*, Mab. n'ont pas été rapportées par M. Mansuy."

Thus some of the forms are apparently extinct. Mr. J. Coggin Brown of the Geological Survey of India, who collected a large series of shells

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[1] *Journ. Conch.* (Paris) LIII, pp. 420-425, figs. 1-5.

in Yunnan, is of the opinion that environment and shell-type are correlated in a general way, but no precise information is available to him.

The case of the Austrian Viviparidae is an even more remarkable one and perhaps in some points more closely parallel to that of the Shan *Taiae*. Neumayr and Paul[1] have discussed it in considerable detail, both from a palaeontological and from a strictly geological point of view, in their treatise on the *Congeria* and *Paludina* Beds of Slavonia. They recognize no less than thirty-nine species, which Neumayr assigns to the subgenus *Tulotoma* of the genus *Vivipara*. The shells of the different species vary greatly in both shape and sculpture and provide a complete transition from normal smooth forms to forms in which the sculpture approaches that of the more highly specialized varieties or species of *Margarya* and *Taia* and agrees very closely with that of the North American living genus or subgenus *Tulotoma*, but apparently there is no excessive individual variation within the limits of each species. All these forms come from Tertiary deposits and have long been extinct, but the racial variation was progressive in time as well as in structure and the smooth shells are older than the highly sculptured ones. About these Viviparidae Neumayr (*op. cit.*) writes as follows :—

"Wie mein Freund Paul im geologischen Theile nachgewiesen hat, sind in den von uns untersuchten Gegenden von Westslavonien die glatten *Viviparen* mit äusserst geringer Ausnahme auf die unteren, die mit ausgesprochenen Kielen und Knoten versehenen Formen vollständig auf die mittleren und oberen Paludinenschichten beschränkt. In der mittleren und oberen Abtheilung konnten zahlreiche Horizonte unterschieden und auf grössere Erstreckung nachgewiesen werden und in Folge dessen konnten die rein morphologisch aufgestellten Formenreihen der gekielten und geknoteten *Viviparen* sofort der geologischen Controle unterworfen werden. Für die unteren Paludinenschichten konnte eine Gliederung noch nicht durchgeführt werden, und es fehlt daher für die glatten, wie für die nicht von uns selbst gesammelten Formen der Nachweis für die Concordanz der chronologischen und morphologischen Reihe."

It is of course impossible to say precisely in what environment the different species flourished, but it is clear from Paul's sections in the geological part of the treatise on these Slavonian beds, that the molluscs all lived in a country similar in some respects to the Shan Plateau and that some of them were certainly lacustrine. Bourguignat[2] says of part of the country in which they were probably evolved :—

"Il a dû y avoir, à cette époque reculée, dans cette partie de la vallée de la Cettina, une vaste dépression remplie d'eau salée, qui, peu à peu, par des causes qui me sont inconnues, sont devenues saumâtres, pour finir par être entièrement douces."

The interest of these two cases so far as our present purpose is concerned lies in the fact that they prove that *Vivipara*, from which *Margarya* and *Tulotoma* are certainly derived, has, in widely separated districts, and in peculiar circumstances, developed a similar tendency to become extremely plastic and to elaborate the sculpture of its shell in spiral series of nodules. What the circumstances probably were will be considered later. A few other, less striking perhaps but none the less interesting instances of the same kind may be cited more briefly.

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[1] *Abh. K. K. Geol. Reichsanstalt*, VII, pp. 1-105, pls. iv-vi (1875). See also Penecke on the Slavonian Paludina Beds in Mojsisovics and Neumayr, *Beitr. Palaeontologie Ost.-Ungarns*, IV, pp. 15-44, pl. ix (6) (1886). I have to thank Mr. G. de P. Cotter of the Geological Survey of India for these references.

[2] *Ét. Fossiles tert. & quatern. de la Vallée de la Cettina*, p. 2 (Saint-Germain : 1880).

In the lakes and rivers of Eastern China many species or races of *Vivipara* occur in which the shells are ornamented with spiral ridges of a more or less marked character but are much smaller and thinner than those of *Margarya*. Figures of these forms will be found in Kobelt's monograph and in Heude's[1] account of the molluscs of the Yang-tse. I have recently observed *V. lapillorum* (Heude), a member of this group, in natural conditions in the Tai-Hu (Great Lake) in the Kiangsu province of China. It lives chiefly on stones near the edge of the lake, in very muddy water and in a district in which limestone is abundant. It is a variable species and apparently not found together with any closely allied form.

Single species of the genus with similarly but even more strongly sculptured shells have been described from several other eastern lakes and lacustrine districts, *e.g.*, *V. grossicosta*, von Martens[2] from Lake Singkarah in Sumatra, *V. persculpta*, P. & E. Sarasin,[3] from Lake Posso in Celebes and *V. oxytropis* (Benson)[4] from Manipur in Assam, the basin of a lake which has shrunk in recent ages to small dimensions.

Moreover, Neumayr's *Viviparae* from Slavonia, though the most complete series as yet known, are by no means the only forms of a similar nature that have been described from Tertiary beds in Eastern Europe. The first instance of the kind to be discussed was that of certain forms from the island of Cos to which Edward Forbes[5] drew attention in 1847.

## Pelecypoda.

We may consider the three genera of Pelecypoda that occur in the Inlé basin together. They are *Physunio* of the family Unionidae, *Corbicula* and *Pisidium* of the family Cyrenidae. *Corbicula* is the only one of these represented, so far as we know, in the deposits of the district and it is only found in quite superficial deposits.

Two species of *Physunio* are found living in the district, one (*P. ferrugineus*) in the open parts of the lake, the other (*P. micropteroides*) in the streams that run into it. A feature of the genus is the production of a triangular " wing " on the dorsal surface ; as I have shown above, this wing is used by the lake-form in ploughing its way through semi-liquid mud. The structure exhibits, in this and other species, a great difference in shape and relative size at different periods of growth, being much smaller in very young and very old shells than it is in those which are just attaining maturity. Otherwise, *P. ferrugineus* shows only slight variations in outline and proportion and in the structure of the

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[1] Heude, *Mem. Nat. Hist. Emp. Chinois* I, pl. xl (1880-1890).

[2] v. Martens in Weber's *Zool. Ergebn. Niederl. Ost.-Ind.* IV, p. 25, pl. ii (1897).

[3] P. and E. Sarasin, *Sussw.-Moll. Celebes*, p. 62, pl. x (1898).

[4] Benson, *Journ. As. Soc. Bengal* V, p. 745 (1836). He does not state the precise locality of his specimens, but the Indian Museum possesses others collected in Manipur by Godwin-Austen.

[5] Forbes, *Edinb. Phil. Journ.* XLII, p. 271, pl. ii (1847). See also Newton, who gives other references : *Proc. Mal. Soc London* IX, p. 363 (1911). In the Tertiary beds of Eastern Europe other families of molluscs, especially the Neritidae and the Hydrobiidae, exhibit a similar evolution, while in the recent fauna of the Yang-tse, which possesses a remarkable resemblance to the later Tertiary freshwater faunas of Eastern Europe, peculiar shells occur in the Hydrobiidae in many respects analogous to those of the Tertiary *Viviparae* or of the living *Taiae*.

hinges of the shell, and these variations seem to be entirely individual. The Yawnghwe river-species differs from the lake-form in its smaller. thicker and higher shell and also in the very feeble development of the wing. Possibly this last character is correlated with life in much stiffer mud. This species is not a variable one.

The only *Corbicula* found in the Inlé basin is *C. noetlingi*, a form that has a wide range in the Shan States. Von Martens refers to a small variety which has a certain difference in outline from the typical form, but we did not find this variety in the Inlé and He-Ho basins. The species lives in streams and does not enter the lake. Subfossil shells do not differ constantly from living ones and there is no very definite racial difference between shells from altitudes varying from 3,000 to 4,500 feet, but the local phase has probably developed into a distinct race. I have refrained from giving it a name and from discussing it in detail because great confusion exists as to both the nomenclature and the specific limits of the eastern *Corbiculae*.

*Pisidium casertanum* is perhaps the most interesting bivalve mollusc found in the district, as it is a characteristic Palaearctic form. Specimens from the lake do not exhibit any great individual variation. The species is an extraordinarily plastic one, with a very wide geographical range. The limits of its variation have been discussed in great detail by B. B. Woodward[1] in his catalogue of the British species of the genus. He says :—

> "In external conformation this is a most variable species and may at times, especially when dwarfed, resemble forms of *P. pusillum* .... *P. personatum*.... and even *P. nitidum*.
>
> "There is one well marked form, a lake or still water form, which almost amounts to a variety. In this the shell is rounder than the type, and more compressed ..... whilst the hinge being narrower and lighter is less arcuate and the flexure less pronounced."

In three localities in Eastern Asia a form has been found that resembles "this lake or still water form," *viz.*, in Lake Biwa in Japan, in Lake Baikal in Siberia, and in the Inlé Lake on the Shan Plateau. I have not seen shells from Lake Baikal, but those from the Inlé Lake resemble Lindholm's figure [2] very closely. The Japanese shell, which is a little wider than Inlé specimens, has been examined by Woodward,[3] who remarks that it was "rather more oval than usual," *i.e.*, in the still water form. A single shell from a stream on the He-Ho plain is much more inflated than those from the lakes and approaches the Himalayan *P. atkinsonianum*,[4] which is also found in streams.

## CONCLUSIONS.

This is not a general treatise on variation or evolution, but merely an attempt to demonstrate so far as demonstration is possible, and with as little reference to contentious works as may be, certain phenomena

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[1] *Catalogue of the British Species of Pisidium in the Collection of the British Museum*, pp. 31-44, pls. i, figs. 3-6 ; iii, fig. 3 ; xiii-xviii (London : 1913).

[2] Lindholm in Korotneff's *Wiss. Ergebn. Zool. Exp. Baikal-See*, IV (Moll.), p. 85, pl. ii, figs. 45, 46.

[3] See Preston, *Ann. Mag. Nat. Hist.* (8), XVII, p. 162 (1916).

[4] See Preston, *Faun. Brit. Ind. Moll.*, p. 226, fig. 29 (1915).

manifested by the aquatic molluscs of a single district. Parallel cases have been cited for comparison, not to support any one theory.

Four facts stand out prominent in reference to these Mollusca :—

(1) That racial plasticity is a more common phenomenon among them than extreme individual variability, and that the two are not necessarily correlated.

(2) That both plasticity and individual variability are specific characters ; they may be almost absent for the time being in a stable species, but may be either acquired or lost in the course of evolution.

(3) That in very few instances is it possible to detect any advantage that the race can have gained by its plasticity.

(4) That the moulding forces, or the causes of plasticity, of greatest influence are not the same in all species, and that apparently slight differences in environment are sometimes of greater practical moment than changes which seem to be much greater.

I will deal with each of these points in some detail.

(1)

In most of the aquatic molluscs of the Inlé district, individuals from the same environment are very like one another. The main exceptions are *Planorbis velifer* (of which two distinct varieties live together), *Melania baccata*, *Taia naticoides* and *Taia elitoralis*.

The case of *Taia naticoides* is a remarkable one, for the species is both variable and plastic. Individuals from any one environment differ greatly from one another, falling roughly into three groups, the limits of which are, however, undefined. At the same time races from different types of environment differ from one another, while retaining their individual variability in slightly modified ways. It is, however, to the most extreme variety of the species (*carinata*, Theobald) that all the more highly modified forms of the genus are most closely related. Indeed, one of these forms (*intermedia*) is little more than a fixed race of this variety. *T. intermedia* is not, however, precisely speaking, a mutation in the sense in which the term is used by most biologists, because it is not descended, so far as can be seen from the evidence available, from a single individual or group of individuals that have departed suddenly from the normal type of the species. *T. naticoides* has a fairly wide distribution, and the variety *carinata* always occurs with the typical form. Moreover the transition between the two forms is quite gradual.

The circumstances of *T. elitoralis* are different in that it is only known from a single locality and a single type of environment, but it also seems to have given rise to a constant species very like itself, namely, *T. intha*, which is at once the most highly specialized form and one of the most constant forms in the genus.

On the other hand *Taia theobaldi*, probably the parent form of all these species, is a constant species. So also, in a sense, is *Hydrobioides nassa*, which has produced four races, each fairly constant in its own type of environment. Further, *H. nassa* is derived from another constant

form, *H. avarix*, in which its most striking peculiarity (the varix) is absent.

(2)

In species such as *Planorbis exustus* neither individuals nor local communities as a rule differ much one from another. A deficiency—it is not of course an entire absence—in variation of all kinds is also well exemplified in *Taia theobaldi* and *Hydrobioides avarix*. Yet these two constant forms have both given rise to species that are both variable individually and plastic: to *T. naticoides*, in which both individual variation and plasticity are extreme, in the one case, to *H. nassa*, in which plasticity is more marked than individual variability, in the other. *Limnaea shanensis*, on the other hand, has proved itself plastic without exhibiting individual variability; we only know it as a plastic species because of the discovery of shells of extinct phases: each phase was constant in its proper environment. *Taia intha*, a highly specialized form descended from ancestors that were both plastic and variable individually, has become in its own proper habitat a constant species and has apparently lost plasticity. That *Limnaea mimetica* has done so is proved by its continued existence as a modified form in conditions totally different from those with which its modification must be correlated; for its resemblance to deep-water forms is not merely superficial as in some of the instances cited on p. 174, but so detailed as to be almost beyond dispute.[1] Further, it is even possible that plasticity once lost may in certain circumstances be regained. This is, however, more difficult to demonstrate. The He-Ho living phase of *T. naticoides* may conceivably be descended direct from *T. intermedia* and represent a reversion to the variability of the ancestral form, but it seems on the whole more probable that *T. naticoides*, even after giving rise to *T. intermedia*, persisted in the neighbourhood unchanged, in a different environment from its daughter form.

(3)

The species or groups of species that have exhibited greatest plasticity are *Limnaea andersoniana*, *L. shanensis*, *Melania tuberculata*, *Hydrobioides avarix* and *nassa*, and the species of *Taia*.

On general grounds it is clear that two types of aquatic environment are the most favourable, at any rate in tropical and subtropical climates, for the type of plasticity that results in the evolution of peculiar species and genera. They are small mountain streams and large lakes. This is the case not only with molluscs but also with other groups of animals. Many of the most highly modified Indian genera of fish and of aquatic molluscs, as well as the most peculiar species of Batrachian and insect larvae, live in small streams in the hills, *e.g.*, *Pseudecheneis* of the family Siluridae among the fish; the almost neritiform *Stomatodon* of the family Melaniidae among the molluscs; and the tadpoles of such frogs and

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[1] Compare the blind prawn *Typhocaris galilea*, which has all the characters of an underground animal but now lives in an open fountain in which it has probably been isolated by an earthquake. See Annandale and Kemp, *Journ. As. Soc. Bengal*, IX (*n. s.*), p. 245 (1913).

toads as *Rana afghana*,[1] *Bufo penangensis*[2] and *Megalophrys montana*.[3] On the other hand, in countries in which large lakes exist many of the most highly specialized genera are found only in them, *e.g.*, the peculiar Mollusca of Lake Tanganyika in Central Africa, of Lake Tali Fu in Western China and of the deeper lakes of Celebes, or the peculiar prawns and crabs of Tanganyika, or even the peculiar fish of the Inlé Lake. We may assume therefore that in hill streams and large lakes there are certain factors that encourage extreme plasticity; but they cannot be the same in both instances.

In most of the highly modified genera and species that inhabit hill streams, the modifications in structure have a definite function in enabling the animal to cling tightly to rocks or other solid bodies in rapid-running water. But this is not the case with most modified organisms from large lakes.

It is possible[4] that in *Limnaea*, a pulmonate mollusc that has no gills or other special organ by means of which oxygen can be absorbed direct from the water, it may be advantageous in deep water or in water highly charged with vegetable matter to have a relatively large aperture to the shell; for this enables a large surface of skin to be extruded and it is probable that oxygen, in conditions in which the animal cannot rise to the surface, must be absorbed through the skin. If, however, this is the case, it is probable that the benefit is to a large extent fortuitous, for we have no evidence whatsoever that the modification has been produced through any kind of selection of individuals; it rather seems to be the result of the direct influence of physical or chemical forces working suddenly or gradually on a plastic organism, as is suggested by the series of shells figured on plate X, figs. 5-8, as well as by the experiments cited above. Further, the deep-water forms of the genus resemble the young of shallow-water forms in the shape as well as the size of the shell. They are essentially forms which retain when adult the external characters of immaturity.

As I have already pointed out it is not uncommon in *Ampullaria* for ridges to be produced on the surface of the body-whorl owing to the resumption of growth after a period of rest. There is every reason to think that the varix of *H. nassa* has a similar origin, but whereas in *Ampullaria* the lip of the shell is thin and therefore the ridge representing it is low, in *H. nassa* the lip and the ridge representing it are thick. Our visit to the Inlé Lake was made in early spring, at a time when many hibernating animals were just beginning to awake from their winter sleep. I noticed that large numbers of young individuals of *H. nassa* of from 2 to 3 mm. long had at this season a very thick lip, but that in others only slightly longer or even a little shorter, the thickening had disappeared and the lip was thin and sharp. It seems probable, therefore, that the marginal thickening can be absorbed in the course of growth. The retention of the varix in adult shells would seem to indicate merely that at a certain period of growth the animal

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[1] Annandale, *Rec. Ind. Mus.*, VIII, p. 9 (1912).
[2] Flower, *Proc. Zool. Soc. London*, (1899), p. 908.
[3] Annandale, *Mem. As. Soc. Bengal*, VI, p. 155 (1917).
[4] Pelseneer, *Arch. de Biol.* XIV, p. 379 (1895).

loses the power of absorbing the ridge left when the shell grows beyond the old lip. All this is in favour of the view that the varix is a vestigial structure, vestigial that is to say so far as the individual and not the race is concerned. It may otherwise be considered as a sign of the approach of senescence or at any rate of full maturity, for when the old lip ceases to be absorbed the animal has not the power to grow very much larger.

It is difficult to see in what way differences of size in the shells of *Melania* or of shape and sculpture in those of *Taia* could be of any benefit to the race either directly or indirectly. The shells in the latter genus are as a rule so thin and fragile, even when highly decorated, that they could not protect the animal from powerful enemies of any kind. Neither could the knobs and scales on their surface protect them from parasites. *T. intha* at any rate, the species which I have been able to observe most closely in natural conditions, seems to be a peculiarly sluggish and unprotected animal, and to be altogether devoid of enemies except leeches of the genus *Glossosiphonia*, which make their way in through the mouth of the shell and are not deterred from doing so by the sculpture round the aperture or on the surface.

(4)

We have seen that in *Limnaea* the cause of change in the shape of the shell is, in some species, the change from running to still water or conversely, and that this change acts directly on the young individual. In other species of the same genus, however, other forces come into play and the case becomes much more complicated. Indeed, almost all that can be said with certainty is that the shells of individuals living in water of peculiar chemical composition, as all the Inlé species do, are usually dwarfed, and that individuals living in deep water are still more strongly dwarfed and very narrow and have the mouth of the shell very long and the spire short, and that these are essentially immature characters.

In *Melania tuberculata* overcrowding, especially in a small space, and also undue salinity of the water in some cases, produces dwarfing, but in the Lake of Tiberias, where the water is distinctly saline, the shells are large and well-developed.

We know that *Hydrobioides nassa distoma* survived for a considerable period both in lacustrine and paludine conditions without change, although the species, probably under slightly different conditions, has developed a distinct race in the central region of the Inlé Lake, and the race *distoma* has become extinct.

Some of the different races of *Taia* that have become so far differentiated as to be regarded conventionally as distinct species, have been produced, so far as we can see, in circumstances that differ little, and the same thing has apparently occurred in *Margarya* in Yunnan, in the Tertiary Viviparidae of Slavonia and in other widely scattered instances.

It follows almost as a corollary that similar modifications may be brought about in very different biological circumstances. This is clearly shown by the resemblance between the shells of *Succinea indica* and *Limnaea mimetica*; but it must be noted that only the *Limnaea* can

be considered to be a highly modified form. The *Succinea* is a normal form of its genus.

The smaller mollusca of the Inlé Lake, especially those belonging to the genera *Limnaea*, *Planorbis* and *Pisidium*, would undoubtedly be taken for deep-water forms by a conchologist accustomed to the deep-water molluscs of the Swiss Lakes.[1] Their minuteness, their fragility, the lack of pigment in both shell and soft parts, and, in the *Limnaea*, the extremely long mouth of the shell and the rudimentary but relatively narrow shape of the spire, are all features characteristic of deep water. The Inlé Lake was once very much deeper than it is now and *Limnaea mimetica* is probably a deep-water form that has survived from the period when that was the case, but two of the three species of *Planorbis* that are now found in the central region of the lake are also found, with some of the same characters, in waters that can never have been deep and never even have formed part of a lake-system. The *Pisidium* is no smaller or more fragile than the form (*P. atkinsonianum*) common in small streams in the Himalayas. Indeed, it is very like this form, except that the shell is less swollen, a feature in which it also differs from the phase found in streams on the He-Ho plain.

Moreover, smallness, fragility and colourlessness of shell in the case of bivalve molluscs are often associated with life in soft mud in shallow water in very different biological conditions. This is so not only with *P. atkinsonianum* in small mountain streams, but also with *Corbicula tenuistriata* [2] in the Whangpoo River near Shanghai, and with species of a number of different families in the brackish water of the Chilka Lake.[3]

In the life of these bivalve molluscs there is a common biological feature in that they live in soft mud, and the modification of the shell may be of practical utility to the individual and the race. In the bionomics of *Taia*, *Margarya* and the Slavonian Viviparidae also it is not improbable there is or was some common feature, but there is no evidence that it was of biological importance and, if it existed, it is, with our present knowledge, obscure. In any case the circumstances of their life-history cannot have been by any means identical. All that can be said is that in each case the peculiar forms with highly sculptured shells seem to have been evolved in a region of great lakes, in which an abundance of soluble mineral salts was present and in which the climate was temperate rather than tropical, warm rather than cold. Apparently also the water did not possess any marked power of erosion of the shell, which would have destroyed the sculpture and rendered its perfection impossible.

From the facts stated and the inferences already drawn it seems very doubtful whether the peculiar modifications of the shell observed in so many of the aquatic molluscs of the Inlé Lake can have any bearing on the more highly specialized modern theories of evolution, which, even if sound in certain instances, are perhaps of less general application than their rival exponents are willing to admit. None of

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[1] See Zschokke, *Die Tiefseefauna der Seen Mitteleuropas*, pp. 155, 164 (1911).
[2] Annandale, *Mem. As. Soc. Bengal*, VI, pt. i, p. 67 (1916).
[3] Annandale and Kemp, *Mem. Ind. Mus.*, V, p. 341 (1916).

these theories have been put forward with the same wealth of natural illustration that Darwin gathered together in his *Origin of Species*, and it is just as important that observations should be continued in the field on as large a scale as possible, and without reference to any one preconceived theory, as that experiments should be conducted in the laboratory or garden-plot with a theory to support. I do not think that any single formula can express, much less explain, evolution.

I am of the opinion that the Inlé shells illustrate two different and possibly somewhat exceptional lines along which evolution may proceed.

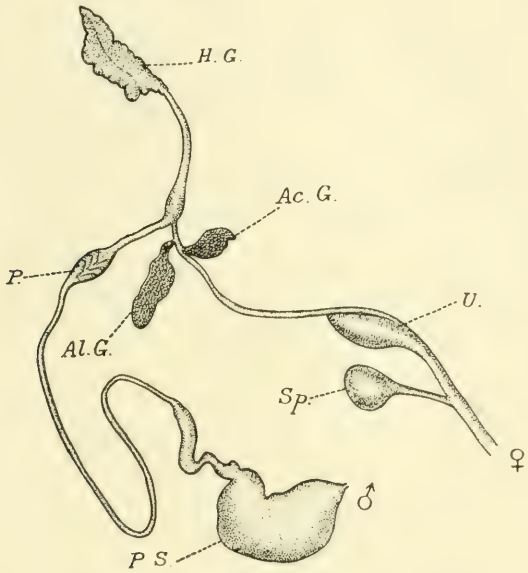


Fig. 9.—Genitalia of *Limnaea mimetica*.

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

We know that in some forms of *Limnaea* the plasticity is of the young individual, and that modification can be produced and reproduced in either direction from one generation to another. Probably, however, even in comparatively simple shells such as those of *Limnaea*, a time would come, if the environment were constantly changed in one direction, at which plasticity disappeared. This is indicated by Whitfield's observation that individuals of this genus if kept in captivity for several generations lost their monoecious structure and became dioecious. He was of the opinion, that this was directly due to abortion of that part of the shell in which certain of the sexual organs were normally lodged. It follows, therefore, that in suggesting that altered environment may finally result in a modification of the race rather than of individuals, one is not necessarily expressing heretical views as to the inheritance of acquired characters—a series of phenomena, or supposed phenomena, which it seems to be quite impossible either to prove or definitely to disprove. If the organs of one sex in a monoecious animal can disappear after several generations as a direct result of a change of conditions on the shape of inanni-

mate parts, there can be no difficulty in claiming that change of conditions may ultimately affect the gonads in such a way that a new race or species is evolved, for either the animal must become parthenogenetic or else new combinations in the germ-plasm must be liable to occur. The precise meaning of Whitfield's statement is, however, obscure, and it cannot be applied to *Limnaea mimetica*, in which the genitalia are quite normal and as usual hermaphrodite. I reproduce a figure (fig. 9) prepared for me by Mr. Baini Prashad to illustrate this point.

It does not seem to be possible to explain the extraordinary development of the forms of *Taia* in the same way as that of the genera already discussed. The history of the genus as we know it may be summarized as follows :—*Taia theobaldi*, a constant species, lived and lives in running water in mountainous districts. It gave rise, how we do not know, to *T. naticoides*, an extremely variable species that lives in ponds and marshes and the backwaters of streams. Some individuals of *T. naticoides* closely resemble the parent form, while others depart from it widely and represent a much higher degree of specialization. From this extreme form of *T. naticoides* some ten or eleven other forms have been derived, mostly if not solely in large lakes. Evolution, therefore, seems to have taken place in this genus along somewhat peculiar lines, but the highly specialized sculpture of the shell can hardly have been more than a by-product of evolution.[1] Dendy and Nicholson[2] have recently shown that certain sponge-spicules of somewhat elaborate outline owe their peculiar shape to the mechanical forces produced by the flow of water through the sponge. Dendy has also pointed out, however, that advantage is taken of the modifications thus produced, should they chance to be useful. The cases are o course analogous, not homologous, for the forces, be they chemical or purely physical, to which a free-living mollusc is subjected in still water cannot be the same as those that have moulded the spicules into shape ; and even the analogy must not be pressed too far, for we have evidence in *Taia naticoides* that at any rate the rudiments of the peculiar sculpture of the shell may appear without the application of any well-defined physical or chemical force. The resemblance consists in this—that in both cases highly peculiar and elaborate forms have been produced in the inanimate parts of living organisms without any apparent utility in the first instance, but capable of utilization and as it were of standardization. In the life-history of *Taia* there seems to have been no economic need for the application of these peculiarities, but they have become standardized by what seems to have been a racial (or possibly a germinal) as distinct from an individual selection ; *Taia intermedia* affords no evidence of the survival of the fittest individuals but suggests rather that all the individuals born in a certain locality and type of environment were formed in accordance with a certain pattern that already existed, with others, in the reproductive potentialities—the phrase is purposely vague—of *T. naticoides*, its immediate ancestor.

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[1] Dendy, *Journ. Quekett Micr. Club* (2), XIII, p. 38 (1916).

[2] Dendy, *ibid.*, XIII, pp. 1-16 (1917) ; Dendy and Nicholson, *Proc. Roy. Soc.*, London (B), LXXXIX, pp. 573-587.

The knobs, ridges and spines on the shell of *Taia intha*, the culminating species of the genus, seem to be of no use to the animal, which is a sluggish creature, quite incapable, so far as it is possible to judge, of aesthetic perception of its own beauty. Its shell has reached perfection in calm and undisturbed surroundings, which place no bar in the path of eccentricity. The sculpture seems to have made its appearance in a primitive form in *T. theobaldi* in circumstances that forbade its full development, and to have had a cumulative development in proportion as the surroundings became more and more peaceful and settled. Lack of enemies, abundance of food, absence of aquatic currents, abundance of free oxygen, an equable temperature without frost, absence of free acid and erosive algae have all combined to give an inherent tendency full play, probably not through the elimination of individuals in which this tendency was feeble so much as through its strengthening in all individuals.

The Inlé Lake, or rather the system as a shrunken relic of which it persists, was, on a comparatively small scale, one of those districts, such as Lake Tanganyika or the lake country of Celebes, in which phenomena of the kind have been manifested to an exceptional degree.

*List of species giving approximate age, etc.*

| | Fossil. | | | | |
|---|---|---|---|---|---|
| | Hsin-Dawng. | He-ho. | Sub-fossil. | Living. | |
| *Succinea indica*, Pfeiffer | | | — | — | |
| *Limnaea andersoniana*, Nevill | | | | — | in streams and ponds. |
| „ *shanensis*, Annandale, A | | — | | | |
| „ „ , B | | | — | | |
| „ „ , C | | | | — | |
| „ „ , D | | | | | ? |
| „ *mimetica*, Annandale | | | | — | |
| „ ? prox. *ovalis* Gray | | — | | | |
| *Planorbis exustus*, Deshayes | | | | — | |
| „ *saigonensis*, Crosse and Fischer | | | — | | |
| „ *velifer*, Annandale | | | — | — | |
| „ „ var. *ciliata* | | | | — | |
| „ *trochoideus*, Benson | | — | | — | |
| „ *calathus*, Benson | | | | — | |
| „ *caenosus*, Benson | | | | — | |
| *Melania tuberculata* (Müller) | | | — | — | |

*List of species giving approximate age, etc.*—contd.

| | Fossil. | | | | |
|---|---|---|---|---|---|
| | Hsin-Dawng. | He-ho. | Sub fossil. | Living. | |
| *Melania terebra*, Benson | | | | — | Yawnghwe river. |
| ,, *baccata* (Gould) var. *elongata* | | | — | — | |
| *Paludomus ornata*, Benson | | | | — | in running water. |
| *Hydrobioides turrita* (Blanford) | | | — | | |
| ,, *nassa* (Theobald) | | | | — | |
| ,, ,, var. *lacustris* | | | | — | |
| ,, ,, var. *rivulicola* | | | | — | in running water. |
| ,, ,, var. *distoma* | | — | — | | |
| ,, *avarix*, Annandale | | | | — | in running water. |
| ,, *nana*, Annandale | | | | — | |
| ,, *physcus*, Annandale | | | | — | |
| *Amnicola alticola*, Annandale | | | — | — | |
| *Vivipara lecythis* (Benson) | | | | — | |
| *Taia theobaldi* (Kobelt) | — | — | — | — | |
| ,, *naticoides* (Theobald) | | | | — | in swamps and backwaters. |
| ,, *intermedia*, Annandale | | | — | | |
| ,, *obesa*, Annandale | — | | | | |
| ,, *shanensis* (Kobelt) | | | | — | |
| ,, *cylindrica*, Annandale | — | | | | |
| ,, *lacustris*, Annandale | | — | — | | |
| ,, *analoga*, Annandale | | | — | | |
| ,, *conica*, Annandale | — | | | | |
| ,, *clitoralis*, Annandale | | | | — | |
| ,, *intha*, Annandale | | | | — | |
| *Ampullaria winkleyi*, Pilsbry | | | | — | |
| *Physunio micropteroides*, Annandale | | | | — | in streams. |
| ,, *ferrugineus*, Annandale | | | | — | |
| *Corbicula noetlingi*, Martens | | | | — | in ponds, marshes, and slow streams. |
| *Pisidium casertanum* (Poli) | | | | — | |

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# NOTE ON THE PALAEONTOLOGY OF THE INLE MOLLUSCA.

*By* E. Vredenburg, *B.L., B.Sc., F.G.S., etc., Superintendent, Geological Survey of India. Communicated by kind permission of the Director, Geological Survey of India.*

The shells occurring in various geological formations have been classified, by Dr. Annandale, according to their relative antiquity, as sub-fossil and fossil. How far these two groups correspond with the two divisions generally recognised by geologists in the Quaternary era, the " Pleistocene " and the " Holocene " (or " sub-recent " or " recent ") cannot at present be definitely settled.

In Europe and in many other temperate regions, the termination of the Glacial Period forms a convenient datum line for separating the two divisions. In India, the study of the corresponding formations has not yet progressed far enough to correlate them in detail with the sequence of local physical changes.

Nevertheless, the shells which Dr. Annandale has classified as " sub-fossil " may confidently be regarded as " holocene " or " sub-recent," but it would be difficult at present to say for certain whether those described as " fossil " should be ascribed to an earlier phase of the " holocene," or else regarded as frankly pleistocene, though the latter alternative is more probable.

Considering the great plasticity of some of the forms above described, length of time need not represent a factor of primary importance in the evolution of the extinct and living mutations or species under consideration. Their transformations seem directly connected with the changes in physical geography of the Shan plateau, and, without precise information as to the geological dates of the physiographical evolution of that region, we are unable to fix the exact period of the correlated biological changes.

## EXPLANATION OF PLATE X.

**Limnaea andersoniana,** Nevill.

Fig. 1.—Living shell from pond near Yawnghwe. Length 12 mm.
Fig. 2.—Living shell from small stream at Fort Stedman. Length 9 mm.

**Limnaea** sp. (prox. *ovalis*, Gray).

Fig. 3.—Fossil shell from lake deposit on He-Ho plain. Length 9 mm.

**Limnaea bowelli,** Preston.

Fig. 4.—Living shell (type-specimen) from Tibet. Length 8·5 mm.

**Limnaea shanensis,** sp. nov.

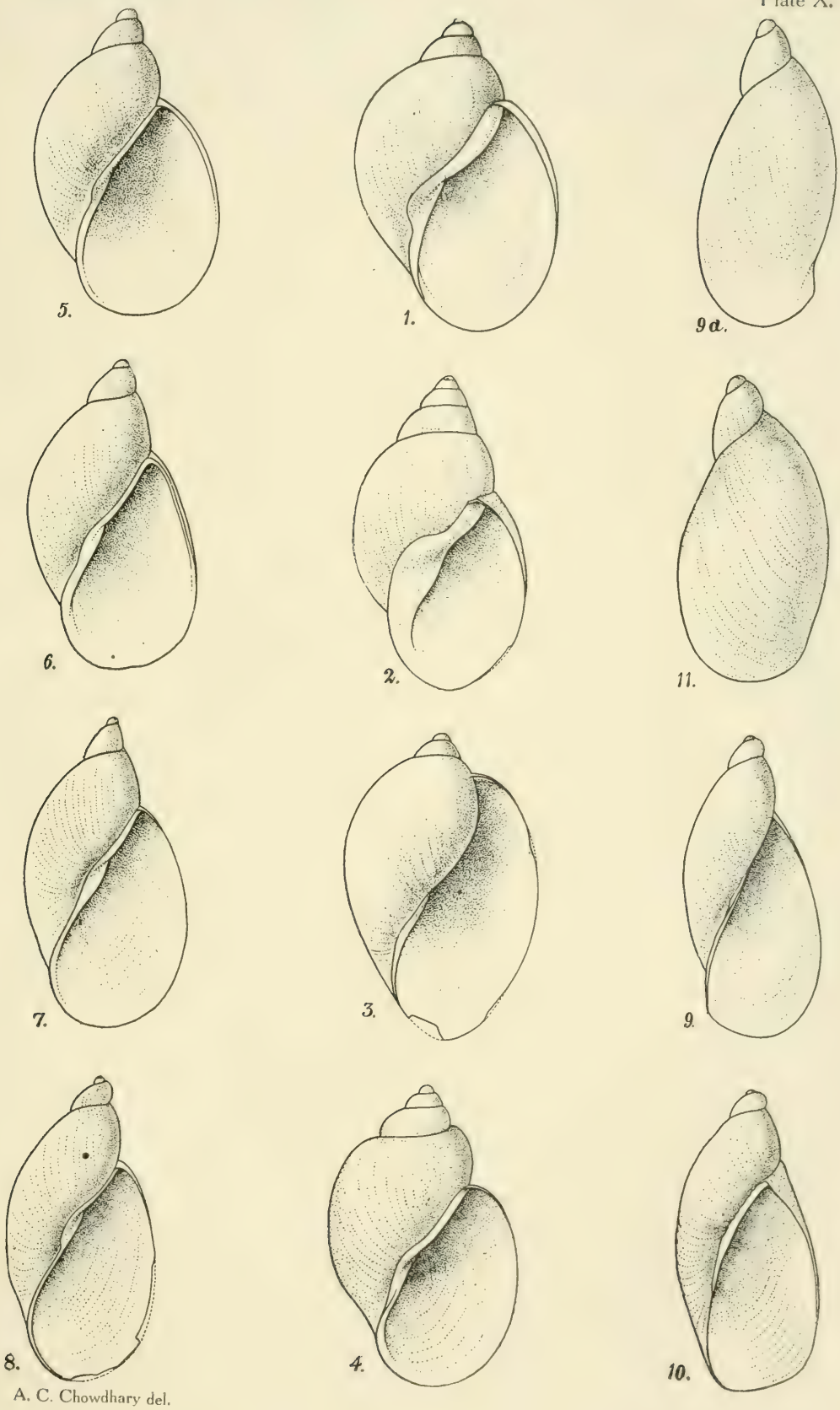
Fig. 5.—Fossil shell of phase A from lake deposit on He-Ho plain. Length 9 mm.
Fig. 6.—Subfossil shell of phase B from edge of He-Ho stream. Length 10 mm.
Fig. 7.—Living shell of phase C from the Inlé Lake. Length 10·25 mm.
Fig. 8.—Fossil shell of phase D from bottom of Inlé Lake. Length 6·5 mm.

**Limnaea mimetica,** sp. nov.

Figs. 9, 9*a*.—Type specimen (living shell). Length 6 mm.

**Succinea indica,** Pfeiffer.

Fig. 10.—Living shell from Inlé Lake. Length 14 mm.
Fig. 11.—Subfossil shell from edge of He-Ho stream. Length 14 mm.

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## EXPLANATION OF PLATE XI.

**Planorbis exustus,** Deshayes.

FIGS. 1, 1*a*.—Young shell from Inlé Lake, highly magnified.

**Limnaea shanensis,** sp. nov.

FIG. 2.—Marginal teeth of radula, ×554.
FIG. 3.—Central and lateral teeth of radula, ×554.

**Limnaea mimetica,** sp. nov.

FIG. 4.—Lateral and marginal tooth of radula, ×554.

**Succinea indica,** Pfeiffer.

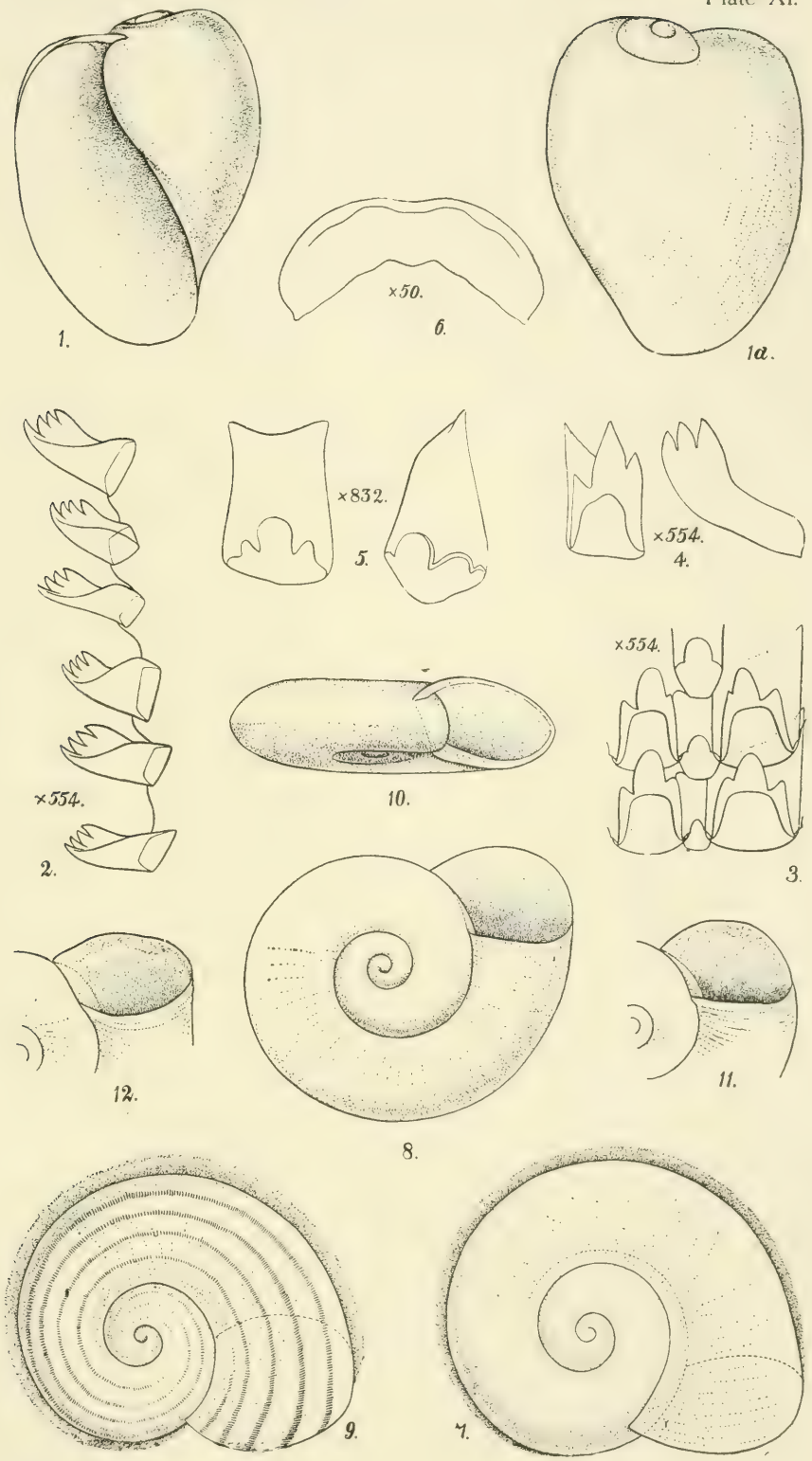
FIG. 5.—Lateral and marginal tooth of radula, ×832.
FIG. 6.—Upper jaw, ×50.

**Planorbis velifer,** sp. nov.

FIG. 7.—Upper view of shell of typical form, ×13.
FIG. 8.—Lower view of same shell, ×13.
FIG. 9.—Upper view of shell of the var. *ciliata*, ×13.
FIG. 10.—Front view of shell of typical form, ×13.
FIG. 11.—Lower view of mouth of another shell of the typical form, ×13.

**? Planorbis saigonensis,** Crosse and Fischer.

FIG. 12.—Lower view of mouth of subfossil shell from edge of He-Ho stream, ×13.

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&
D. Bagchi del.

## EXPLANATION OF PLATE XII.

Direct photographs of shells of *Melania* and *Ampullaria ;* natural size.

**Melania tuberculata,** Müller.

FIG. 1.—Living shell from Inlé Lake.
FIG. 2.—Large subfossil shell from He-Ho plain.

**Melania baccata** (Gould.).

FIGS. 3, 3*a*.—Type-specimen of the var. *elongata* from swamp on He-Ho plain.
FIGS. 4, 5.—Living shells of small phase from the Yawnghwe river.
FIGS. 6, 7.—Subfossil shells from He-Ho plain.

**Melania variabilis,** var.

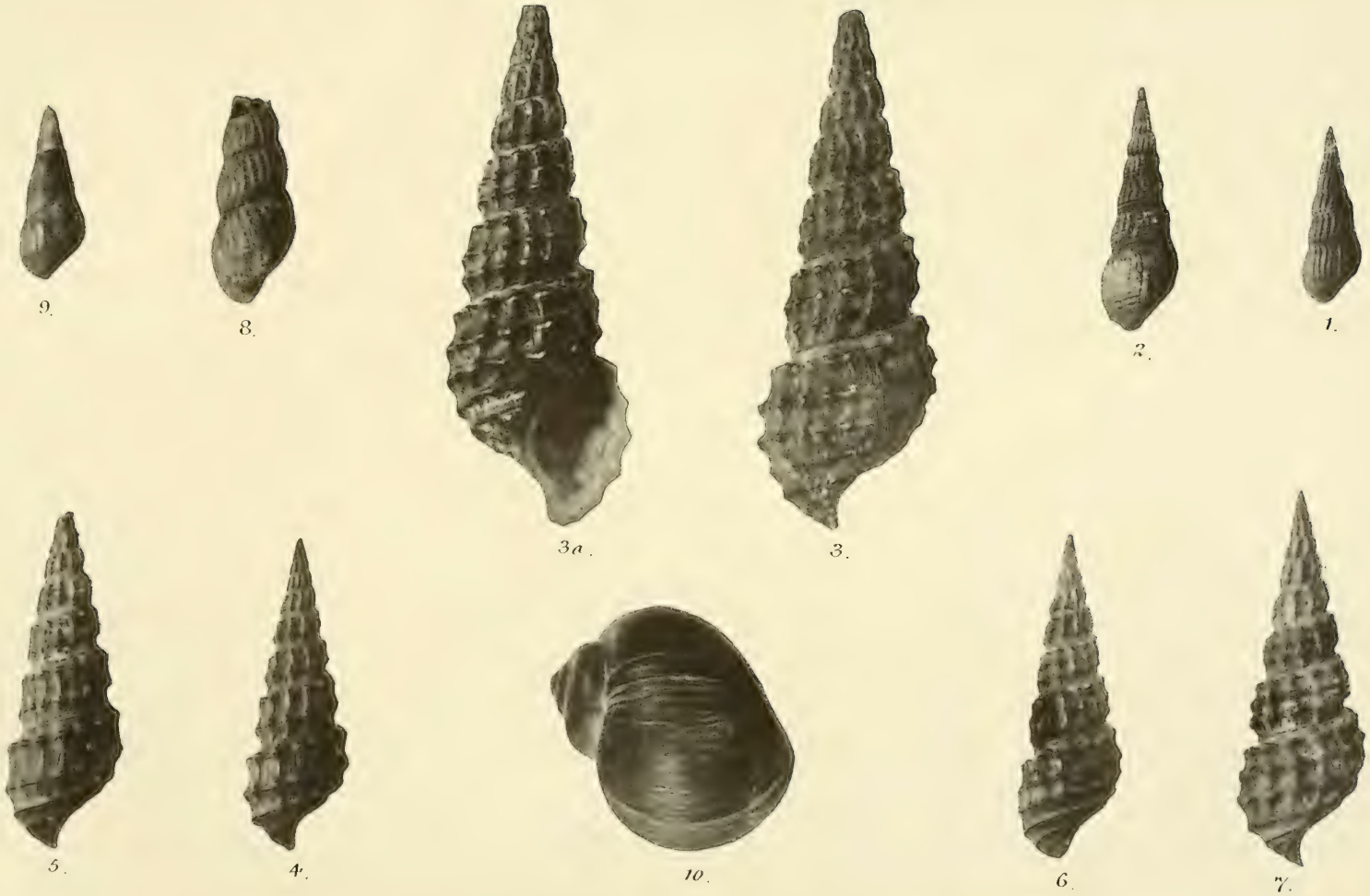
FIG. 8.—Fossil shell from cave deposit at Hsin-Dawng.

**Melania terebra,** Benson.

FIG. 9.—Living shell from the Yawnghwe river.

**Ampullaria winkleyi,** Pilsbry.

FIG. 10.—Small shell showing periods of growth from the Yawnghwe river.




S. C. Mondul, Phot.

Photo-engraved & printed at the Offices of the Survey of India, Calcutta, 1918.

## EXPLANATION OF PLATE XIII.

Shells of *Hydrobioides nassa* (Theobald) and *H. physcus*, sp. nov.

**Hydrobioides nassa** (Theobald).

FIGS. 1, 1*a*.—Shells of the subspecies *distoma* from lake deposit on the He-Ho plain, × 4.

FIG. 2.—Subfossil shell of the same subspecies from the He-Ho plain, × 4.

FIG. 3.—Living shell of the *forma typica* from a pond near Yawnghwe, × 4.

FIGS. 4, 4*a*, 5, 5*a*.—Shells of the subspecies *lacustris* from the Inlé Lake, × 4.

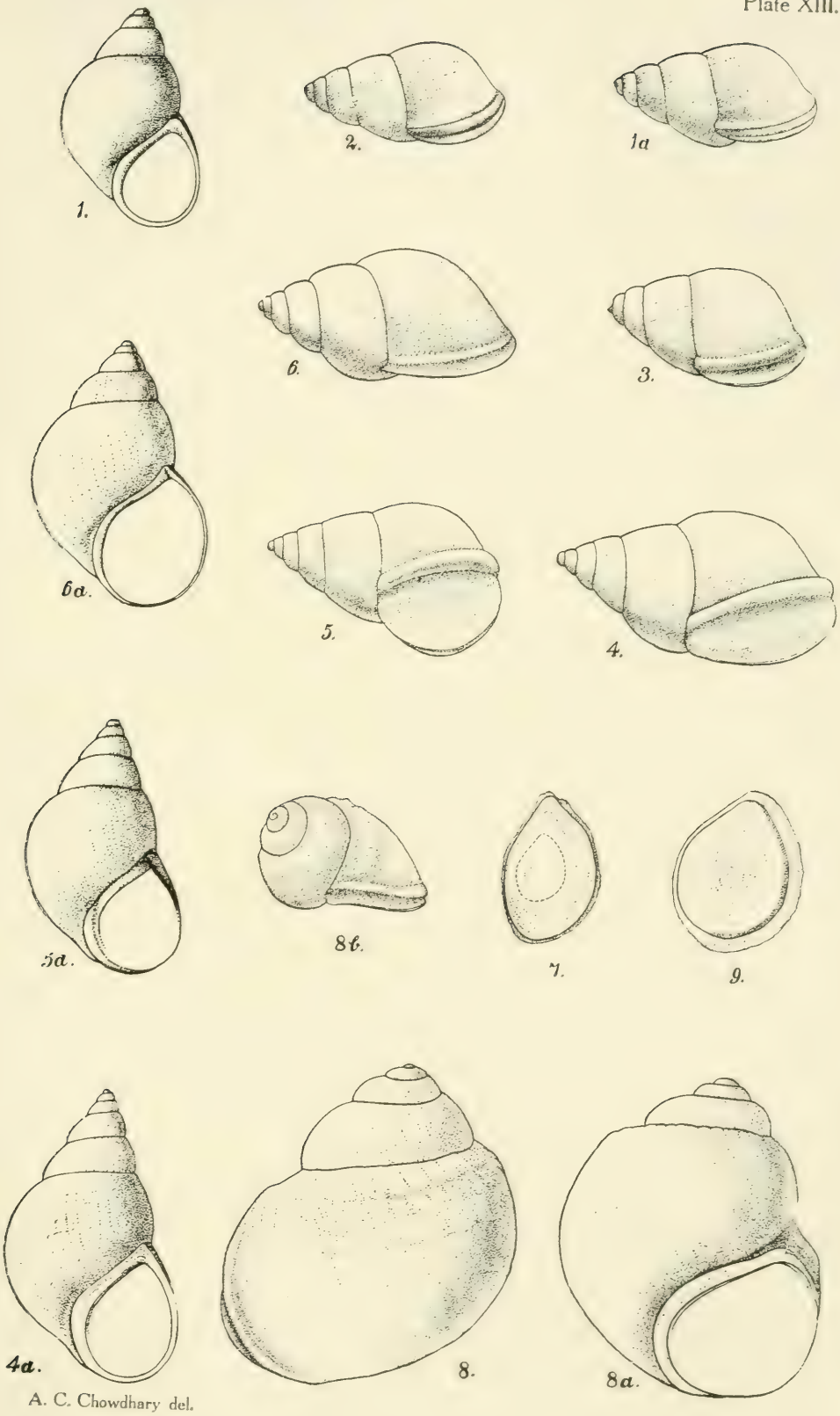
FIGS. 6, 6*a*.—Shells of the subspecies *rivulicola* from Thamakan, × 4.

FIG. 7.—Operculum of the subspecies *lacustris* (magnified).

**Hydrobioides physcus,** sp. nov.

FIGS. 8, 8*a*.—Shell from the Inlé Lake. Length 7 mm.

FIG. 9.—Operculum of the same shell.

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## EXPLANATION OF PLATE XIV.

Shells, radular teeth, etc., of *Hydrobioides* and *Amnicola*.

**Hydrobioides avarix,** sp. nov.

FIGS. 1, 2, 2*a*, 2*b*, 2*c*.—Shells, opercula and radular teeth of specimens from a small stream near Fort Stedman.

(FIGS. 1, 2, 2*a*, 2*b*, × *ca.* $7\frac{1}{3}$; radular teeth highly magnified.)

**Hydrobioides nana,** sp. nov.

FIG. 3.—Type-specimen from the Inlé Lake, × *ca.* 19.

**Hydrobioides nassa** (Theobald).

FIGS. 4, 4*a*.—Radular teeth and male organ.

(FIG. 4 highly magnified; fig. 4*a* × 20.)

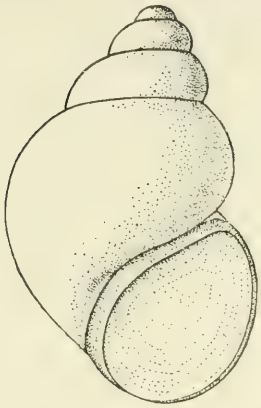
**Hydrobioides physcus,** sp. nov.

FIGS. 5, 5*a*.—Same structures.

(FIG. 5 highly magnified; fig. 5*a* × 20.)

**Amnicola alticola,** sp. nov.

FIGS. 6, 6*a*.—Shell and operculum; the operculum as seen from within. Length of shell 2·75 mm.



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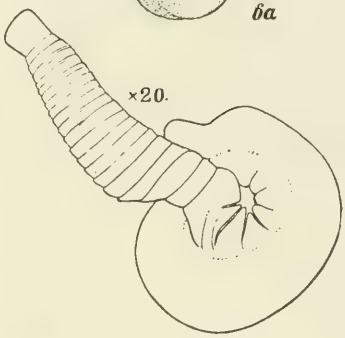


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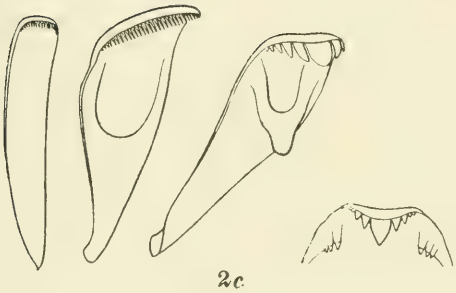

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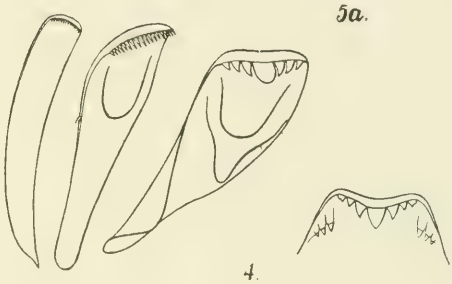

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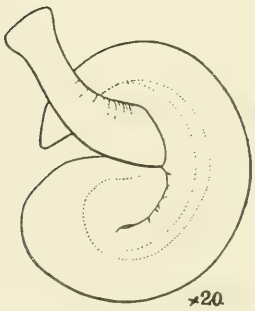


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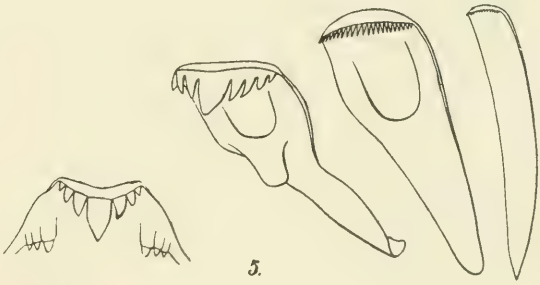

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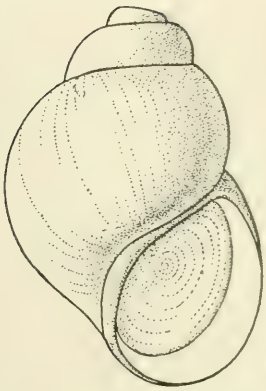

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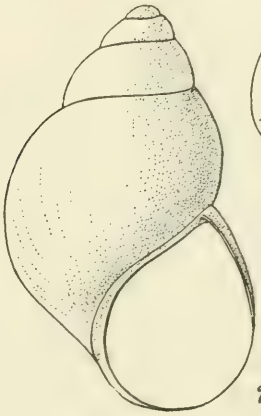

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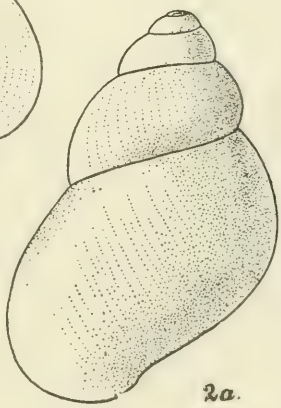

2a.

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## EXPLANATION OF PLATE XV.

Photographs of shells of the Shan species of *Taia:* all natural size.

**Taia intha,** sp. nov.

FIG. 1.—Shell from near the edge of the Central Region of the Inlé Lake.

FIG. 2.—Shell with the spines abnormally developed, from the middle of the lake.

FIG. 3.—Type-specimen, from the middle of the lake.

**Taia elitoralis,** sp. nov.

FIG. 4.—Unusually large and elongate male shell from the Intermediate Zone of the Inlé Lake.

(Shell is covered by a colony of the Polyzoon *Hislopia lacustris.*)

FIG. 5.—Type-specimen (female shell) of the same species.

**Taia analoga,** sp. nov.

FIGS. 6, 7.—Type-specimens from peaty deposit on the He-Ho plain.

FIG. 12.—Young shell of the same species from the same deposit.

**Taia conica,** sp. nov.

FIG. 8.—Co-type from the Hsin-Dawng cave deposits.

**Taia cylindrica,** sp. nov.

FIG. 9.—Type-specimen from the same deposit.

**Taia lacustris,** sp. nov.

FIG. 10.—Type-specimen from the lacustrine deposit on the He-Ho plain.

FIG. 11.—Young shell from superficial deposit on the same plain.

**Taia intermedia,** sp. nov.

FIG. 13.—Type-specimen from superficial deposit on the He-Ho plain.

**Taia shanensis** (Kobelt).

FIGS. 14, 15.—Male and female shells from Marginal Zone of the Inlé Lake.

**Taia naticoides** (Theobald).

FIGS. 16, 17.—Shells of the Yawnghwe phase.

**Taia theobaldi** (Kobelt).

FIG. 18.—Subfossil shell from the soil at Kalaw.

**Taia obesa,** sp. nov.

FIG. 19.—Type-specimen from cave deposit at Hsin-Dawng.


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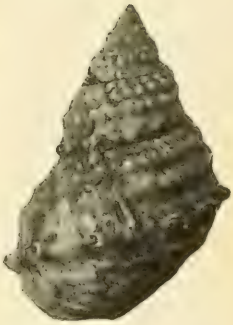
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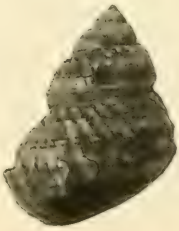
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S. C. Mondul phot.

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## EXPLANATION OF PLATE XVI.

Outline drawings illustrating the sculpture of shells of the Shan species of *Taia*. The line between the two views of each shell shows the actual length.

**Taia theobaldi** (Kobelt).

Fig. 1.—Living shell from the Yawnghwe plain.

**Taia obesa,** sp. nov.

Fig. 2.—Type-specimen from Hsin-Dawng caves.

**Taia naticoides** (Theobald).

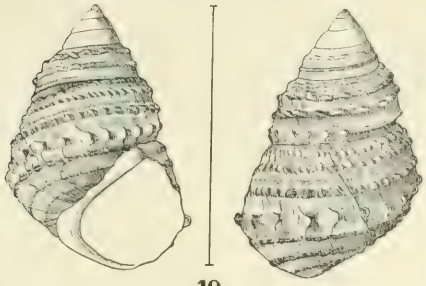
Figs. 3, 4.—Shells of the Yawnghwe phase.
Figs. 5, 6.—Shells of the He-Ho phase.

**Taia intermedia,** sp. nov.

Figs. 7, 8, 9.—Shells from superficial deposits on the He-Ho plain.

**Taia shanensis** (Kobelt).

Fig. 10.—Shells from the Marginal Zone of the Inlé Lake.



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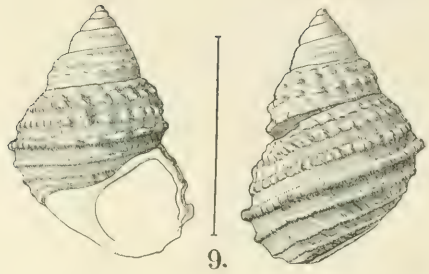

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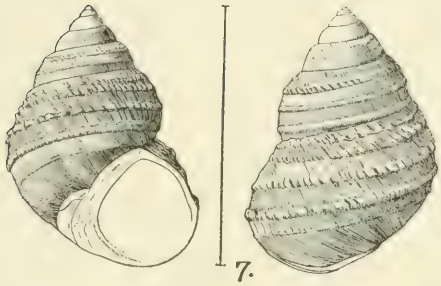

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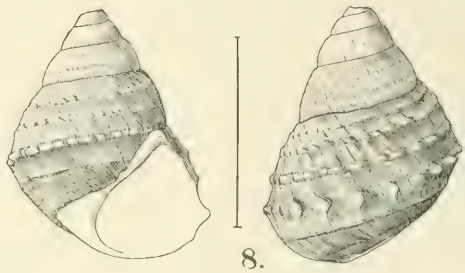

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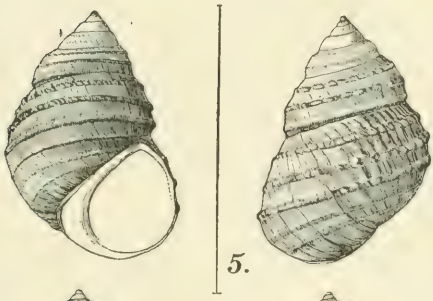

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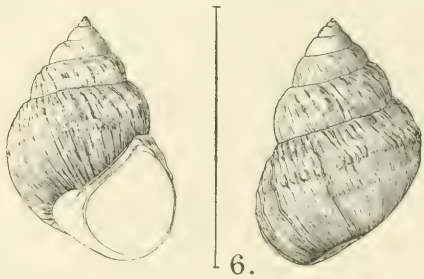

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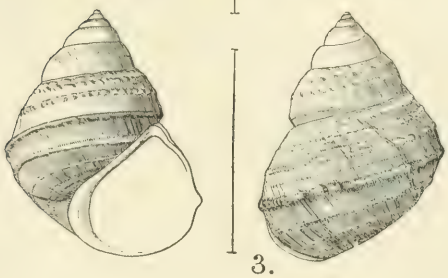

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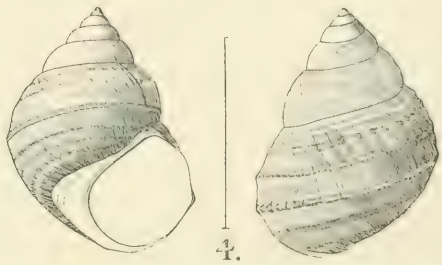

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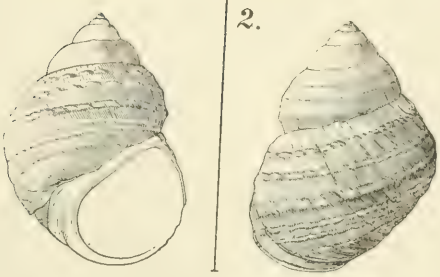

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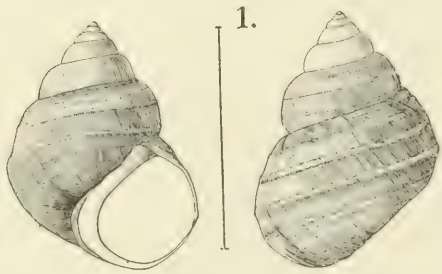


A. C. Chowdhary del.

## EXPLANATION OF PLATE XVII.

Outline drawings illustrating the sculpture of the shells of the Shan species of *Taia*. The line between the two views of each shell shows the actual length.

**Taia lacustris,** sp. nov.

Fig. 1.—Type-specimen from lacustrine deposit on the He-Ho plain.

**Taia cylindrica,** sp. nov.

Fig. 2.—Type-specimen from Hsin-Dawng cave deposits.

**Taia analoga,** sp. nov.

Figs. 3, 4.—Shells from peaty deposits on the He-Ho plain.

**Taia elitoralis,** sp. nov.

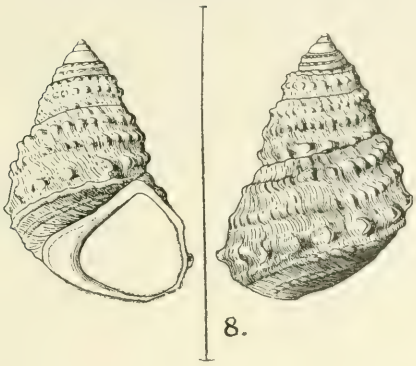
Figs. 5, 6.—Male and female shell from the Intermediate Zone of the Inlé Lake.

**Taia intha,** sp. nov.

Fig. 7.—Typical shell from the middle of the Inlé Lake.

**Taia conica,** sp. nov.

Fig. 8.—Type-specimen from Hsin-Dawng cave deposits.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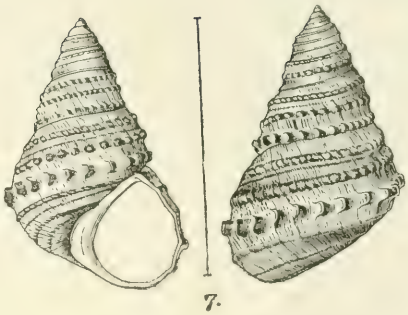
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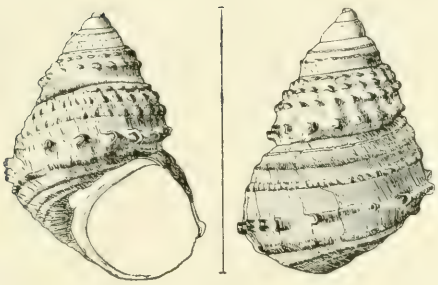
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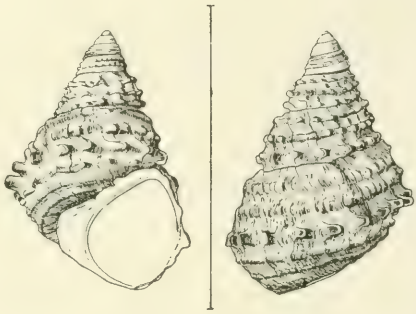
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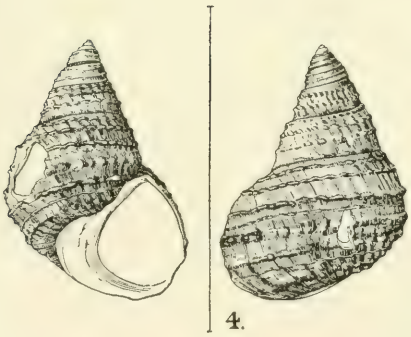
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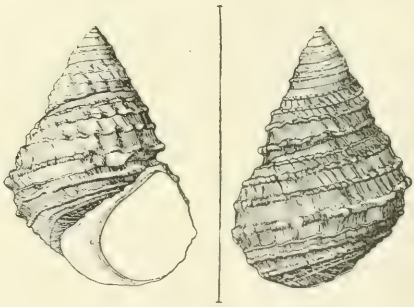
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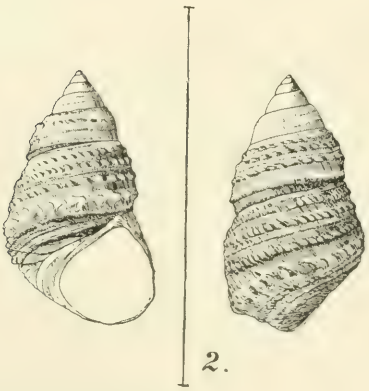
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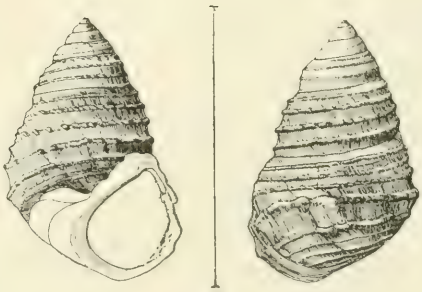
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A. C. Chowdhary del.

## EXPLANATION OF PLATE XVIII.

Embryonic shells, etc., of Shan species of *Taia*.

**Taia naticoides** (Theobald).

FIG. 1.—Operculum, $\times 1\frac{1}{2}$.
FIG. 2.—Radular teeth, $\times 62\frac{1}{2}$.
FIG. 3.—Embryonic shell, $\times 3$.

**Taia shanensis** (Kobelt).

FIG. 4.—Operculum, $\times 1\frac{1}{2}$.
FIG. 5.—Embryonic shell, $\times 3$.
FIG. 6.—Radular teeth, $\times 62\frac{1}{2}$.

**Taia lacustris,** sp. nov.

FIGS. 7, 8.—Embryonic shells, $\times 3$.
FIG. 9.—Young shell, $\times 2$.

**Taia intha,** sp. nov.

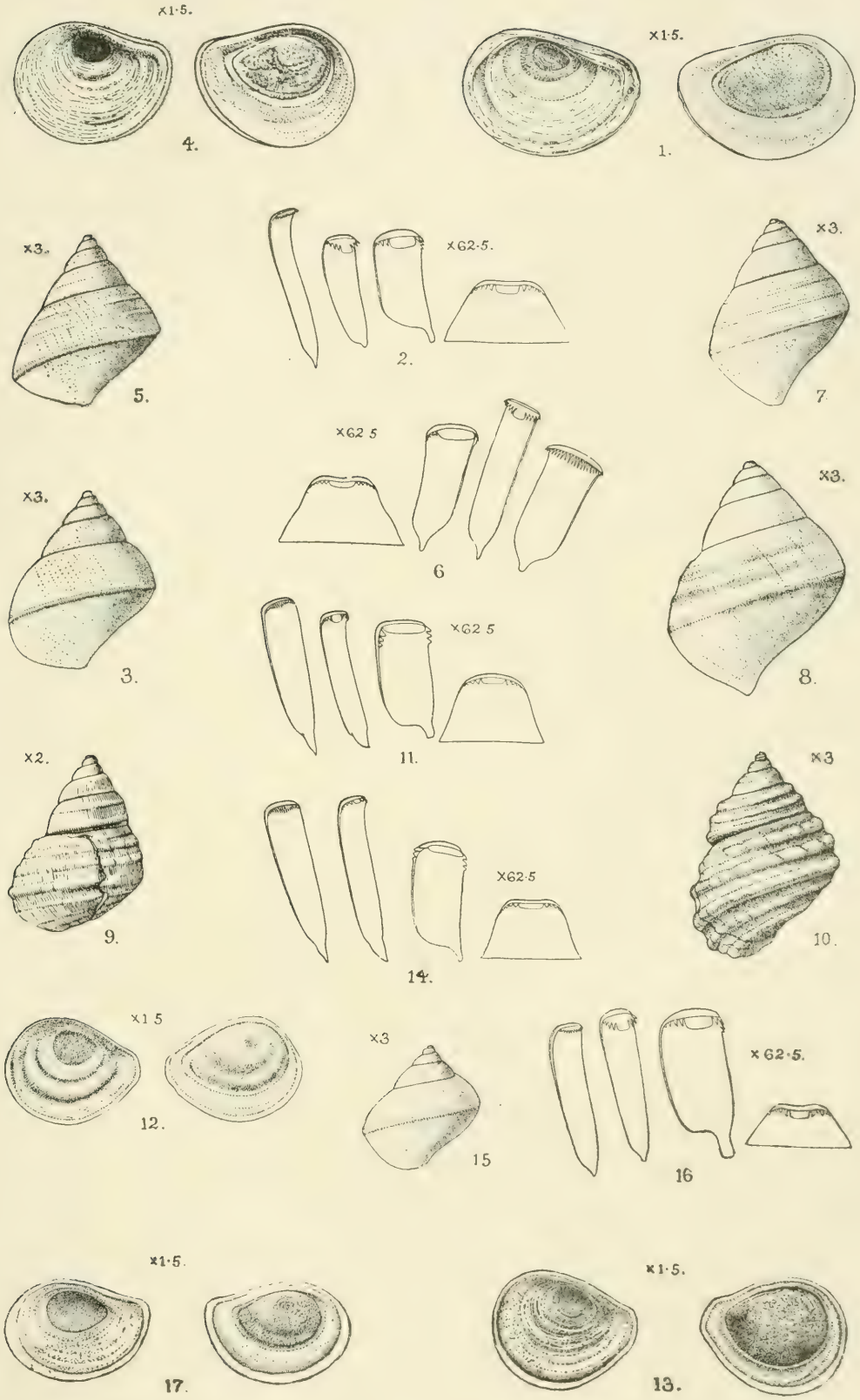
FIG. 10.—Embryonic shell, $\times 3$.
FIG. 11.—Radular teeth, $\times 62\frac{1}{2}$.
FIG. 12.—Operculum, $\times 1\frac{1}{2}$.

**Taia elitoralis,** sp. nov.

FIG. 13.—Operculum, $\times 1\frac{1}{2}$.
FIG. 14.—Radular teeth, $\times 62\frac{1}{2}$.

**Taia theobaldi** (Kobelt).

FIG. 15.—Embryonic shell, $\times 3$.
FIG. 16.—Radular teeth, $\times 62\frac{1}{2}$.
FIG. 17.—Operculum, $\times 1\frac{1}{2}$.




A. C. Chowdhary
&
D. Bagchi del.

## EXPLANATION OF PLATE XIX.

Bivalve shells from the Inlé basin. All the figures except figs. 13 and 14 are slightly below the natural size. Figs. 13 and 14 are greatly enlarged.

**Physunio micropteroides,** sp. nov.

FIGS. 1-3.—Type series from the Yawnghwe river.

**Physunio ferrugineus,** sp. nov.

FIGS. 4-9.—Series from the Central Region of the Inlé Lake, illustrating growth of shell.

FIGS. 10, 11.—Old shells from the same part of the lake.

(In old shells the posterior exposed part of the valves is always covered by a rather dense growth of algae).

**Corbicula noetlingi,** v. Martens.

FIG. 12.—Shell from Yawnghwe river.

**Pisidium casertanum** (Poli).

FIG. 13.—Shell from the Central Region of the Inlé Lake. Length 3·5 mm.

FIG. 14.—Shell from the edge of the He-Ho stream. Length 3·75 mm.


S. C. Mondul photo.

Photo.-engraved & printed at the Offices of the Survey of India, Calcutta, 1918.

# STUDIES ON THE ANATOMY OF INDIAN MOLLUSCA.

## 1. THE MARSUPIUM AND GLOCHIDIUM OF THE GENUS *PHYSUNIO*.

*By* Baini Prashad, *M.Sc., Superintendent of Fisheries, Bengal Fisheries Laboratory, Indian Museum, Calcutta.*

(Plate XXII).

On the occasion of a tour in the Southern Shan States Dr. N. Annandale and Dr. F. H. Gravely collected specimens of two new species of the genus *Physunio*, Simpson. These are the only two Unionidae found in the basin of the Inlé Lake, where the specimens were collected. *P. ferrugineus* is a true lacustrine form and is found in the middle of the lake in very clear water, whilst the other species (*P. micropteroides*) is found in a muddy stream opening into the lake.

Dr. Annandale was kind enough to give me specimens of both the forms in order that I might describe their glochidia. Whilst working out the structure of these, it was found that the marsupium of the genus was peculiar, and an account of this structure is also included here. At Dr. Annandale's suggestion I looked through the large collection of fishes made at the same locality, and I was fortunate enough to find specimens with glochidia attached to their fins.

My sincere thanks are due to Dr. Annandale for giving me the opportunity of making this very interesting study, and for kind help at all times. I am also highly obliged to Mr. T. Southwell, A.R.C.S., F.Z.S., Director of Fisheries, Bengal and Bihar and Orissa, for kindly allowing me to undertake and publish this work.

*Marsupium.*—By the term marsupium in the description of the freshwater mussels, we mean those portions of the gills in which the eggs are received from the supra-branchial chambers after ovulation and which serve as brood-pouches for the retention and nurture of the embryos and glochidia until the latter are shed. As different portions of the gills are specialized in the various groups of Unionidae to serve as a marsupium and as this has been found to be a constant character, the marsupium has been used as the chief diagnostic character of these groups. Simpson (4) divided the Unionidae according to this character into Exobranchiae, with the marsupium comprising the outer gill on each side or all four gills, and the Endobranchiae, in which the inner pair of gills alone serve as the brood-pouch. In the genus *Physunio* nothing was known about the anatomy of the animal, but Simpson, judging from the shell-characters alone, was led to include it amongst the Endobranchiae. This was an entirely wrong conclusion. Gravid females were found in both the two new species collected and described by Dr. Annandale, and it is to this fortunate chance that I owe the description of the marsupium and the glochidium of the genus. No attempt is made to describe the histological or anatomical structure of the gills in the present account as the anatomy of the animal is being described in detail by Dr. Ekendranath Ghosh.

In both the species only the middle region of the outer gills is specialized to serve as a marsupium, while a larger posterior and a much smaller anterior portion retain the ordinary respiratory character. The marsupial region in both species is much swollen and in the preserved specimens is of a creamy colour. It is clearly marked off from the anterior and posterior respiratory regions. In *P. micropteroides* seventeen water-tubes are modified to serve as a brood-pouch, while in *P. ferrugineus* only eleven are thus modified.

The characters of the marsupium of the genus may be summed up as follows. Marsupium formed by 11-17 simple water-tubes in the middle region of the outer gills, leaving a larger posterior and a much smaller anterior unmodified portion for respiration.

From these characters it will be seen that *Physunio* should be included in the group Exobranchiae of Simpson, and comes into his sub-group Mesogenae. He established this sub-group to include the genera *Cyprogenia* and *Obliquaria*, in both of which a variable number (7-23) of tubes in the middle region of the outer gills are specialized as the marsupium, a larger anterior and a shorter posterior region remaining respiratory. The marsupium of *Physunio* agrees with the above two genera in having the middle region of the outer gills modified, but differs in that the shorter respiratory portion of the gills is anterior and not posterior as in the American forms ; also the modified water-tubes are in no way specially elongated. Ortmann (3) as a result of his anatomical researches has found it necessary to combine Simpson's sub-groups Heterogenae, Mesogenae, Ptychogenae and presumably also the Eschatigenae into one group. In these forms various portions of the outer gills are modified as brood-pouches. Ortmann has included in the united group recognised without special name all the forms in which a differentiated portion only of the outer gills functions as the marsupium.

The genus *Physunio* must, therefore, also be included here and not amongst the Endobranchiae. The water-tubes (fig. 2) are filled with glochidia throughout their length, and in the fully charged marsupium the great antero-posterior distention of the water-tubes is very well marked ; the inter-lamellar junctions also are much elongated in this region. The glochidia were seen to be rather loosely attached to one another by their larval membranes and could easily be shaken apart.

*Glochidium.*—The glochidia of the two species differ mainly in size. In the case of *P. micropteroides* (fig. 3) a glochidium measures 0·32 mm. by 0·29 mm., while that of *P. ferrugineus* (fig. 10) is much smaller, being 0·28 mm. by 0·26 mm. The glochidium of *P. micropteroides* is described here in detail.

The glocidium is of the hookless types. It has the usual two shell valves. As seen in lateral view the shell is semi-circular with a curved lower margin and an upper hinge-line. This line is nearly straight in *P. ferrugineus*, a little curved in *P. micropteroides*. The shell is thin in the middle and all over except along the hinge-line and the border, where it shows a distinct thickening. The whole surface, except the border, is finely granulated. From the inner edge of the ventral border (figs. 4 and 5) a continuous flange projects inwards ; seen from the anterior or posterior side this flange appears as a pointed tooth, but it is a con-

tinuous structure all along the margin. It shows very fine ridges on its ventral surface. Amongst the hookless glochidia like the present example this flange must serve the same purpose as the tooth in the hooked glochidia though perhaps in a less efficient manner. Between the two valves of the shells a ligament is present and can be easily distinguished in sections and stained preparations.

The inside of the shell valves is lined by the larval mantle (figs. 6 and 7), which is formed of large cells. The cells have a conspicuous nucleus and the cytoplasm is filled with a large number of minute granules. In the mantle flap of each side two pairs of sensory cells (*s.c.*) can be distinguished, one lying below the other. The adductor muscle (*a. m.* figs. 9 and 6), which is seen as a whitish nearly circular area through the shell in lateral view, lies near the anterior and dorsal margins of the shell. The muscle consists of muscle-fibres stretching from one valve to the other ; these fibres have elongated unclei and are seen to divide before becoming attached to the valves. Lying just posterior and at a little higher level than the adductor muscle is a triangular area (*an.* figs. 3 and 7). This is the rudiment of the various organs of the future adult mollusc. It consists of closely packed cells and extends a little below the posterior margin of the adductor muscle.

*Fish host.*—It is a well-known fact that after being shed from the marsupium, the glochidia, whether of the hooked or hookless type, become attached to the gills or the fins of fishes and that each species usually affects a single host or a group of closely allied hosts.

The glochidia in the present case were seen attached to the caudal fins of three species of fishes. The specific characters of the larvae can be easily distinguished and hence the infection of the fish appears to have occurred recently. The specimens were obtained at the end of February and the beginning of March. The glochidia of *P. micorpteroides* were found on the caudal fins of *Nemachilus brunneanus* (fig. 8) and *Nemachilus brevis* (fig. 9) ; both these species of fish were taken in streams. A single glochidium of *P. ferrugineus* was found, on the other hand, deeply embedded in the caudal fin of *Barilius auropurpureus* (fig. 11). The two species of *Nemachilus* are found among weeds near or at the bottom and the *Barilius*, though it usually swims near the surface, goes down to the bottom at mid-day and was observed searching for insect larvae, etc., in the mud at places at which *P. ferrugineus* was abundant.

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3. ORTMANN, A. E.—" A monograph of the Najades of Pennsylvania." *Memoirs of the Carnegie Museum*, Pittsburgh, Vol. IV, 1911.
4. SIMPSON, C. T.—" Synopsis of the Naiades or pearly fresh-water Mussels." *Proceedings of the United States National Museum*, Vol. XXII, 1900.

## EXPLANATION OF PLATE XXII.

FIG. 1.—Gravid female of *Physunio micropteroides*. *M.*=marsupium.

FIG. 2.—Horizontal longitudinal section of a water-tube of gravid marsupium showing the glochidia in the water-tube (*w. t.*).

FIG. 3.—Lateral view of a glochidium. *a.m.*=adductor muscle ; *an.* =anlagen.

FIG. 4.—Anterior end view of the glochidium. *S.c.*=sensory cells.

FIG. 5.—Glochidium after removal of one of the shells. *A. m.*=adductor muscle ; *an.*=anlagen ; *f.*=flange.

FIG. 6.—Transverse section of a glochidium through the region of the adductor muscle (*a. m.*). *M.*=mantle.

FIG. 7.—Transverse section of a glochidium through the anlagen (*an.*) of the various organs.

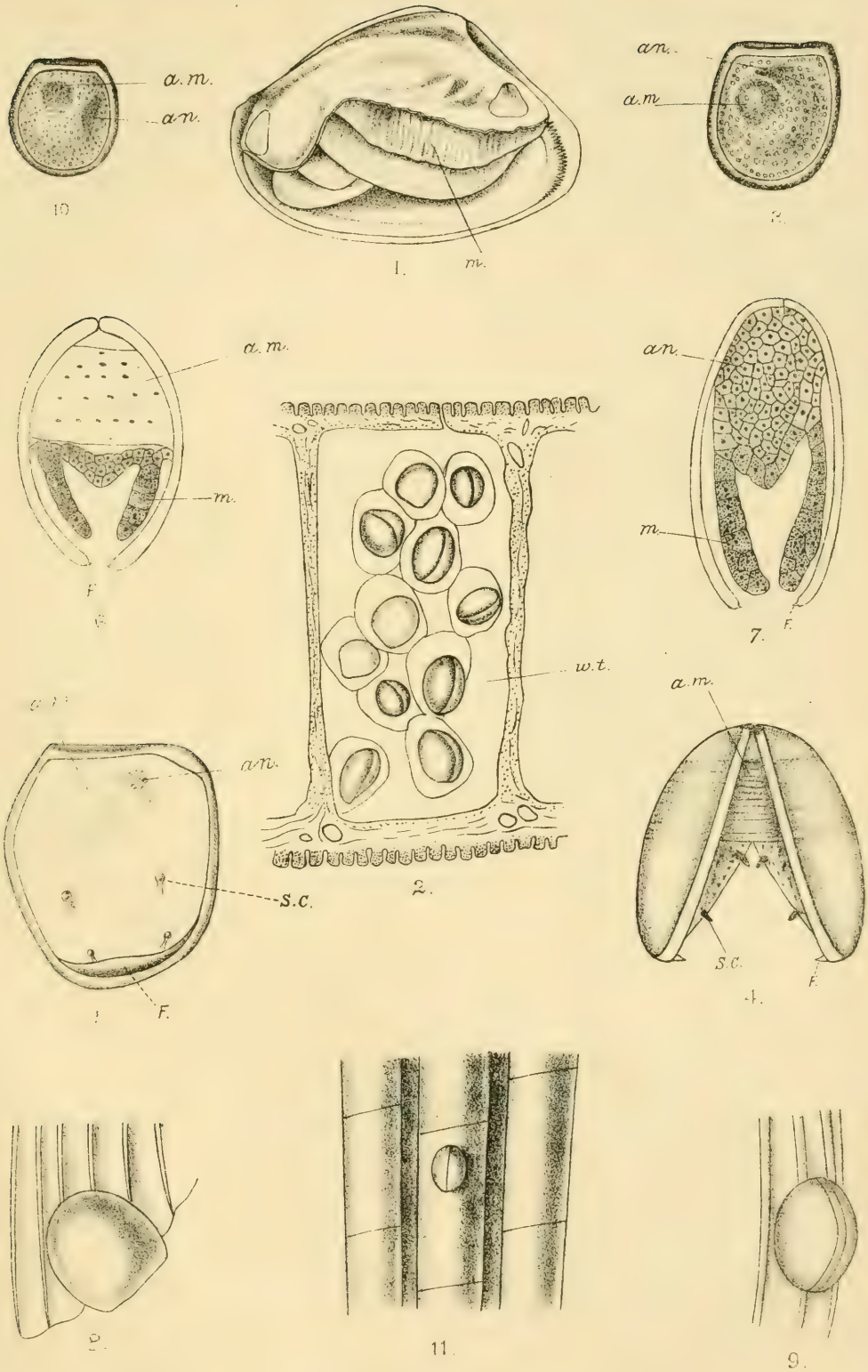
FIG. 8.—Glochidium on the edge of the caudal fin of *Nemachilus brunneanus*.

FIG. 9.—Glochidium on the caudal fin. of *N. brevis*.

FIG. 10.—Lateral view of a glochidium of *P. ferrugineus*.

FIG. 11.—A glochidium of *P. ferrugineus* embedded in the caudal fin of *Barilius auropurpureus*.

Figures 2-9 are from specimens of *P. micropteroides*.




B. Prashad,
& S.C. Mondul del.

S.C. Mondul lith.

MARSUPIUM AND GLOCHIDIUM OF PHYSUNIO.

# FRESHWATER TRICLADS FROM THE BASIN OF THE INLE LAKE.

*By* Tokiō Kaburaki, *Rigakushi, Science College, Imperial University, Tokyo.*

(Plate XXVII).

In the present paper a record is given of three new species of freshwater planarians from the basin of the Inlé Lake, Southern Shan States, Burma, which were collected by Dr. N. Annandale and Dr. F. H. Gravely of the Zoological Survey of India, in the latter part of February, 1917. The specimens were sent to Professor Oka of the Higher Normal School of Tokyo, who kindly gave them over to me for examination. To the gentlemen named I beg to express my thanks for the opportunity of studying these interesting planarians. I deem it my duty to mention my indebtedness to Professor Ijima for kind assistance in many respects.

## **Planaria burmaensis,** n. sp.

Pl. XXVII, figs. 1, 4, 5.

This new species is represented by six individuals (W. $\frac{118}{1}$) in the collection. They were obtained from the middle of the Inlé Lake, Southern Shan States, from a muddy bottom in about 12 feet of water.

The head in the preserved state presents a triangular shape and merges behind in the trunk without being marked off by a neck-like narrowing. The trunk gradually widens backwards to the region of the genital end-organs and then begins to taper rather abruptly, to end with a point at the posterior body-end. The mature specimens measure 5—7 mm. in length and 1·5—2 mm. across the widest part of the body.

The ground colour of the dorsal surface is usually light drab. There exist no pigments. One of the individuals with well-developed genital organs presents on the dorsal side a light grayish-olive colour due to the gut contents, the positions of the pharynx and copulatory organs being marked by clear brownish colouration (fig. 1); the ventral surface is of a much lighter colour, except the genital end-organs which appear of a blackish colour.

The crescentic eyes exist at about the level of the tips of the lateral lappets; the distance between them is somewhat less than that of either eye from the tip of the lappet of the same side. Only in the grayish individual mentioned above the eye is surrounded by a colourless area. The eye consists of a pigment cup and of numerous retina cones, just as in *Pl. gonocephala*. The species is wholly destitute of colourless areas corresponding to the auricular sense organ.

The epidermis is somewhat thicker on the dorsal than on the ventral side. The complete absence of rhabdites in both the epidermis and

the parenchyma is of interest. In addition to the glands opening submarginally on the ventral surface there are some eosinophil glands which open here and there in scattered distribution all over the entire surface of the body.

The dermal musculature is well developed and consists as usual of circular, diagonal and longitudinal layers. Dorso-ventral fibres occur also in the usual manner.

The mouth is placed slightly in front of the commencement of the posterior third of the body. The pharynx is inserted a short distance in front of the middle of the body ; its length is nearly equal to one-sixth that of the body. The intestines are quite of the Triclad type. The anterior trunk extends to a point far in front of the brain and usually sends out 8 pairs of lateral branches, which are sometimes bifurcated and sometimes multifurcated. The posterior trunks are provided with 13—15 subdivided branches. So far as I have observed, Minot's glands are altogether absent in the intestinal epithelium. The food of the worm seems to consist of small organisms, either planktonic or littoral. Remains of a crustacean were found in the pharyngeal chamber and intestinal canal. Moreover, the latter was found to be filled with a dense coagulum.

Of the excretory canals I have been able to obtain no more insight than a few loops at some points in the dorso-lateral parts of the body.

The exact arrangement of the nervous system could not be ascertained, but it seemed to be quite similar to that of *Pl. gonocephala.* Each longitudinal nerve-trunk forms anteriorly a well-developed brain-mass, those of the two sides being connected by a number of strong commissures. From each brain-mass arise a few forwardly-directed sensory and numerous lateral nerves. Posteriorly the longitudinal trunks proceed, running nearly parallel to each other, to the tail-end of the body, and are connected together by fine transverse commissures. Lateral nerves are given off from the main trunks usually at points opposite to the union of the latter with transverse commissures. Marginal nerves could not be brought under observation.

The genital opening lies nearly midway between the mouth and the hind end of body. It leads into the narrow vestibulum, which receives in front the opening of the penis-sheath. Both the vestibulum and the penis-sheath are lined with a single epithelium resting upon a fine basement membrane, beneath which are found circular and longitudinal muscular layers. Eosinophil glands are found all round the vestibulum, into which they open. In one individual a compact mass of spermatozoa was observed in the penis-sheath, close to the tip of the penis.

Numerous testes occur, occupying a dorsal position in the body. They are arranged in two lateral zones beginning from the brain region and extending behind nearly to the posterior end of the body. As is well known, each testis is made up of sperm-mother cells and spermatozoa in all stages of development, surrounded by the tunica propria. Usually each testis gives rise, on its lower side, to a fine testicular canal or vas efferens. This can be made out only by a careful search. The vasa efferentia run down between gut diverticula, frequently uniting with

one another to form somewhat wider ducts, and then take a course directed towards either of the vasa deferentia, which are distinctly discernible in the pharyngeal region. The vasa deferentia, proceeding backward inside the longitudinal nerve cords on the ventral side, rise upward to enter the penis-bulb separately on the sides and finally open into the lumen of the penis or the ejaculatory duct (see figs. 4 and 5). The vas deferens, which is filled with spermatozoa, has the wall consisting of an epithelium and an outer layer of ring-muscle fibres best developed in the neighbourhood of the penis.

The penis consists as usual of two parts, *viz.*, the free, conical and massive intromittent part lying horizontally in the penis-sheath, and the bulbous basal part of strongly muscular nature. The latter part encloses a wide and smooth-walled cavity of a spheroidal shape, the seminal vesicle ; posteriorly this is continuous with the ejaculatory duct, which opens into the penis-sheath at the under side of the tip of the penis. In its course the ejaculatory duct makes an obliquely anteriorly directed annular outbulging, much as in *Pl. gonocephala* ; consequently there is formed in the lumen a small backwardly directed process surrounded by the said outbulging and which is axially traversed by the narrow anterior section of the ejaculatory duct. It is a short distance in front of the above process that the duct receives laterally the outer ends of the vasa deferentia. Imbedded in the parenchyma around the penis-bulb are numerous eosinophil penis-glands, the ducts of which enter the penis at the base and open into the ejaculatory duct behind the outbulging mentioned above.

The paired ovary is situated far behind the brain and between the fourth and fifth anterior lateral branches of the gut. It is of a nearly spherical shape.

The vitelline glands are represented by cellular cords with the cells arranged in one or more rows ; they are very extensively distributed posteriorly from the region of the ovaries and in the interstices between gut diverticula, and stand at many points in connection with the oviduct.

The oviduct of each side starts from the antero-lateral aspect of the ovary as an ampullaceous passage filled with spermatozoa ; this soon assumes the character of a narrow tube, which proceeds straight backwards just along the outside of the nerve-cord. In the region of the genital aperture, the oviduct rather abruptly bends mediad, at the same time rising slightly upward, soon to open into the vestibulum from behind near the outer end of the vaginal canal, without uniting with its fellow of the opposite side into a common duct. The oviduct shows a distinct lumen in its entire length. Its actual wall is formed by a homogeneous and ciliated layer which shows no nuclei ;—apparently a part of an epithelium, of which the nucleus-containing parts are sunk into the surrounding parenchyma, as has been observed by several investigators to be the case in *Pl. gonocephala*, *Pl. polychroa*, *Dendrocoelum lacteum*, etc. Directly external to the layer mentioned are the two layers of internal circular and external longitudinal muscular fibres. An inversion in the relative position of these two muscular layers does not occur in the terminal parts of the oviduct, as it does in some species according

to v. Graff,[1] Stoppenbrink[2] and others. Outside the muscular layers there exists a cellular coating which probably represents the insunken parts of the lining epithelium. Processes from the cells are occasionally seen to extend to and to join the ciliated lining layer.

As already indicated, the oviduct receives the vitelline glands at several points of its course. The mode of the connection is quite similar to that described by Kennel,[3] Ijima,[4] v. Graff and others in *Pl. gonocephala, Pl. polychroa, Dendr. lacteum* and some land-planarians. It is effected by means of a pyriform or spherical giant cell, which usually contains an internal space filled with spermatozoa and probably communicating with the lumen of the oviduct. The cytoplasm of the cell is finely granular and exhibits but little affinity for haematoxylin ; the nucleus is by far larger than those of surrounding tissues. In no case have I been able to demonstrate the polycellular club-shaped body which was described by Stoppenbrink in place of the single giant cell. In sections the cellular cords of the yolk-gland are seen to be attached to the surface of the giant cell, but exactly how the yolk-cells reach the oviduct lumen cannot be elucidated. As has been pointed out by previous authors, the giant cell in question is probably of a glandular nature. It may be that its secretion disperses into the parenchyma and acts as an attractive agent, which may cause the yolk-cells to collect at its position. Eventually the cell breaks up and disappears, and then the yolk-cells may be said to be in a position to make their way unhindered into the oviduct.

The receptaculum seminis (uterus) is a large sac-like organ occupying a position between the pharyngeal chamber and the penis. Its wall is an epithelium made up of large columnar cells of a glandular nature, resting on a delicate basement membrane, beneath which are layers of fine circular and longitudinal muscular fibres. In the specimens I have examined, the organ seems to have been in secretory activity, the cells containing some refringent globules besides being vacuolated. In one individual, the organ contained spermatozoa enveloped in a coagulum of the secretion, while in another it contained a well-formed spermatophore of an elongate ovoidal shape.

From the postero-superior end of the receptaculum arises the vaginal canal, which runs backward, passing dorsally to the left of the penis, and then dips below to open into the vestibulum. The vagina is internally lined with an epithelium made up of cylindrical cells resting on a fine basement membrane. Just external to this are found the internal longitudinal, the middle circular and the external longitudinal muscular layers in direct succession. Of these the circular layer is best developed, thickest in the middle parts of the course of the canal. Towards both ends of the canal, the muscular layers as a whole gradually grow thinner.

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[3] Kennel, J., 1879. "Die in Deutschland gefundenen Landplanarien, *Rhynchodemus terrestris* O. F. Müll. und *Geodesmus bilineatus* Metschn." *Arbeiten des zool.-zoot. Inst. zu Würzburg.*

[4] Ijima, I., 1884. "Untersuchungen über Bau und die Entwicklungsgeschichte der Süsswasser-Dendrocölen (Tricladen)." *Zeitschr. f. wiss. Zool.*, Bd. XL.

Outside them the canal is surrounded by a large number of cells, which seem to be of a glandular nature. Processes from these cells are sometimes observed to extend right to the internal epithelium. In one individual, I have found spermatozoa in considerable quantity in the lumen of the canal.

### **Planaria annandalei,** n. sp.

Pl. XXVII, figs. 2, 6, 7.

This new species is based on a single specimen (W. $\frac{121}{1}$) which was collected about half a mile off Kyezagon, in the Inlé Lake, Southern Shan States, from a muddy bottom in about 7 feet of water.

The body-shape in the preserved condition is closely similar to that of *Pl. torva* and *polychroa* in the same state. The head is broadly rounded and merges into the trunk, from which it is indistinctly separated by a slight neck-like narrowing. From the region of the genital organs the sides of the trunk converge backward to the rounded posterior extremity. The specimen measures about 6 mm. in length and 1·5 mm. across in the broadest part of the body at the pharyngeal region.

The dorsal side of the specimen is of a buffy-brownish colour, which acquires a much darker tone in the median parts from behind the eyes to the posterior body-region. The ventral surface is of a much lighter colour than the dorsal side.

Two crescentic eyes, each surrounded by a small oval space without pigment, lie slightly in front of the line drawn across in the broadest part of the head; the distance between them is about equal to that between either of them and the lateral head margin of the same side.

The auricular sense organ of each side, visible as a slender colourless streak, extends posteriorly from the level of the eyes, exactly as in *Pl. polychroa.*

The epidermis is somewhat thinner on the dorsal surface than on the ventral or at the body-margin. It nowhere contains rhabdites except on the head near the anterior margin, where they are found in very small numbers, evidently situated between the epidermal cells. In the part of the body just indicated and immediately beneath the dermal musculature, there occur such rhabdites as are still contained in their mother cells. These are scattered in a sparse number in the parenchyma. There are some eosinophil glandular cells, situated in the parenchyma, opening to the exterior at various points of the entire body-surface, much as in the preceding species.

The mouth is situated at the end of the middle third of the body. In the specimen examined the pharynx is entirely missing, apparently having been lost by breaking through the dorsal body-wall before preservation. The unpaired anterior main trunk of the intestine extends to a point in front of the brain. It seemed to be provided with at least 8 pairs of lateral branches, while each of the posterior trunks gives off a larger number. Among the columnar cells of the intestinal epithelium Minot's glands are but rarely found.

The genital aperture lies slightly in front of the middle of the posterior third of the body. It leads directly into the simple penis-sheath

(fig. 6, *ps.*), much as in *Pl. polychroa.* A large number of eosinophil unicellular glands, occurring in a cluster around the genital aperture, discharge themselves into the atrial part of the sheath.

Numerous follicular testes are placed close together in the dorsal parts of the body, arranged in two longitudinal lateral zones which extend from the ovarian region to nearly the posterior end of the body.

The vasa deferentia, filled up with spermatozoa, can be clearly made out in the pharyngeal region. After running backward in the usual way, they rise obliquely upward to enter, each separately, the bulbous part of the penis at the upper lateral sides. After that they again slant down and finally open into the lumen of the penis or the ejaculatory duct. This is devoid of the annular outbulging which we have seen in the preceding form.

The penis consists of the hemispherical bulb and the conical and massive intromittent part which is horizontally disposed in the penis-sheath. The bulb contains a relatively narrow and smooth-walled seminal vesicle, which posteriorly narrows gradually into the ejaculatory duct. In its course the ejaculatory duct receives laterally the vasa deferentia and throughout its length the eosinophil penis-glands, which are profusely present in the body-parenchyma around the penis-bulb.

The ovaries are nearly spherical in shape and are present in a pair close behind the brain and probably between the first and second pairs of the lateral branches of the anterior gut-trunk.

The oviduct of either side leaves the ovary in the form of a funnel-like widening, which is filled with spermatozoa. For the rest of its length it is a narrow duct running just outside the longitudinal nerve-trunk ; in the region of the genital opening it nears the median line, slightly rising at the same time, and finally opens into the vaginal canal from behind and at a point near the outer end of it. The vitelline glands extensively fill up the interspaces between gut diverticula. They are in connection with the oviduct at numerous points by means of a spherical or pyriform giant cell.

The receptaculum seminis is a nearly fusiform sac-like organ, situated dorsally in front of the penis. It is lined with an epithelium of elongate cylindrical or pyriform cells. The appearance of the cells varies much with the state of their secretory activity ; the protoplasm is either entirely homogeneous or contains some globules, and at other times it is vacuolated. They rest upon a delicate basement-membrane, close to which is a feeble layer of muscular fibres. Some small glandular cells of a pyriform shape are found in close apposition to the wall of this organ in the posterior parts, as shown in fig. 7.

Of interest is the fact that the receptaculum seminis of this specimen contained a spermatophore, or rather the capsule of an empty spermatophore. Unlike that of *Pl. torva, gonocephala, striata* and of the preceding species, the spermatophore of the present species appears to be of a tubular form, irregularly twisted as it lies in the cavity of the receptaculum. The capsule is thin, homogeneous and apparently of an elastic nature ; it stains deeply with eosin, agreeing in this respect with the eosinophil secretion of the penis-gland, and differing from the cyanophil secretion of the receptaculum seminis. The fact

manifestly stands in favour of the view (Schultze,[1] Woodworth,[2] Bergendal[3] and Weiss[4]) that the formation of the spermatophore takes place in the penis-lumen, and not in the receptaculum seminis. Still another point which lends probability to this view is the fact that in the present species the spermatophore is tubular in conformity with the general shape of the lumen of the penis.

The receptaculum seminis gives rise posteriorly to the vaginal canal, which runs above and somewhat to the left of the penis. It opens into the penis-sheath from above. The cylindrical epithelium of its wall rests on a delicate basement membrane, beneath which is a muscular coat consisting of an internal circular and a thinner external longitudinal layer. Further, the vagina is surrounded by a large number of pyriform cells, which appear to represent the unicellular glands seen in the preceding form in the same situation.

### **Planaria bilineata,** n. sp.

Pl. XXVII, fig. 3.

This new species is represented again by a single specimen (W. $\frac{124}{1}$), taken on the lower surface of a stone in a small stream in Yawnghwe State above Fort Stedman, at an altitude of about 3,500 ft. above sea-level, Southern Shan States.

Externally the specimen looks very much like *Pl. gonocephala, subtentaculata, maculata, aborensis*, etc., so far as concerns the shape in the preserved condition. The head is somewhat markedly triangular, with a slight prominent lappet on either side. There thus exists behind the head a somewhat neck-like constriction. The trunk in the hind parts gradually tapers to the bluntly pointed posterior extremity, which in the present specimen bears a sign of regeneration in that it exhibits pigmentation in a somewhat less degree than the rest of the body-surface (fig. 3). The worm measures 8 mm. long by 2·5 mm. across in the broadest part of the body.

The colour of the dorsal surface is darkish olive-brown, with two longitudinal well-defined blackish bands running on either side of the median line from the eyes to the posterior end. These bands are narrower and much more distinctly defined than those sometimes observed in *Pl. gonocephala*. The ventral surface is as usual of a somewhat lighter colour than the dorsal.

The crescentic eyes, each situated at the inner edge of an oval colourless area, are situated about midway between the anterior extremity and the line connecting the apices of the lateral head lappets, and are separated from each other by a space about equal to the shortest

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[1] Schultze, M., 1854. "Zoologische Skizzen." *Zeitschr. f. wiss. Zool.*, Bd. IV, pp. 186, 187.

[2] Woodworth, W. McM., 1891. "Contributions to the Morphology of the Turbellaria I. On the structure of *Phagocata gracilis* Leidy." *Bull. Mus. Comp. Zool. Harvard Coll.*, Vol. XXI, pp. 31, 32.

[3] Bergendal, D., 1892. "Einiges über den Uterus der Tricladen." *Festschr. z.* 70 ten *Geburtstag R. Leuckarts*, p. 318.

[4] Weiss, A., 1910. "Beiträge zur Kenntnis der australischen Turbellarien. I, Tricladen." *Zeitschr. f. wiss. Zool.*, Bd. XCIV, pp. 584-586.

distance of either eye from the lateral head-margin of the same side. Auricular sense organs are present on each side as very distinct, reniform, non-pigmented areas on the cephalic lappet, much as in *Pl. gonocephala.*

The epithelium is full of minute rhabdites. Those inclosed in the subcutaneous cells occur in wide distribution over various parts of the body.

The mouth is situated about between the third and the fourth quarter of the body. The insertion of the pharynx takes place slightly in front of the middle of the body, being somewhat shorter than one-third the body-length. The anterior gut-trunk extends as far forward as the eyes and gives off on either side approximately seven branching diverticula, while the posterior trunks are provided each with at least thirteen bifurcated or trifurcated diverticula. Minot's glands are found in abundance in the gut epithelium.

The nervous system seems to be in its main features similar to that of *Pl. burmaensis.* The sexual organs were not yet developed in the individual examined.

## EXPLANATION OF PLATE XXVII.

FIG. 1.—*Planaria burmaensis*, n. sp. in the preserved condition. × 6.

,, 2.—*Planaria annandalei*, n. sp. in the preserved condition. × 5·5.

,, 3.—*Planaria bilineata*, n. sp. in the preserved condition. × 5·5.

,, 4.—*Planaria burmaensis*, n. sp. Diagrammatic representation of the organization of an entire worm, as seen from the dorsal surface.

,, 5.—The same. Diagram of sexual organs in sagittal section. × 90.

,, 6.—*Planaria annandalei*, n. sp. Diagram of sexual organs in sagittal section. × 100.

,, 7.—The same. Sagittal section through receptaculum seminis, containing fragments of spermatophore capsule. × 150.

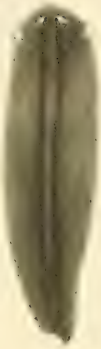
*Explanation of lettering.*

| | | | | | |
|---|---|---|---|---|---|
| *br* | ... | Brain. | *pgl* | ... | Penis-gland. |
| *de* | ... | Ductus ejaculatorius. | *ph* | ... | Pharynx. |
| *e* | ... | Eye. | *ps* | ... | Penis-sheath. |
| *egl* | ... | Eosinophil gland. | *rs* | ... | Receptaculum seminis (uterus) |
| *g* | ... | Gut. | *sph* | ... | Spermatophore. |
| *gp* | ... | Genital pore. | *t* | ... | Testis. |
| *gv* | ... | Genital vestibulum. | *ugl* | ... | Unicellular uterine gland. |
| *m* | ... | Mouth. | *v* | ... | Vagina. |
| *od* | ... | Oviduct. | *vd* | ... | Vas deferens. |
| *ov* | ... | Ovary. | *vg* | ... | Vitelline gland. |
| *p* | ... | Penis. | *vs* | ... | Vesicula seminalis. |

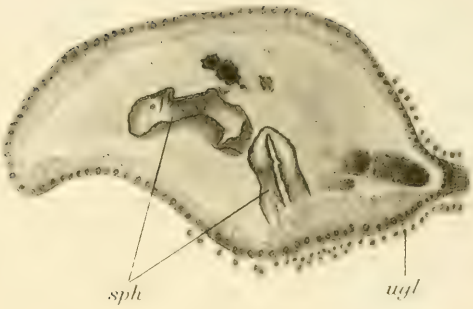
1.

2.

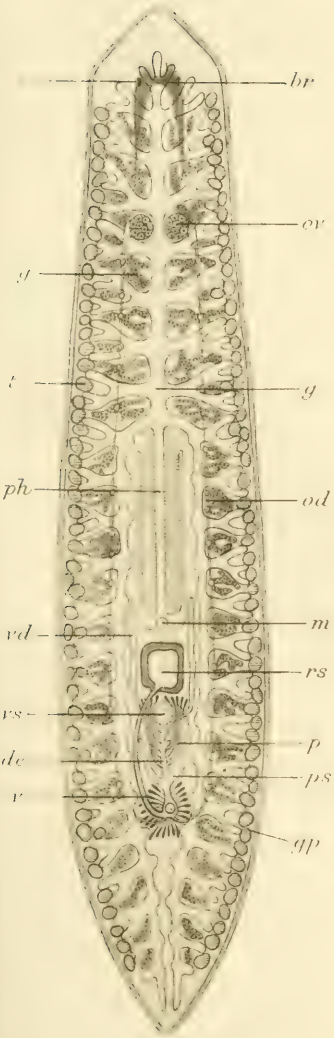
3.



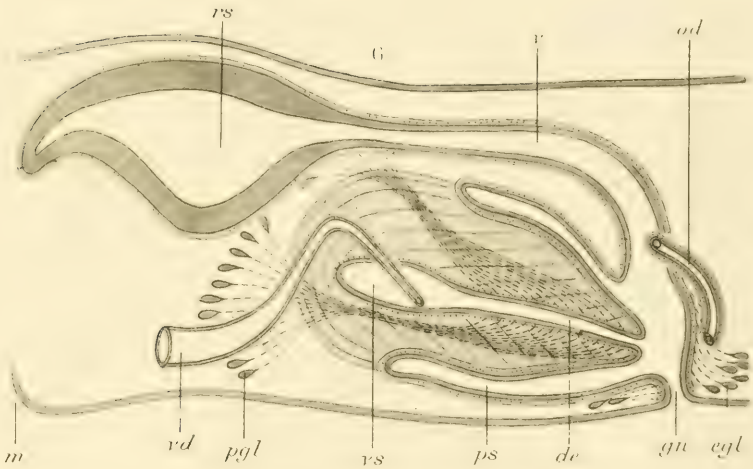
7



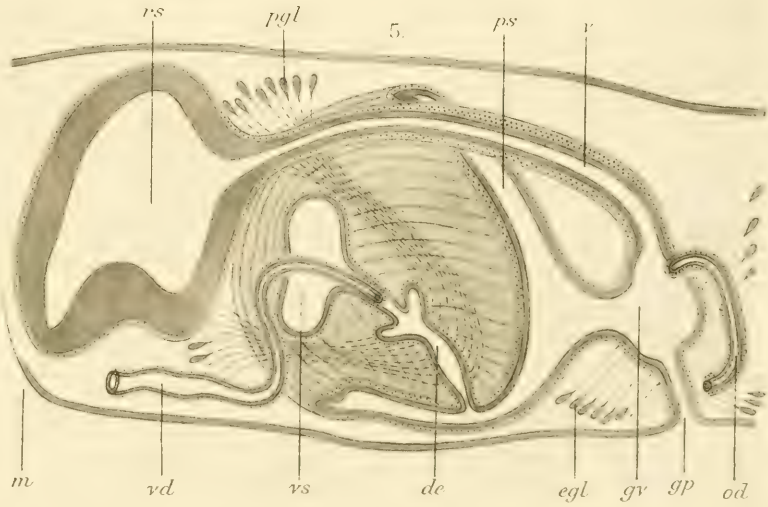

4




6




5.




Kaburaki, del.

Photogravure, Survey of India Offices, Calcutta, 1918.

# THE FAUNA OF THE INLE LAKE.

## SUMMARY OF RESULTS.

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

With Plate XXVI.

The object of this paper is to summarize what has been said in previous papers in this volume on the biology, the geographical relations and the origin of the fauna of the Inlé Lake.

In the time at our disposal in the Shan States Dr. Gravely and I were able to study only the macroscopic fauna and I must ignore one important element, namely the plancton, which I have purposely omitted from consideration. At the time of our visit to the lake, in early spring, floating organisms were extremely scarce and it is always necessary if the plancton of fresh water is to be examined in a satisfactory manner that collections should be made at all seasons. We know that many of the organisms are plastic and vary greatly with temperature and the like, and I am not at all sure that descriptions of stray samples of plancton are not liable to obscure rather than to elucidate the biology of a given body of water. In another direction we were able to do little—in the collection of aquatic reptiles, Batrachia and the more delicate insects, mainly because we were on the lake too soon after winter.

### Zones of Life in the Inle Lake.

Three zones of life can be distinguished in the Inlé Lake :—a Marginal Zone, an Intermediate Zone and a Central Region.

*Marginal Zone.*—This is a zone of varying width that encircles the lake. It owes its most peculiar features to the fact that it is covered with floating islands of dead and living plants in which the dead matter is undergoing a transformation into fen-peat. The process produces chemical changes in the water and also in both the chemical and the physical condition of the mud at the bottom, which is black, fairly coherent and often malodorous. Contamination of another kind is due to the villages built at the edge of the lake and on piles in the water. The floating islands provide abundant cover, with the floating plants on the channels between them, while the villages provide food for foul-feeding animals ; but the conditions prevalent in this zone are unfavourable to the more delicate forms of life and the environment is of the paludine rather than the lacustrine type. At the two ends of the lake, and to a less extent at certain places on the western shore, the ring of floating islands merges gradually into a great marsh, covered with a network of natural and artificial waterways and containing numerous small stagnant pools. This marsh is buried in gigantic reeds, which are burnt

down by the villagers in spring and explode with reports like pistol-shots, producing dense clouds of smoke. The floating islands are often reversed and cultivated or made to support pig-styes or even human habitations.

*Intermediate Zone.*—On the inner edge (*i.e.*, the edge nearer the centre of the lake) of the Marginal Zone the water, though doubtless less pure than that of the central parts, is clear, and the mud, though black, is less coherent and less malodorous. Submerged thickets of such plants as *Ceratophyllum*, *Hydrilla* and *Utricularia* flourish, those of *Ceratophyllum* being particularly luxuriant. This part of the lake may be conveniently considered as an Intermediate Zone, but its boundaries, whether inwards or outwards, are ill-defined.

*Central Region.*—In the open central parts of the lake the water is of the most perfect transparency, oxygenation of dead vegetable matter takes place rapidly and completely, and the bottom is composed of minute calcareous particles and fragments of dead plants mingled together to produce a peculiar greyish semi-liquid mud much less solid than good porridge. It has no foul odour. Mr. R. V. Briggs has provided the following analyses of dried mud and of water from this region :—

*Water from Surface in Central Region.*

| | Per litre. |
|---|---|
| Total solids | 0·1710 |
| Organic matter | 0·0160 |
| Calcium | 0·0222 |
| Magnesium | 0·0279 |
| Chlorine | 0·0017 |
| Sulphate ($SO_4$) | 0·0017 |
| Silica | 0·0010 |
| Carbonic Acid ($CO_3$) | 0·1030 |
| Iron | Less than one part in 5 million. |

*Mud from Bottom of Central Region.*

| | Per cent. |
|---|---|
| Insoluble Silicious matter | 0·98 |
| Alumina | 1·30 |
| Oxide of Iron | 2·25 |
| Lime | 45·31 |
| Magnesia | 1·25 |
| Potash | 0·12 |
| Soda | 0·46 |
| Moisture | 3·10 |
| Carbonic Acid | 33·15 |
| Phosphoric Acid | 0·17 |
| Sulphuric Acid | 0·41 |
| *Organic matter and combined water by difference | 11·50 |
| | 100·00 |
| *Containing Nitrogen | ·0619 |

A considerable part of the Central Region, from which, despite its shallowness, plants growing up out of the water or floating on the surface are practically absent, is filled almost to the surface with thickets of *Ceratophyllum*, but the bottom in many places is almost bare, with scattered plants of *Potamogeton* and *Hydrilla* or with clumps of Characeae, the growth of which seems to choke that of other plants. The Intha fishermen have the custom of protecting the houses occasionally built on poles in the Central Region in connection with fisheries or for other purposes, by floating breakwaters formed of strips cut off from the islands of the Marginal Zone, towed out and anchored by bamboo poles thrust through them into the bottom. These artificial floating islands flourish and produce in their immediate vicinity conditions similar in some respects to those prevalent in the Intermediate Zone, but they are not numerous and their influence is on the whole of small importance.

## ANIMAL LIFE IN THE MARGINAL ZONE.

The most striking feature of the fauna of this zone is its wealth of insect life. Characteristic species occur among the fish and molluscs, but most of them are also found in marshes and pools and the fauna as a whole is paludine.

SPONGES.—*Ephydatia fluviatilis* var. *intha* is occasionally found and *Spongilla fragilis* var. *calcuttana* and *S. lacustris* var. *proliferens* occur.

ANNELIDS.—In mud at the edge of the lake we found two species of Oligochaeta, the Tubificid *Branchiura sowerbyi*, one of the few species with external gills, and the Megascolecid *Perionyx fulvus*, a form that possesses no obvious modification for an aquatic life. The specimens of *Branchiura* are of normal size with the gills long and as a rule numerous. A small almost colourless leech of the genus *Glossosiphonia* is common on the gastropod molluscs *Taia shanensis* and *Ampullaria winkleyi*, and we found specimens of a larger species of the same family on the tortoise *Cyclemys dhor shanensis*.

POLYZOA.—The Ctenostome *Hislopia lacustris* sometimes grows on Gastropod shells, but not so commonly or so luxuriantly as in other parts of the lake.

DECAPOD CRUSTACEA.—The little Atyid prawns *Caridina annandalei* and *C. weberi* occur, but *C. weberi*, which apparently enters the lake occasionally from small streams, is much less abundant than its congener. The crab *Potamon acanthicum* is fairly common among the roots of floating islands and *P. curtobates* probably wanders in occasionally from the rice-fields and marshes it usually inhabits.

INSECTS.—Both larval and adult aquatic insects are very abundant, but the latter are mainly surface-forms, the family best represented both in species and individuals being the Hydrometridae, which are attracted both by the shelter afforded by the islands and the floating plants on the waterways, and also by the abundance of food. As all members of the family are rapacious or feed on dead insects that have fallen into the water it is important for them to live in places where other insects are abundant, while their movements on the surface are greatly impeded by even small waves. The commonest species of Hydrometridae on the Inlé Lake are *Gerris fossarum* and *G. nepalensis*. Another family of Rhynchota, not surface forms, is well represented in the Corixidae, but Nepidae are comparatively scarce. Water-beetles of all families are also rather scarce. Dragon-fly larvae (Agrionidae and Aeschnidae) are abundant. Among Dipterous larvae we observed those of Culicidae (both Culicinae and Anophelinae,[1] both very scarce), Chironomidae and Stratiomyidae. Caddis-worms were not very common.

Speaking generally, therefore, the insects of this zone are just such as would be found in any Oriental marsh, though the number of apparently endemic species is large. No special modifications were observed.

MOLLUSCS.—The characteristic molluscs of this zone are *Planorbis exustus*, *Ampullaria winkleyi*, *Hydrobioides nassa typica*, *Hyrobioides nana* and *Taia shanensis*. All of these but the last, which has not

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[1] *Anopheles barbirostris*, v. d. Wulp. I have to thank Dr. Baini Prashad for naming specimens of larvae.

been recorded from any other definite locality, are also found in swamps, pools and canals in the neighbourhood and have a wide distribution at any rate in Burma. *Hydrobioides nassa lacustris* occurs with the typical form in this zone only. Probably the pond form of *Limnaea andersoniana*, of which a dead shell was found floating on the surface, visits it occasionally, but the smaller Limnaeidae of other parts of the lake are scarce if not altogether absent. *Succinea indica* is found at the margin. We took no specimens of *Melania* or of any Pelecypod.

Fish.—Most or all of the fish of the Central Region of the lake wander as far as the Marginal Zone occasionally, but its characteristic species, which rarely or never visit the Central Region, are the eels *Amphipnous cuchia* and *Monopterus albus*, the cat-fish *Clarias batrachus* and the minute but brilliantly coloured Cyprinid *Microrasbora erythromicron*. With the exception of the last, these are mud-haunting species of wide geographical range that flourish in marshes, rice-fields, ditches, canals and slow streams. *M. erythromicron* is, however, a surface or mid-water fish that conceals itself under floating vegetation. It is only known from the Inlé Lake and from other parts of the Inlé basin, in which it is, to judge from its frequent occurrence in the dried whitebait sold in the Intha bazaars, by no means uncommon. A single specimen of the peculiar little eel *Chaudhuria caudata* was taken in this zone.

Reptiles.—The tortoise *Cyclemys dhor shanensis*, only known from the Inlé system, is not uncommon at the edge of the lake.

## Animal Life in the Intermediate Zone.

There are few species confined to this zone, which is naturally a meeting-place for those of the Central Region and those of the Marginal Zone. Perhaps the most characteristic feature is the rich growth of sponges, mainly *Ephydatia fluviatilis* var. *intha*.

Sponges.—The *Ephydatia* is very common on weeds and *Spongilla lacustris* var. *proliferens* occurs.

Hydrozoa.—Numerous specimens of *Hydra vulgaris* were found amidst a growth of *Hislopia* on a post in this region.

Annelida.—Minute free-living Oligochaetes of the family Naididae are common among weeds and Polyzoa, but the only specimens collected were from the canals of *Ephydatia*. They represent three species of the genus *Chaetogaster*, one of which has recently been described from freshwater sponges in Japan, while another was originally found in the same organisms in Calcutta, the third being Palaearctic and often quasi-parasitic on *Limnaea*.

Polyzoa.—The house-posts of fishing-huts erected in this zone are covered with a growth of *Hislopia lacustris*, which also occurs very commonly on the shells of living molluscs of the genera *Hydrobioides* and *Taia*. We found, on the stem of a plant, a single colony of *H. malayensis*, an allied species described from a small lake in the Siamese Malay States and also common in the River Hughli at Calcutta.

Decapod Crustacea.—Probably the only Decapod Crustacea that live in this zone are the same as those found in the Central Region, namely *Potamon acanthicum* and *Caridina annandalei*,

INSECTS.—Insects are much scarcer than in the Marginal Zone. Most if not all of the marginal species, however, make their way into it occasionally. Several Chironomid and free-living Trichopterous larvae were found in the canals of *Ephydatia*, together with one of the Neuropterous genus *Sisyra* (Hemerobiidae), a genus whose larva is always found in sponges.

MOLLUSCS.—The most characteristic molluscs of the zone is *Taia elitoralis*, which is not known elsewhere but is closely allied to the fossil *T. conica* from the Hsin-Dawng valley in the same district. It reaches a larger size than any other Gastropod of the lake except *Ampullaria*. *Hydrobioides nassa lacustris* grows larger here than in the Central Region. *Ampullaria winkleyi* is fairly common at some places, but *Planorbis exustus* does not come so far from the margin of the lake. The smaller Limnaeidae are perhaps more numerous in this zone than in any other ; their shells are often a little darker in colour than in the Central Region.

FISH.—There is no fish peculiar to the Intermediate Zone, but the little Cyprinidae *Microrasbora rubescens* and *Sawbwa resplendens*, which are also common in the Central Region, perhaps breed in the former only, for it was only in this zone that we found the males in full breeding colour. *Barilius auropurpureus*, on the other hand, is neither so big nor so brightly coloured, though common enough, as in the Central Region. All weed-haunting species are abundant, *e.g.*, the Shan Carp (*Cyprinus carpio intha*), *Cirrhina latia*, *Ophiocephalus* spp., *Mastacembelus* spp., etc.

## ANIMAL LIFE IN THE CENTRAL REGION.

This is the only part of the lake in which the fauna can be said to be completely lacustrine. In it most of the peculiar species (excluding insects) occur in abundance and in many respects it is the most characteristic of the three regions. A curious feature is the complete absence of sponges, a fact for which no explanation is at present forthcoming. A similar lack is that of Phylactolaematous Polyzoa, but this is a feature of other parts of the lake also. The bottom fauna is perhaps richer than elsewhere, and it was only in the Central Region that we found Pelecypoda.

PLATYHELMINTHES.—Small Planaria of very normal appearance (*P. burmaensis* and *P. annandalei*) were dredged from the bottom. The most interesting feature about them is the complete or partial absence of rhabdites from their integument. The aberrant Trematode or Temnocephaloid *Caridinicola* is common in the gill-chamber of *Caridina annandalei*.

ANNELIDA.—The only Oligochaete we collected was *Branchiura sowerbyi*, which in the semi-liquid mud of this region attains an unusual size and has as a rule its gills less well developed than in the Marginal Zone, in which the water is much less thoroughly oxygenated. Great length is necessary for a cylindrical animal in the peculiar mud of the Central Region, if it would maintain a vertical position. A small red leech of the actively predaceous family Herpobdellidae is found occasion-

ally on the bottom and a *Glossosiphonia*, probably the same as that taken in the Marginal Zone, is not uncommon on *Taia intha*.

Polyzoa.—The only Polyzoon seen was *Hislopia lacustris*, colonies of which often cover living shells of *Taia* and *Hydrobioides* and grow on the exposed part of the valves of *Physunio*. This animal also grows over posts in the water. Its growth must be rapid, for it is known to cover a post in a few weeks.

Decapod Crustacea.—*Caridina annandalei* is very abundant among weeds and we dredged several specimens of *Potamon acanthicum* from the bottom.

Insects.—Adult aquatic insects are scarce in this region. At places where artificial breakwaters have been made by anchoring strips of floating islands a few individuals of *Gerris fossarum* and *G. nepalensis* may occasionally be seen on the surface, in the shelter of the breakwaters. A *Micronecta* also occurs beneath floating masses of *Ceratophyllum*.

The number of insect larvae, on the other hand, is enormous, but rather in individuals than in species. At the season of our visit (the latter part of February and the beginning of March) vast swarms of small midges, caddis-flies and may-flies issued from the water every evening at dusk. They consisted mainly of three species, a small Chironomid of a genus I have been unable to identify, a small may-fly of the family Baetidae and a small caddis-fly of the family Leptoceridae. All three species are able to live, if they survive the attacks of the fish *Barilius auropurpureus* (which feeds extensively upon them) and other enemies, for several days. By day they conceal themselves; we found them in abundance between our books and in every possible corner. Fortunately none of them were blood-suckers. In spite of the prodigious abundance of the midge we were unable to identify its larva; possibly it is a red "blood-worm" very like that of many European species and common in mud at the bottom. The larva of the caddis-fly lives in great numbers among weeds in a little horn-shaped case of consolidated silk. Its feet are fringed with long hairs and it swims about vigorously by means of them. The Ephemerid larva is also found among weeds. It is a rather sluggish little animal of the type normal in its family. Other larvae found in this region are those of numerous species of dragon-flies, Agrionidae and Aeschnidae among weeds and Libellulidae on the bottom. The commonest species are the Agrionids *Ischneura* sp. and *Pseudagrion microcephalum*. The only other larva that we found at all common was that of the Chironomid *Polypedilum*. This larva constructs a case of silk to which it affixes living Protozoa (*Epistylis*), and lives among weeds, feeding on the Protozoa and other small animals. No burrowing larvae were observed except the red "blood-worms."

Molluscs.—All the characteristic molluscs of the lake (except *Taia shanensis* and *T. elitoralis* and the paludine species of the Marginal Zone) are to be found in large numbers in this region. *Taia intha* and *Physunio ferrugineus* are apparently endemic in it, while the widely distributed *Melania tuberculata* and *Pisidium casertanum* were not found in any other part of the lake. *Taia intha*, *Hydrobioides nassa lacustris*

and *H. physcus* are much the most abundant species. *Amnicola alticola* is also very common, and *Physunio ferrugineus* fairly so. The smaller Limaeidae occur in small numbers among weeds.

FISH.—All the fish of the lake (except the mud-loving eels and catfish and *Microrasbora erythromicron*) probably enter this region, but *Barbus schanicus*, which is not a true lacustrine fish, avoids it habitually and we have no evidence as to the occurrence of *Lepidocephalus berdmorei*, which is little more than a stray immigrant in the lake. The most characteristic species is *Barilius auropurpureus*, which swims in large shoals just below the surface of the water. *Chaudhuria caudata* is found among weeds.

The fauna of the Central Region (*i.e.*, the true lacustrine fauna) of the lake consist mainly, from a biological point of view, of two elements, *viz.*, animals that live among weeds and bottom forms. Surface organisms of all kinds are, at any rate in early spring, very scarce and even *Barilius auropurpureus* descends to the bottom in the heat of the day.

The bottom fauna includes comparatively few burrowing forms, probably on account of the tenuity of the mud, which renders burrowing for any but very small and light or extremely elongate animals difficult. Among the few burrowers are *Physunio ferrugineus*, which works its way through the mud with the aid of a sharp projecting "wing" and is never entirely submerged, a very small form of *Pisidium casertanum*, the Oligochaete worm *Branchiura sowerbyi* (which is much longer than usual in this position and, like the Unionid, only buries the anterior part of its body) and small red Dipterous (Chironomid) larvae. *Melania tuberculata* crawls habitually on the bottom, on which, as well as among weeds, *Taia intha* and the species of *Hydrobioides* are also to be found. We dredged a few small Planarians of normal appearance and some flattened Libellulid dragon-fly nymphs, also mud-crawlers.

Life is rich among the weed-thickets of this region. Most of the fish conceal themselves and probably spawn among them. The small Limnaeidae so characteristic of the lake as a whole, *Caridina annandalei* and the larvae of Agrionid dragon-flies and of the Trichoptera and Ephemerids that swarm in the evening in a winged state find their home here. The peculiar larva of the midge *Polypedilum* in its case (which is also its larder) decorated with living Vorticellid Protozoa, also lives amidst the thickets of *Ceratophyllum*. A prolonged search would certainly reveal other interesting forms. A peculiarity of the weeds of this region is the total absence of sponges and polyzoa.

The house-posts of our dwelling in the middle of the lake had an interesting fauna, which it was possible to observe in almost ideal conditions. The house had been erected only a few weeks before our visit, but the surface of some of the posts on which it stood was almost completely covered with large colonies of *Hislopia lacustris*, the upper parts of which were perishing as the water sank. Considerable numbers of the mollusc *Taia intha* sat on the posts, sometimes without moving from day to day, and the two commonest species of *Hydrobioides* crawled on them more actively. The curious fish *Discognathus lamta* also

frequented them, clinging to them with its peculiar lip, gradually swimming up them, browsing on the way on *Hislopia* and algae.

## Groups of Animals represented.

Considered as a whole, the fauna of the lake is remarkably rich in fish and molluscs, both of which are abundant in species and individuals and include peculiar and apparently endemic forms. The Mollusca exhibit extraordinary plasticity and in several instances a very high degree of specialization in shell-form. The fish are almost equally remarkable. Included among them are several minute brilliantly coloured species and also the eel *Chaudhuria*, which is very small but not brilliantly coloured—a form so peculiar that a new family has had to be founded for its reception. A characteristic feature of most of the fish, doubtless correlated with the clearness of the water, is the large size of their eyes and the poor development of tactile organs such as barbels. The lower vertebrates, on the other hand, are poorly represented and in no way remarkable or highly specialized. Sponges are apparently absent altogether from the Central Region, though one species (*Ephydatia fluviatilis*) is common in the Intermediate Zone, while the Polyzoa are represented in the fauna only by the Ctenostomatous genus *Hislopia*, a species (*H. lacustris*) of which is common all over the lake. Notwithstanding a careful search, we were unable to find any Amphipod or Isopod Crustacea. Only two species of Decapoda penetrate as far as the Central Region, and the lower groups of Crustacea are apparently scarce throughout the lake. In the Marginal Zone numerous species of aquatic insects of the orders Odonata, Diptera, and Rhynchota occur, but beetles are scarce in all regions. In the Central Region the larvae of certain Diptera, Trichoptera and Ephemeridae swarm, but the number of species is limited. Dr. F. F. Laidlaw has kindly given me the following note on the Odonata in our collection :—

" The most interesting species in the collection is perhaps a small orange and black *Ischneura*, closely allied to *I. rufostigma*, Selys, from Bengal and Assam but quite distinct, and apparently new to science. A number of examples of the beautiful *Rhinocypha iridea*, Selys, hitherto recorded from Burma, form an addition to the Museum list of species ; and *R. biforata*, Selys, is also represented. Specimens of a species of *Ceriagrion* present some difficulties in identification, they are possibly examples of my *C. olivaceum* recorded from the Abor country. The collection of larval forms is large and includes specimens belonging to species not represented amongst the adults ; amongst others one that is possibly the larva of a *Disparoneura*. The adults, with the exception noted, are mostly to be referred to common and widely spread species. Possibly the season of the year was unsuitable for the obtaining of some species, but on the whole the collection of adults is not so rich as one would have expected from the variety of the larvae."

Some of these dragon-flies breed in the lake, notably the *Ischneura*, while others (*e.g.*, *Rhinocypha* spp.) are jungle forms only found in thickets on the hills. These latter probably breed in small streams.

## GEOGRAPHICAL RELATIONS OF THE FAUNA.

The lower invertebrates of the lake and its connected waters throw little light on the geographical relations of the fauna, and the aquatic insects (none of which, of course, are completely aquatic in a literal sense) are still, with the exception of the Rhynchota and the Odonata, unknown. I will deal with the Rhynchota separately. Among the strictly aquatic forms we need consider only the Decapod Crustacea, the Mollusca and the fish. The facts about the geographical distribution of these groups will be found on pp. 37-38, pp. 81-82 and pp. 145-148. of this volume. They may be summarized as follows :—

33 genera are represented, of which 2 (fish) are endemic in the lake=*ca.* 6 per cent.

2 other genera (molluscs) are practically confined to the Shan Plateau, giving a total of four endemic Shan genera=*ca.* 12 per cent.

67 species and races have been found, of which 30 have been found only in the lake and connected waters, giving a percentage of *ca.* 45 per cent.

2 other species and two races are practically confined to the Shan Plateau, giving a total of endemic Shan forms of 34 =nearly 51 per cent.

The fauna is thus mainly a fauna endemic on the Shan Plateau, with a very large percentage of peculiar lake forms probably not existing outside the Inlé system. The only other elements that can be detected are (*a*) one consisting of widely distributed Oriental species, (*b*) one consisting of Indian forms found on both sides of the Bay of Bengal, (*c*) a very small Indo-Chinese element, represented by general affinities rather than common species, and perhaps faint traces of (*d*) an Eastern Palaearctic element. The true aquatic fauna of the Inlé system belongs, therefore, to that of the Indo-Burmese area, but represents a distinct off-shoot thereof. It will probably be found, when the upper waters of the Salween are investigated, that this offshoot is well established in the watershed of that river, in so far as it is not purely lacustrine.

A word may be said here about the aquatic Rhynchota. No less than 33 species, representing 20 genera, are known to occur in the Inlé system, and 13 (*ca.* 39 per cent.) are known only from that system. The rest are species widely distributed in India or the Oriental Region generally, with one Palaearctic species (*Gerris paludum*). No peculiar Indo-Chinese forms are found, and no endemic genera. The only genus not of very wide general distribution is *Perittopus*, which seems to be Malayan in origin but occurs in Assam as well as in Java, Malaya and Tenasserim. The number of endemic species is surprisingly large in view of the wide range of many aquatic bugs. The facts known about the Inlé representatives of this order, therefore, bear out what has been said as to the true aquatic fauna in the preceding paragraph. It is probable, however, that none of the Rhynchota are exclusively lacustrine.

## Origin of the Fauna.

The aquatic and quasi-aquatic fauna of the Inlé district as a whole was separated from the common fauna of the Oriental Region at a remote but not extremely remote period. The fossil remains of the district are not sufficiently well known to cast much light on the precise period at which this occurred. The local fauna developed in circumstances that favoured plasticity but did not render peculiar adaptations to environment necessary. Primitive forms such as *Chaudhuria*[1] were able to survive side by side with highly modified forms such as *Sawbwa*, *Taia* and *Hydrobioides*. In still, deep lakes, with transparent water containing abundant salts of lime and other minerals, in a temperate climate free from extremes of cold or heat, with a heavy but not excessive rainfall, conditions were perhaps ideal for the rapid evolution and the preservation of peculiar forms, modified superficially but not changed in fundamental structure or adapted in direct correlation with their mode of life. On the one hand competition was less keen than in strictly tropical surroundings and physical barriers interfered with the immigration of alien forms ; on the other there was nothing to check the momentum of eccentricity and small peculiarities were intensified rather than eliminated. The communities of different lakes developed slight racial or even specific peculiarities, but the fauna as a whole remained uniform over a large area. With the growth and deepening of the old lakes of the Shan Plateau this process continued, but the day of the great lakes was soon over. The lakes appeared and grew deep, changed their communications from time to time, and finally shrank and for the most part disappeared, owing to allied causes—the dissolving action of water, the re-deposition in solid form of the salts dissolved, and the formation of peat and of finely divided insoluble matter. The insoluble debris of the rocks eaten away by water accumulated in the form of red soil and masses of peat were heaped up as vegetable remains were transformed into this substance, until most of the basins were filled. At some places lakes dried up owing to their water eating through soluble barriers of hard limestone, at others new lakes were formed by the deposition of calcareous dams. The Inlé Lake, which was probably the largest of the system, has survived, shrunken in area and shallowed, but still a lake. In it the fauna of the old lakes has become as it were concentrated. This fauna has lost the power to resume the normal characters of a swamp-fauna, or perhaps in its isolated state there has been no reason why it should do so ; it retains the peculiar features acquired in conditions quite other than those in which it now lives.

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[1] Mr. R. H. Whitehouse, basing his view on a study of the structure of the tail, regards *Chaudhuria* as a highly specialized form. See p. 66 of this volume.

## LIST OF THE FAUNA OF THE INLE LAKE SYSTEM.

*Only species that have been identified at least generically are included. Under the heading "Marginal Fauna" notes are given on species found in ponds or marshes, but the fact is noted in each instance.*

| Name | General Distribution. | Distribution in Lake System. | | | |
|---|---|---|---|---|---|
| | | Marginal zone. | Intermediate zone. | Central Region. | Running water.. |
| PROTOZOA. | | | | | |
| *Epistylis flavicans*, Ehrenb. ... | Cosmopolitan ... ... | ... | ... | On larval case of *Polypedilum*. | ... |
| *Cothurnia* sp. ... ... | Genus cosmopolitan ... ... | ... | ... | On *Caridina* ... | ... |
| PORIFERA. | | | | | |
| *Spongilla lacustris* var. *proliferens*, Annd. | Species cosmopolitan. Var. in India and Burma. | Scarce ... | ... | ... | ... |
| *Spongilla fragilis* var. *calcuttana*, Annd. | Species cosmopolitan. Var. in Gangetic delta. | Do. ... | ... | ... | ... |
| *Ephydatia fluviatilis* var. *intha*, Annd. | Species cosmopolitan. Var. only known from the lake. | Do. ... | Abundant ... | ... | ... |
| TURBELLARIA. | | | | | |
| *Planaria burmaensis*, Kab. ... | Only known from the lake ... | ... | ... | Common ... | ... |
| *Planaria annandalei*, Kab. ... | Only known from the lake ... | ... | ... | Scarce ... | ... |
| *Planaria bilineata*, Kab. ... | Only known from the lake basin ... | ... | ... | ... | In hill streamlet. |
| TEMNOCEPHALOIDEA. | | | | | |
| *Caridinicola* sp. ... | Genus known from India. Ceylon. China and Japan. | ... | ... | Common on *Caridina*. | ... |

LIST OF THE FAUNA OF THE INLE LAKE SYSTEM—*contd.*

| Name. | General Distribution. | Distribution in Lake System. | | | |
|---|---|---|---|---|---|
| | | Marginal zone. | Intermediate zone. | Central Region. | Running water. |
| POLYZOA. | | | | | |
| *Hislopia lacustris*, Carter ... | India ; Burma ... ... | Scarce ... | Abundant ... | Abundant ... | ... |
| *Hislopia malayensis*, Annd. ... | Peninsular Siam ; Gangetic delta ... | ... | Scarce ... | ... | ... |
| OLIGOCHAETA. | | | | | |
| *Chaetogaster annandalei*, Steph. | Japan ... ... ... | ... | In *Ephydatia* ... | ... | ... |
| *Chaetogaster limnaei* ?, v. Baer | Europe ; W. Himalayas ... | ... | Do. ... | ... | ... |
| *Chaetogaster bengalensis*, Annd. | Gangetic delta ... ... | ... | Do. ... | ... | ... |
| *Tranchiura sowerbyi*, Bedd. ... | Probably endemic in Eastern Asia ; also found in Europe. | Common ... | ... | Common ... | In stream from hot spring. |
| *Perionyx fulvus*, Steph. ... | Gangetic delta ... ... | Scarce ... | ... | ... | Common in Yawnghwe River. |
| CRUSTACEA. | | | | | |
| *Potamon* (*Potamon*) *brownianum*, Kemp. | Only known from the lake system ... | ... | ... | ... | Common in streams. |
| *Potamon* (*Potamon*) *acanthicum*, Kemp. | Only known from the Shan States | Fairly common | ... | Scarce ... | Do. |
| *Potamon* (*Potamon*) *curtobates*, Kemp. | Only known from the lake basin ... | Common in swamps. | ... | ... | ... |
| *Palaemon naso*, Kemp. ... | Only known from the lake system ... | ... | ... | ... | Abundant in river below lake. |
| *Palaemon* sp. ... ... | Probably identical with species from N. Shan States. | ... | ... | ... | In warm spring. |
| *Palaemon hendersoni*, de Man ... | E. Himalayas ; hills of Assam and Upper Burma. | ... | ... | ... | Fairly common. |
| *Caridina annandalei*, Kemp. ... | Tenasserim ... ... | Abundant ... | Abundant ... | Abundant ... | Less common. |
| *Caridina weberi*, de Man, var. ... | Species widely distributed in Malaysia and India. | Scarce ... | ... | ... | Common. |

| | | | | | |
|---|---|---|---|---|---|
| INSECTA. | | | | | |
| Odonata.[1] | | | | | |
| *Pseudagrion microcephalum* (Ramb.) | Oriental Region ... ... | Larva abundant | Larva abundant | Larva abundant | ... |
| *Ceriagrion olivaceum* ?, Laidlaw | Abor Hills, Assam . . ... | Larva perhaps from this zone. | ... | ... | ... |
| *Ischneura*, sp nov. ... ... | ..... | Larva abundant | Larva abundant | Larva abundant | ... |
| *Rhinocypha iridea*, Selys. ... | Burma ... ... ... | ... | ... | ... | Larvae probably in jungle streams. |
| *Rhinocypha biforata*, Selys. ... | Burma ; Malay Peninsula ... | ... | ... | ... | Do. |
| Rhynchota. | | | | | |
| *Mesovelia vittigera*,[2] Horv. ... | Syria, Egypt ; Oriental and Ethiopian Regions, New Guinea. | Common ... | ... | ... | ... |
| *Velia Y-alba*, Paiva ... | Only known from the lake ... | A single specimen. | ... | ... | ... |
| *Microvelia burmanica*, Paiva ... | Tenasserim ... ... | ... | ... | ... | Common in small streams above lake. |
| *Microvelia diluta*, Dist. ... | Bengal ... ... ... | Small pool near Yawnghwe. | ... | ... | ... |
| *Perittopus breddini*, Kirk. ... | Java ; Malay Peninsula ; Tenasserim | ... | ... | ... | Common in small streams. |
| *Gerris anadyomene*, Kirk. ... | Ceylon ; Philippines ... ... | Small pool ... | ... | ... | ... |
| *Gerris nepalensis*, Dist. ... | Northern India ; Tenasserim ... | Common ; also in ponds. | ... | ... | ... |
| *Gerris fossarum* (Fabr.) ... | Bengal ; Malay to Philippines and Australia. | Abundant ... | Abundant ... | Occasional ... | ... |
| *Gerris nitida* (Mayr.) ... | India ; Burma and Ceylon ... | Scarce ... | ... | ... | ... |
| *Gerris tristan*, Kirk. ... | India ; Burma and Ceylon ... | Do. ... | ... | ... | ... |
| *Gerris paludum*, Fab. ... | Palaearctic Region ; Upper Burma | Canal ; scarce | ... | ... | Small stream ; scarce. |
| *Gerris spinolae*, Leth. and Sev. ... | Oriental Region ... ... | Common ... | Common ... | Occasional ... | ... |
| *Ptilomera laticaudata* (Hardw.) ... | Oriental Region ... ... | ... | ... | ... | Common on jungle streams. |
| *Onychotrechus lyra*, Paiva ... | Only known from the lake system ... | ... | ... | ... | On hill streams. |
| *Ventidius distanti*, Paiva ... | Only known from the lake system ... | ... | ... | ... | Do. |

[1] Our collection from the Inlé Lake, which is now in the hands of Dr. F. F. Laidlaw, has not yet been completely worked out.
[2] *Mesovelia mulsanti*, Buch. White. See Paiva, p. 20 in this volume, and Bergroth, *Philippine Journ. Sci.* XIII, p. 121 (1918)

List of the Fauna of the Inle Lake System—*contd.*

| Name. | General Distribution. | Distribution in Lake System. | | | |
|---|---|---|---|---|---|
| | | Marginal zone. | Intermediate zone. | Central Region. | Running water. |
| Insecta—*contd.* | | | | | |
| Rhynchota—*contd.* | | | | | |
| *Metrocoris nigrofasciatus*, Dist. | Himalayas ; Burma ; Malaya ; Siam | Common on ponds | ... | ... | ... |
| *Naboandelus signatus*, Dist. | Gangetic delta ... | Common in this zone. | ... | ... | ... |
| *Rhagadotarsus kraepelini*,[1] Bredd. | Oriental Region ... | Scarce ... | ... | ... | ... |
| *Ranatra varipes*, Stal. | Widely distributed in Asia ... | From marsh; scarce. | ... | ... | ... |
| *Cercotmetus pilipes* (Dall.) | Bhutan ; E. Himalayas ... | From marsh; scarce. | ... | ... | ... |
| *Sphaerodema rusticum* (Fabr.) | India to Philippines ; China and Australia. | Common ... | ... | ... | ... |
| *Enithares templetoni* (Kirby) | India ; Ceylon ; Peninsular Siam ... | ... | ... | ... | Common in hill streams. |
| *Enithares intha*, Paiva | Only known from the lake ... | Scarce ... | ... | ... | ... |
| *Anisops niveus* (Fab.) | Widely distributed in S. Asia ... | From muddy pool. | ... | ... | ... |
| *Anisops sardea* (Herr.-Schaff.) | Widely distributed in S. Asia ... | From pool ... | ... | ... | ... |
| *Nychia infuscata*, Paiva | Only known from the lake ... | Common ... | ... | ... | ... |
| *Plea quinquenotata*, Paiva | Only known from the lake ... | Scarce ... | ... | ... | ... |
| *Plea areolata*, Paiva | Only known from the lake system ... | ... | ... | ... | One specimen from stream. |
| *Corixa septemlineata*, Paiva | Only known from the lake system ... | From pool ... | ... | ... | ... |
| *Corixa unicolor*, Paiva | Only known from the lake system ... | Do. ... | ... | ... | ... |
| *Micronecta substriata*, Paiva | Only known from the lake ... | Five specimens | ... | ... | ... |
| *Micronecta soror*, Paiva | Only known from the lake ... | One specimen | ... | ... | ... |
| *Micronecta fulva*, Paiva | Only known from the lake ... | Three specimens | ... | ... | ... |

| | | | | | |
|---|---|---|---|---|---|
| DIPTERA. | | | | | |
| *Anopheles barbirostris*, v. d. W. | Widely distributed in S. E. Asia ... | Larva (scarce) in this zone. | ... | ... | ... |
| *Polypedilum* sp. ... ... | ..... | ... | ... | Larvae not uncommon. | ... |
| MOLLUSCA. | | | | | |
| Gastropoda. | | | | | |
| *Succinea indica*, Pfeiffer ... | Himalayas ... ... ... | At edge: common. | ... | ... | ... |
| *Limnaea andersoniana*, Nevill ... | Yunnan; Shan States ... ... | Occasional: one phase common in ponds. | ... | ... | One phase in streams. |
| *Limnaea shanensis*, Annd. ... | Only known from lake system ... | Scarce; common in ponds. | ... | ... | ... |
| *Limnaea mimetica*, Annd. ... | Only known from lake ... ... | ... | Rather scarce | Scarce ... | ... |
| *Planorbis exustus*, Desh. ... | Oriental Region ... ... | Common at edge. | ... | ... | ... |
| *Planorbis velifer*, Annd. ... | Only known from lake ... ... | ... | Not uncommon | Less abundant | ... |
| *Planorbis trochoideus*, Benson ... | Gangetic delta ... ... | Scarce ... | Do. ... | Not uncommon | ... |
| *Planorbis colathus*, Benson ... | Himalayas; Ceylon; Siam ... | Do. ... | Do. ... | Do. ... | ... |
| *Planorbis caenosus*, Benson ... | N. India; Ceylon ... ... | Do. ... | ... | ... | ... |
| *Melania tuberculata* (Müller) ... | N. Africa; Ethiopian and Oriental Regions, etc. | ... | ... | Common ... | Common in muddy streams. |
| *Melania terebra*, Benson ... | ..... | ... | ... | ... | Do. |
| *Melania baccata elongata* (Gould) | Species in Shan States and Upper Burma. Var. only known from lake system. | In marshes ... | ... | ... | Do. |
| *Paludomus ornata*, Benson ... | Irrawadi and Brahmaputra ... | ... | ... | ... | In runnel. |
| *Hydrobioides nassa* (Theobald) | Shan States ... ... | Common; also in ponds and marshes. | ... | ... | ... |
| *Hydrobioides nassa lacustris*, Annd. | Only known from lake ... ... | Fairly common | Common ... | Common ... | ... |
| *Hydrobioides physcus*, Annd. ... | Only known from lake system ... | Common; also in swamp. | Do. ... | Do. ... | ... |

[1] *Nacebus dux*, Dist. See Paiva, p. 26 in this volume, and Bergroth, *op. cit.* p. 122.

LIST OF THE FAUNA OF THE INLE LAKE SYSTEM—*contd.*

| Name. | General Distribution. | Distribution in Lake System. | | | |
|---|---|---|---|---|---|
| | | Marginal zone. | Intermediate zone. | Central Region. | Running water. |
| MOLLUSCA—*contd.* | | | | | |
| Gastropoda—*contd.* | | | | | |
| *Hydrobioides avarix*, Annd. ... | Tenasserim ... ... | ... | ... | ... | In small stream of warm water. |
| *Hydrobioides nana*, Annd. ... | Only known from lake ... ... | Rather scarce | ... | ... | ... |
| *Amnicola alticola*, Annd. ... | Only known from lake ... ... | Fairly common | Fairly common | Fairly common | ... |
| *Vivipara lecythis* (Benson) ... | Assam ; Burma ; W. China ... | Very scarce ... | ... | ... | ... |
| *Taia naticoides* (Theobald) ... | Shan States ; Upper Burma ... | Common in marshes. | ... | ... | In backwaters. |
| *Taia theobaldi* (Kobelt) ... | Shan States ; " Burma " ... | ... | ... | ... | Common. |
| *Taia shanensis* (Kobelt) ... | S. Shan States ... ... | Common ... | ... | ... | ... |
| *Taia elitoralis*, Annd. ... | Only known from lake ... ... | ... | Rather scarce | ... | ... |
| *Taia intha*, Annd. ... ... | Only known from lake ... ... | ... | ... | Very abundant | ... |
| *Ampullaria winkleyi*, Pilsbry ... | L. Burma ... ... ... | Common near edge. | Much scarcer ... | ... | In stream from hot spring. |
| Pelecypoda. | | | | | |
| *Physunio micropteroides*, Annd.... | Only known from Yawnghwe River | ... | ... | ... | Common in mud. |
| *Physunio ferrugineus*, Annd. ... | Only known from lake ... ... | ... | ... | Common ... | ... |
| *Corbicula noetlingi*, v. Martens | Shan States ... ... | In ponds and marshes. | ... | ... | Common in sluggish streams. |
| *Pisidium casertanum* (Poli) ... | Europe ; Siberia ; Japan ... | ... | ... | Not uncommon | Scarce ; in back-water. |
| FISH. | | | | | |
| *Chaudhuria caudata*, Annd. ... | Genus only known from lake ... | Scarce ... | Scarce ... | Scarce ... | ... |
| *Amphipnous cuchia* (Ham. Buch.) | India ; Burma ; Malay Peninsula ... | Common ... | ... | ... | In sluggish streams. |
| *Monopterus albus* (Zuiew) ... | S. Asia east of Bay of Bengal ; N. China ; Japan. | Do. ... | ... | ... | Do. |

| | | | | | |
|---|---|---|---|---|---|
| *Clarias batrachus* (Linn.) ... | India to Philippines ... ... | Do. ... | ... | ... | Do. |
| *Lepidocephalus berdmorei* (Blyth) | Burma ... ... ... | Occasional ... | ... | ... | Common. |
| *Nemachilus botia* (Ham. Buch.)... | India ; Burma ... ... | ... | ... | ... | In hill streams. |
| *Nemachilus brevis*, Boulenger ... | Only known from lake system ... | Abundant ... | Abundant ... | Abundant ... | In slow streams. |
| *Nemachilus brunneanus*, Annd. | Only known from Yawnghwe Valley | Do. ... | Do. ... | Do. ... | In slow and rapid streams. |
| *Discognathus lamta* (Ham. Buch.) | India ; Burma ... ... | Fairly common | Fairly common | Fairly common | In sluggish streams. |
| *Discognathus*[1] sp. ... ... | Only known from He-Ho ... | ... | ... | ... | Do. |
| *Cirrhina latia* (Ham. Buch.) ... | India ; Burma ... ... | Abundant ... | Abundant ... | Abundant ... | ... |
| *Barbus sarana caudimarginatus*, Blyth | Subsp., Upper Burma and Tenasserim ; species, India. | Do. ... | Less common | Less common | ... |
| *Barbus dukai*, Day ... ... | E. Himalayas ; Burma ; Sumatra ... | ... | ... | ... | In hill streams. |
| *Barbus tor* (Ham. Buch.) ... | Several local races in India ... | ... | ... | ... | In streams and rivers. |
| *Barbus nigrovittatus*, Boulenger | Only known from Fort Stedman ... | ... | ... | ... | ? In streams. |
| *Barbus schanicus*, Boulenger ... | Only known from lake system ... | ? Occasional ... | ... | ... | In larger streams. |
| *Barbus stoliczkanus*, Day ... | Burma ; ? India ... ... | ... | ... | ... | In hill streams. |
| *Barbus stedmanensis*, Boulenger | ..... | ... | ... | ... | ... |
| *Cyprinus carpio intha*, Annd. ... | Southern Shan States ... ... | Abundant ... | Abundant ... | Abundant ... | ... |
| *Sawbwa resplendens*, Annd. ... | Genus only known from lake ... | Do. ... | Do. ... | Do. ... | ... |
| *Microrasbora rubescens*, Annd. ... | Only known from lake system, also in ponds. | Do. ... | Do. ... | Do. ... | ... |
| *Microrasbora erythromicron*, Annd. | Only known from lake system ... | Rather scarce ; common in rice-fields. | ... | ... | ... |
| *Barilius auropurpureus*, Annd. ... | Only known from Yawnghwe Valley | Abundant ... | Abundant ... | Abundant ... | In sluggish streams. |
| *Barilius ornatus*, Sauvage ... | Menam River ... ... | ... | ... | ... | ? Rivers. |
| *Notopterus notopterus* (Pallas) ... | India ; Burma ; Siam ; Malaysia ... | Abundant ... | Abundant ... | Scarcer ... | In sluggish streams. |
| *Mastacembelus oatesii*, Boulenger | Only known from lake system ... | Common ... | Common ... | Common ... | Do. |
| *Mastacembalus caudiocellatus*, Boulenger | Only known from lake system ... | Do. ... | Do. ... | Do. ... | Do. |
| *Ophiocephalus striatus*, Bloch. ... | India ; Burma ... ... | Do. ... | Do. ... | Do. ... | ... |
| *Ophiocephalus gachua*,[2] Ham. Buch. | Persia ; India ; Burma ; Malaysia, etc. | ? | ? | ? | ? |

[1] The examination of a large number of specimens of *Discognathus* since my paper on the Inlé fish was written has removed all doubts as to this form being an undescribed species. I will describe it shortly in the *Records of the Indian Museum*, vol. XVI.

[2] Possibly the form I have called *O. harcourt-butleri* is the same as that identified by Boulenger as *O. gachua* (*Ann. Mag. Nat. Hist.* (6) XII, p. 198).

LIST OF THE FAUNA OF THE INLE LAKE SYSTEM—*concld.*

| Name. | General Distribution. | Distribution in Lake System. | | | |
|---|---|---|---|---|---|
| | | Marginal zone. | Intermediate zone. | Central Region. | Running water. |
| FISH—*contd.* | | | | | |
| *Ophiocephalus harcourt-butleri*, Annd. | Only known from lake system ... | Abundant ... | Abundant ... | Abundant ... | In sluggish streams. |
| *Ophiocephalus siamensis*, Günther | Menam River ... ... | ? | ? | ? | ? |
| *Danio aequipinnatus* (McCl.) ... | ..... | In rice-fields ... | ... | ... | ... |
| BATRACHIA. | | | | | |
| *Rana kuhlii*, D. and B. ... | Tropical and Sub-Tropical Asia east of Bay of Bengal. | ... | ... | ... | Larvae in hill streams. |
| *Rana limnocharis*, Wiegm. ... | Plains of S. Asia ; N. China ; Japan | Probably common. | ... | ... | ... |
| *Bufo melanostictus*, Schneid. ... | Oriental Region ... ... | ... | ... | ... | Larvae in hill streams. |
| *Megalophrys montana*, Kuhl. ... | Siam ; Malay Peninsula and Archipelago. | ... | ... | ... | Do. |
| REPTITIA. | | | | | |
| *Cyclemys dhor shanensis*, Annd.... | Species, Assam to Malay Archipelago; sub-species only known from lake system. | Not uncommon | ... | ... | At edge of sluggish streams. |
| *Trionyx* sp. ... ... | ? | ? | ? | ? | ... |

## EXPLANATION OF PLATE XXVI.

VIEWS IN THE THREE ZONES OF LIFE IN THE INLE LAKE.

FIG. 1.—Floating gardens in the Marginal Zone, showing crops of spring onions, tomatoes and cucumbers, the last on trellises.

FIG. 2.—View in the Intermediate Zone, showing floating islands in their natural condition in the background and sub-aquatic thickets of *Ceratophyllum* rising to the surface in the foreground.

FIG. 3.—A fishing-hut built on piles in the Central Region and surrounded by a floating breakwater anchored by means of poles stuck through it into the bottom of the lake.

3

2

1

F. H. Gravely, Photo.

# A NEW SPECIES OF *TAIA* FROM THE CHINDWIN VALLEY, UPPER BURMA.

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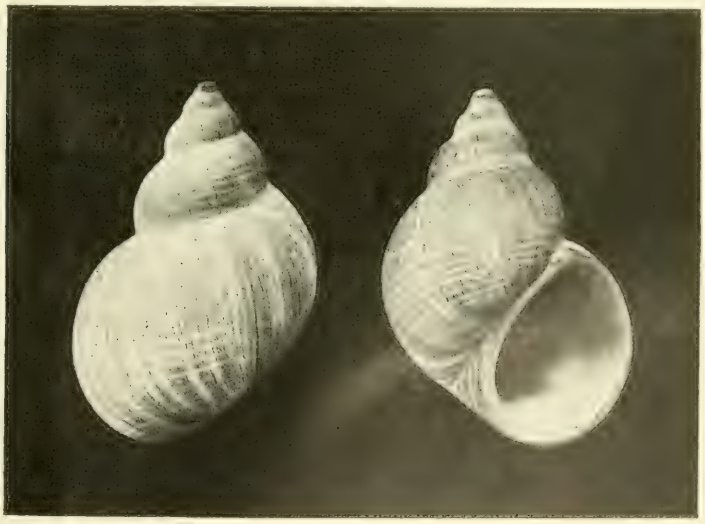
The shell described here has no direct connection with the Inlé Lake, but it will, I think, be convenient to include a description of it in the volume in which the genus is discussed at length (see pp. 123—125). The original specimens reached me, through the Geological Survey of India, from Mr. A. P. Morris some time after my account of the Inlé molluscs was in print.

**Taia incisa,** sp. nov.

The shell is thick, moderately small and sharply conical; it was evidently marked when fresh with two broad brown or purple spiral bands, but the epidermis has entirely disappeared from all the specimens examined and they have assumed a chalky whiteness. The



Photographs of type-specimen of *Taia incisa*. (×2).
Red powder has been dusted on the surface of the shell in order to show up the sculpture in the photographs.

suture is oblique and deeply impressed; the whorls are swollen and distinct, 5½ in number. The spire is short and decreases rapidly towards the apex; it is less than half the length of the body-whorl however measured. The mouth of the shell is large, oblique and prominent, oval or slightly ovoid in shape, with the outer lip slightly expanded outwards and forwards. The columellar callus is expanded and thickened

in the usual way, entirely concealing the umbilicus and in continuity with the outer lip; it is deeply grooved and plicated longitudinally and does not extend so far over the surface of the shell as in some species. The characteristic longitudinal striae are well developed but rather fine; the spiral sculpture consists entirely of incised lines, which are often slightly diverted where they are crossed by the stronger longitudinal striae. On the apex of the shell, which is perhaps worn in all the specimens examined, the spiral lines are obscure, but they are distinct and numerous on the last three whorls. On each of these whorls two or three of them are particularly deep on the upper surface just outside the suture. On the body-whorl the lines are obsolete or obsolescent on the central region but exceptionally strong on the upper part of the lowest third; at the base of the whorl they are well-marked but not so broad or so deep.

*Measurement of shells* (in millimetres).

| | | Type. | |
|---|---|---|---|
| Length ... ... ... ... | 32 | 26 | 22 |
| Breadth ... ... ... ... | 20 | 18 | 15 |
| Length of aperture ... ... ... | 16 | 13 | 12 |
| Breadth of aperture ... ... ... | 11 | 9·5 | 8·5 |

*Type specimen.*—M. $\frac{11377}{2}$, Zool. Survey of India (*Ind. Mus.*).

*Locality, etc.*—A large number of dead shells were collected by Mr. A. P. Morris in obsolete mud-volcanoes at Kin-U north of Shwebo in the Chindwin Valley. They seem to have accumulated in the pools of the mud-volcanoes when the latter became inactive and are probably subfossil. With them were found several shells of *Vivpara viridis* (Reeve) and *Ampullaria winkleyi*, Pilsbry and one of *Bithynia goniomphalos* (Morelet).

The shell of *T. incisa* differs from that of all the species previously assigned to the genus in having only $5\frac{1}{2}$ whorls and in its incised spiral sculpture, but has the characteristic columellar callus well developed. It is perhaps related to *Vivipara chalanguensis* (Deshayes) from Cambodia. A species of *Taia*, *T. noetlingi* (Kobelt), has already been recorded from the Chindwin Valley.